THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

Quod si cui mortalium cordi et curæ sit non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant —*Novum Organum, Præfatio.*

VOLUME THE TWENTY-THIRD.

1867.

PART THE FIRST.
PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:
LONGMAN, GREEN, READER, AND DYER.
PARIS:—FRIED. KLINCKSIECK, 11 RUE DE LILLE; J. ROTHSCHILD, 14 RUE DE BUCI.
LEIPZIG, T. O. WEIGEL.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCLXVII.

List

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Elected February 15th, 1867.

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GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 15, 1867.

REPORT OF THE COUNCIL.

In presenting their Annual Report to the Fellows of the Geological Society of London, the Council are rejoiced at being enabled to again congratulate them on the continued prosperity of the Society, and the sustained annual increase in its numbers.

During the year 1866 the list has been swollen by the election of 55 new Fellows, one of whom, however, died previously to the date of his election; of these 48 had paid their fees up to the end of the year, making with 16 previously elected, who paid their fees last year, a total of 64 new Fellows. Against this increase must be placed the reduction in the number of the Society caused by the resignation of 6 Fellows and the death of 25, some of whom died in former years, but whose deaths had not been ascertained until recently,—giving a net increase of 33 ordinary Fellows.

Three Foreign Members and two Foreign Correspondents have been reported as deceased.

Four Foreign Correspondents were elected in 1866, and one was placed on the list of Foreign Members, to fill the vacancies caused by the above-mentioned deaths.

The total number of the Society at the close of 1865 was 1117; and at the close of 1866, 1149.

The increase in the Society's Income, which was so noticeable in the Balance-sheet of 1865, has continued during the past year, although the actual excess of Income over Expenditure is not so great as in 1865, owing to the payment in 1866 of a considerable amount which properly belonged to the expenditure of the previous year. A large amount has also been spent on the new edition of the Greenough Map; the Expenditure on the Quarterly Journal has been unusually great; and the Library has profited by the exceptionally large expenditure of nearly £170. But notwithstanding these unusual demands on the resources of the Society, the Income of the year has exceeded the Expenditure by £108 6*s.* 8*d.*

The funded property of the Society remains the same as at the last Anniversary, namely £4560.

The Council have to announce the completion of Vol. XXII. of the Quarterly Journal, and the publication of the first part of Vol. XXIII.

They have also to report the appointment of Mr. R. F. Fenton to the office of Clerk in the room of Mr. P. G. Ritchie.

The Council have awarded the Wollaston Medal to George Poulett Scrope, Esq., M.P., F.R.S., in recognition of the highly important services he has rendered to Geology by his examination and published descriptions of the volcanic phenomena of Central France, and by his works on the subject of volcanic action generally throughout the world; and the balance of the proceeds of the Wollaston Fund to William Hellier Baily, Esq., F.L.S., F.G.S., to assist him in the preparation and publication of an Illustrated Catalogue of British Fossils.

Report of the Library and Museum Committee, 1866–67.

The Museum.

The Society's Museum has received but few accessions during the past year. The chief additions made to the Foreign Collection are:—A collection of rocks from Upper Egypt, presented by J. C. Hawkshaw, Esq., F.G.S.; and a number of Microscopic slides of Foraminiferous and Pteropodous shells from the Miocene beds of Malta, presented by Capt. Spratt, C.B., F.R.S., F.G.S.

Presentations to the British department of the Society's collections have been made by the Rev. O. Fisher, M.A., F.G.S., Dr. J. S. Bowerbank, F.R.S., F.G.S., and John Lawson, Esq., the most important gift being the type specimen of *Crioceras Bowerbanki,* presented by Dr. Bowerbank.

The fossils of the British Pliocene deposits have been remounted, named, and arranged in 24 drawers, which have been fitted with glass for the preservation of these more or less fragile specimens. The Committee recommend that all the fragile fossils be similarly protected, as they are cleaned and re-named, in order to preserve them from further injury.

Great progress has been made since the last Anniversary in the naming and general arrangement of the Foreign collection; this work is still in hand, but it is expected that the naming of such remaining Foreign fossils as are more easily determinable will be completed in the course of the present year. This part of the Society's collection is much superior to the British portion, and is more consulted; and your Committee would therefore invite the attention of Fellows, Foreign Members, and Foreign Correspondents to our *desiderata,* the supplying of which would aid in comparisons of British and continental species. The Foreign Collection is chiefly deficient in specimens illustrative of the fossils of the following formations:—Tertiary of the Vienna Basin, Middle Chalk, Aptian, Neocomian, Kimmeridge Clay, Upper and Lower Lias, Rhætic, the marine members of the Upper Trias, the Muschelkalk, and the Upper and Lower Silurian, especially the Primordial zone of Bohemia.

Dr. Duncan has now named all the specimens of the fossil Madreporaria in the Foreign Collection.

The following table contains a summary of the work done in the Museum during the past year, in naming and arranging collections of fossils:—

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In pursuance of a special resolution and grant of the Council, two mahogany glass-top cases have been provided for the Collection of Elephants' teeth named by the late Dr. Falconer, at a cost of £6 10*s*. They are placed in the window-recesses of the Lower Museum.

In the opinion of the Committee the Society is under considerable obligations to Dr. Duncan for having completed the arrangement of the foreign Madreporaria; and they also consider that Mr. Tate has satisfactorily discharged his duties as Assistant in the Museum Department during the past year.

The Committee beg to recommend that a standing Committee be appointed to superintend the Museum and to report to the Council from time to time.

J. GWYN JEFFREYS.
THOS. WILTSHIRE.
ROBERT ETHERIDGE.

The Library.

The Council having adopted the recommendations made by the Committee at their last Annual Meeting (viz. that a larger sum should be expended annually in the purchase of books than had previously been voted for that purpose, and that a standing Library Committee should be appointed), additions of the value of £131 15*s*. 8*d*. have, during the past year, been made to the Library, exclusive of £44 7*s*. 2*d*. expended in binding and map-mounting.

The chief works added to the Library by purchase are De Blainville's 'Ostéographie,' the Palæontological Memoirs of the Geological Survey of California, Ehrenberg's 'Microgeologie,' Geinitz's 'Die Steinkohlen Deutschland's und anderer Länder Europa's,' Watelet's 'Description des Plantes Fossiles du Bassin de

Paris,' Russegger's 'Reisen,' the posthumous parts of Reeve's 'Conchologia Iconica,' and a complete set of the volumes of the 'Annales des Sciences Naturelles' (Zoologie). Among the presentations to the Library may be mentioned:—Professor Ramsay's 'Geology of North Wales,' presented by the Director-General of the Geological Survey; a bound copy of the Maps and Plates to the original edition of Mr. Scrope's 'Geology and Volcanic Formations of Central France,' with explanations, presented by the author; the first volume of the 'Geology of Asia Minor,' by M. P. de Tchihatcheff, with the Palæontological portion by MM. D'Archiac, Fischer, and De Verneuil, presented by M. de Tchihatcheff.

The Map-collection has not been enriched to such an extent as in past years. However, some valuable additions have been made, among which may be mentioned:—'Carte géologique du département de la Seine,' presented by the author, M. Delesse, For. Mem. G.S.; Geological Maps of Southern Norway, by MM. T. Kjerulf and T. Dahll, F.G.S., presented by the authors; some sheets of the Geological Survey-map of Sweden, presented by Dr. A. Erdmann, and of the Netherlands, by the Minister for the Netherlands; numerous sheets of the Ordnance Survey-map of Great Britain and Ireland, presented by the Director-General, Col. Sir Henry James, F.G.S.

Owing to the numerous additions made in the Library during the past few years, it was found necessary last year to erect new book-shelves, for which purpose the Council voted the sum of £14 10*s.*; and for want of available wall-space in the Library or Meeting-room, it has been found necessary to place them in the Tea-room.

The Assistant-Secretary reports that he has been efficiently assisted by Mr. Horace Woodward, who has been very assiduous in the discharge of his duties, and has been of especial aid in the Library, and in preparing Diagrams for the Evening-meetings.

J. GWYN JEFFREYS.
THOS. WILTSHIRE.
ROBERT ETHERIDGE.

Comparative Statement of the Number of the Society at the close of the years 1865 *and* 1866.

	Dec. 31, 1865.	Dec. 31, 1866.
Compounders	167	186
Contributing Fellows	395	429
Non-contributing Fellows	469	449
	1031	1064
Honorary Members	3	3
Foreign Members	44	42
Foreign Correspondents	39	40
	1117	1149

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1865 *and* 1866.

Number of Compounders, Contributing and Non-contributing Fellows, December 31, 1865......			1031
Add Fellows elected during former years and paid in 1866			16
Add Fellows elected and paid in 1866............			48
			1095
Deduct Compounders deceased		2	
Contributing Fellows deceased		3	
Non-contributing Fellows deceased		20	
Contributing Fellows resigned		6	
		—	31
			1064
Number of Honorary Members, Foreign Members, and Foreign Correspondents, December 31, 1865		86	
Add Foreign Member elected in 1866..............		1	
Foreign Correspondents elected in 1866		4	
		91	
Deduct Foreign Members deceased	3		
Foreign Correspondent elected Foreign Member	1		
Foreign Correspondents deceased	2	6	
		—	85
			1149

DECEASED FELLOWS.

Compounders (2).

George Rennie, Esq.
Dr. John Lee.

Residents and other Contributing Fellows (3).

F. A. Jesse, Esq.
Samuel Baines, Esq.
Alexander Bryson, Esq.

Non-contributing Fellows (20).

Henry Stephens, Esq.
Joseph Cox, Esq.
J. W. Robberds, Esq.
Col. Wingfield.
Dr. J. S. Harford.
Sir Charles Hastings.
Dr. W. Somerville.
Rev. J. D. Day.
A. G. Gray, Esq.
Col. T. S. Heneken.
Rev. Dr. H. Robinson.
P. N. Johnson, Esq.
Rev. Dr. W. Whewell.
Capt. T. Hutton.
Rev. W. D. Longlands.
G. W. Featherstonhaugh, Esq.
Charles Maclaren, Esq.
William Hopkins, Esq.
Parkin Jeffcock, Esq.
Prof. H. D. Rogers.

Foreign Members (3).

Prof. Nils de Nordenskiöld.
Sign. Alberto Parolini.
Señor Casiano di Prado.

Foreign Correspondents (2).

Marchese L. D. Pareto.
Dr. C. T. Gaudin.

FELLOWS RESIGNED (6).

Residents and other Contributing Fellows.

Capt. James Vetch.
G. J. Eustace, Esq.
Sidney Beisley, Esq.
J. K. Blackwell, Esq.
Prof. M. Faraday.
Hon. J. L. Warren.

The following Persons were elected Fellows during the year 1866.

January 10th.—Woomes Chunder Bonnerjee, Esq., 108 Denbigh Street, St. George's Road, S.W.; Charles Pannel, Esq., Torquay; and Joseph Wright, Esq., 39 Duncan Street, Cork.

—— 24th.—James Mason, Esq., F.C.S., Brighton; William Nevill, Esq., Langham Cottage, Godalming; and Henry L. T. Von Uster, Esq., 3 Duke Street, Portland Place, W.

February 7th.—Thomas Belt, Esq., Prince of Wales's Mine, Dolgelli; Thomas John Bewick, Esq., Haydon Bridge, Northumberland; Thomas Forster Brown, Esq., H.M. Deputy Gaveller of the Forest of Dean, Coleford; John F. Campbell, Esq., Islay, and Niddry Lodge, Kensington, S.W.; William Cory, Esq., 4 Gordon Place, W.; Anastasius Gowdas, M.D., Athens; William Frederick Cowell Stepney, Esq., 9 Bolton Street, Piccadilly, W.; and John Young, M.D., of the Geological Survey of Great Britain.

—— 21st.—William Henry Corfield, Esq., B.A., Fellow of Pembroke College, Oxford, University College Hospital, Gower Street, W.C.; Henry Lee, Esq., The Waldrons, Croydon; Henry Skiffington Poole, Esq., B.A., Cape Breton, Nova Scotia; Alexander Ramsay, jun., Esq., 45 Norland Square, Notting Hill, W.; Charles Pearce Serocold, Esq., Taplow Hill, and 24 Oxford Square, W.; George Suche, M.D., 77 Grosvenor Street, W.; and James Maurice Wilson, Esq., M.A., Fellow of St. John's College, Cambridge, Rugby School.

March 7th.—Edward Filliter, Esq., Leeds; Myles Kennedy, Esq., Hill House, Ulverston; and Lieut. Charles Warren, R.E., Brompton Barracks, Chatham.

—— 21st.—John Anderson, Esq., Hilbrook, Holywood, Belfast; and the Rev. William Guest, Gothic House, Canonbury Park, N.

April 25.—Henry Bolden, Esq., C.E., 12 Abingdon Street, Westminster, S.W., William Brockbank, Esq., Manchester; William Henry Flower, Esq., F.R.S., Conservator of the Hunterian Museum, Lincoln's Inn Fields, W.C.; Robert John Lechmere Guppy, Esq., of. H.M. Civil Service, Trinidad; John Jones, Esq., Brussels;

Philip Henry Lawrence, Esq., 6 Lincoln's Inn Fields, W.C.; and George Pollock, Esq., Grosvenor Street, W.
May 9th.—The Hon. John Abercromby, 21 Chapel Street, Belgrave Square, S.W.; Edward Davis, Esq., Marina Grande, near Lisbon; and Edward St. John Fairman, Esq., 874 Via Santa Maria, Pisa.
—— 23rd.—John Clarke Hawkshaw, Esq., B.A., C.E., Beverley, Yorkshire; and Lieut.-Col. Valentine Labrow, of the 19th Surrey Rifles, F.S.A., F.R.G.S., Club Chambers, 15 Regent Street, W.
June 6th.—James Gale, Esq., F.C.S., 5 College Terrace, Belsize Park, St. John's Wood, N.W.; William Gillespie, Esq., Torbane Hill, and 5 Queen Street, Edinburgh; and Edward Stringer Westhead, Esq., 6 Cambridge Street, Hyde Park, W.
—— 20th.—George Frederick Armstrong, Esq., B.A., C.E., Albion Place, Doncaster; William Armstrong, Esq., Wingate Grange Colliery, near Ferry Hill, Durham; John Harris, Esq., M.I.C.E., Woodside, near Darlington; and Robert Wigram, Esq., 47 Albemarle Street, W.
November 7th.—The Rev. W. Gover, Saltley College, Birmingham.
December 5th.—C. J. H. Allen, Esq., F.Z.S., 4 Park Crescent, N.W.; Robert Etheridge, Jun., Esq., of the Geological Survey of Victoria, Australia; Marshall Hall, Esq., 3 Cleveland Terrace, Hyde Park, W.; Alfred Gutteres Henriques, Esq., F.Z.S., Heath House, Reigate; Dr. James Murie, Prosector to the Zoological Society of London, 20 Regent's Park Road, N.W.; and John W. Pike, Esq., Mining Engineer, Mexico.
—— 19th.—Theodore Cooke, Esq., Principal of the Engineering College, Poonah; and John Starkie Gardner, Esq., Park House, St. John's Wood, N.W.

The following Person was elected a Foreign Member during the year 1866.

March 7th.—Joseph Leidy, M.D., of Philadelphia.

The following Persons were elected Foreign Correspondents during the year 1866.

March 7th.—Prof. J. P. Lesley, of Philadelphia; and Prof. August Emil Reuss, of Vienna.
June 6th.—M. Victor Raulin, of Paris; and Baron Achille de Zigno, of Padua.

The following Donations to the Museum have been received since the last Anniversary.

British Specimens.

A piece of an Iron Water-pipe from Bath, containing a calcareous incrustation; presented by John Lawson, Esq., F.G.S.
Slab of Kelloway Rock with Belemnites; specimen of *Crioceras Bowerbanki*; presented by Dr. J. S. Bowerbank, F.R.S., F.G.S.

Newer Pliocene Fossils from Suffolk; presented by the Rev. O. Fisher, M.A., F.G.S.

Foreign Specimens.

Siliceous incrustations from the Hot Springs of New Zealand; presented by Miss Kinder, through Sir Charles Lyell, Bart., F.R.S., F.G.S.

Fourteen specimens of Rocks from various localities; presented by W. T. Black, Esq.

Mineral Oils and associated Rocks from the neighbourhood of Pisa; presented by E. St. J. Fairman, Esq., F.G.S.

Nine Microscopic slides of fossil Foraminifera and Pteropoda from Malta; presented by Capt. Spratt, R.N., C.B., F.R.S., F.G.S.

Specimens of Tertiary Sands and Marls from Auckland, New Zealand; presented by Dr. S. Stratford.

Seven Rock-specimens from New South Wales; presented by W. Keene, Esq., F.G.S.

Bones from the Caves and Miocene Deposits of Malta; presented by Dr. A. Leith Adams, F.G.S.

A collection of Rocks from Upper Egypt; presented by J. C. Hawkshaw, Esq., F.G.S.

MAPS, CHARTS, ETC., PRESENTED.

Sveriges Geologiska Undersökning. Nos. 14–18: 1865; presented by Dr. A. Erdmann.

Der Krater von Santorin nach der Englischen Aufnahme u. Mittheilungen von Dr. Julius Schmidt, von A. Petermann; presented by Dr. Petermann.

Carta dell' Etna (12 photographic maps); presented by Baron W. S. von Waltershausen, For. Mem. G.S.

Karten und Profile zur Geologie der Halbinseln Kertsch und Taman, von H. Abich, 1866; presented by the author.

Franz Foetterle's Geologischer Atlas des Oesterreichischen Kaiserstaats. Lief. 1, 1866; presented by John Evans, Esq., F.R.S., Sec. G.S.

Geological Survey-maps of Holland. Sheets 6, 10, 23; presented by His Excellency the Ambassador for the Netherlands.

Nineteen Miscellaneous Charts, published by the Dépôt de la Marine; presented by the Dépôt de la Marine.

Carte Géologique du département de la Seine, by M. Delesse (4 sheets, with geological sections), 1865.

Geological Survey of Great Britain and Ireland. Ireland. Explanations to accompany sheets Nos. 114, 122–125, 160, 161, 167, 168, 171, 172, 176–179, 182, 183, 190, 191, 199, 200, 203–205; presented by the Director-General of the Geological Survey of the British Isles.

Ordnance Survey of Great Britain. Maps, 6-inch scale:—Hampshire, Sheets 89–91, 93–100. Northumberland, Sheets 3, 4, 8–13, 18–25, 28, 34, 38, 40–47, 49–71, 74, 75, 77, 83, 89. Forfarshire, Sheets 19, 20, 24–39, 42. Perthshire, Sheets 94, 95, 98, 100, 104–107, 109–111, 114, 115, 116–118, 120, 122, 124, 125, 128, 130–132, 135–137, 141–143. Perthshire and Clackmannanshire, Sheets 123–126, 133, 134, 139, 140. Ordnance Survey of England. Maps, 1-inch scale:—Sheets 102 (N.E., N.W., and S.W.), 109 (S.E.), 110 (S.E.). Ordnance Survey of Scotland. 1-inch scale:—Sheet 30. Ordnance Survey of Ireland. 1-inch scale:—Sheets 20, 38, 49. Presented by the Director-General of the Ordnance Survey.

Geologisk kart over det Sondenfjeldske Norge, ved Theodor Kjerulf og Tellef Dahll, 1858–1865; presented by the authors.

Carte Géologique de l'Asie Mineure, par P. de Tchihatcheff; presented by the author.

Photographs of Hot Springs in New Zealand; presented by the Rev. T. Kinder, through Sir Charles Lyell, Bart., F.R.S., F.G.S.

Two Water-colour pictures of Hot Springs in New Zealand; presented by C. Heaphy, Esq., through Dr. S. Stratford.

Two Photographs of *Machairodus neogæus* from the Pampas, Buenos Ayres; presented by Sir R. I. Murchison, Bart., K.C.B., F.R.S., F.G.S.

Photographs of ancient sculptures on Reindeer-horn from Caves in the Dordogne; presented by the Marquis de Vibraye, For. Corr. G.S.

Lithograph of *Ammonites Brookii*; presented by Professor Tennant, F.G.S.

Photographs of two species of *Rhizostomites* (*R. admirandus* and *R. lithographicus*, Hkl.) from the Lithographic Slate of Eichstadt; presented by Dr. H. B. Geinitz, For. Mem. G.S.

A Chart of the Genera of Fossil Crustacea, showing the range in time of the several orders, with recent types, arranged by J. W. Salter, F.G.S., and Henry Woodward, F.G.S., 1865; presented by J. W. Lowry, Esq.

Three Lithographs of *Pterygotus Anglicus* from the Old Red Sandstone of Forfarshire; presented by John Evans, Esq., F.R.S., Sec. G.S.

The following Lists contain the Names of the Persons and Public Bodies from whom Donations to the Library and Museum have been received since the last Anniversary, February 16, 1866.

I. List of Societies and Public Bodies from whom the Society has received Donations of Books since the last Anniversary Meeting.

Basel, Natural History Society of.
Berlin. German Geological Society.
——. Royal Prussian Academy.
Berwick. Northumberland and Durham Natural History Society.
Bordeaux, Linnean Society of.
Boston, Natural History Society of.
Bremen, Natural History Society of.
Breslau. Silesian Society for Fatherland Culture.
Brussels. Royal Academy of Belgium.
Caen. Linnean Society of Normandy.
Calcutta. Asiatic Society of Bengal.

Calcutta. Great Trigonometrical Survey of India.
California, Academy of Natural Sciences of.
Cambridge (Mass.). American Philosophical Society.
—— ——. American Academy of Arts and Sciences.
—— ——. Museum of Comparative Zoology.
Carlsruhe, Natural History Society of.
Ceylon Branch of the Royal Asiatic Society,
Chicago, Academy of Sciences of.
Christiania, Royal Academy of.
——, University of.

Dresden, Natural History Society of.
——, Royal Academy of.
Dublin. Royal Irish Academy.
——, Royal Society of.
——. Royal Geological Society of Ireland.

Edinburgh, Geological Society of.
——, Royal Society of.
Exeter. Devonshire Association.

Freiberg. Royal Saxon Mining Academy.

Geneva, Physical and Natural History Society of.
Glasgow, Geological Society of.

Halle, Society of Natural Sciences of.
Heidelberg, Natural History Society of.

Lausanne. Vaudoise Society of Natural Sciences.
Liége, Royal Society of Sciences of.
Liverpool. Lancashire and Cheshire Historic Society.
London, Anthropological Society of.
——, Art Union of.
London. British Association.
——. Chemical Society.
——. Geological Survey of Great Britain.
——. Institute of Actuaries of Great Britain and Ireland.
——. Institute of Civil Engineers.
——, Linnean Society of.
——, Mendicity Society of.
——, Microscopical Society of.
——. Palæontographical Society.
——, Photographic Society of.
——. Ray Society.
——. Royal Asiatic Society of Great Britain and Ireland.
——. Royal Astronomical Society.
——. Royal College of Physicians.
——. Royal College of Surgeons.
——. Royal Geographical So-Society.
——. Royal Horticultural Society.
——. Royal Institution of Great Britain.
——, Royal Society of.
——. School of Mines.
——. Science and Art Department of the Committee of Council on Education.
——. Society of Arts.
——, Zoological Society of.

Manchester, Geological Society of.
——, Literary and Philosophical Society of.
Melbourne. Geological Survey of Victoria.
——. Royal Society of Victoria.
Milan, Royal Lombard Institute.
Montreal, Natural History Society of.
——. Geological Survey of Canada.
Moscow, Imperial Academy of Naturalists of.
Munich, Royal Academy of.

Neuchâtel, Society of Natural Sciences of.
New York, Lyceum of Natural History of.
Nova Scotian Institute.

Offenbach, Natural History Society of.

Paris. Academy of Sciences.
——. Dépôt Général de la Marine.
——. Geological Society of France.
——. School of Mines.
Philadelphia, Academy of Natural Sciences of.
——. American Philosophical Society.
Plymouth Institution.

St. Louis, Academy of Sciences of.
St. Petersburg, Imperial Academy of.
——, Mineralogical Society of.

Shanghai. North China Branch of the Royal Asiatic Society.
Southampton. Ordnance Survey.
Strasbourg, Society of Natural Sciences of.
Stuttgart. Natural History Society of Würtemberg.

Tasmania, Royal Society of.
Teign Naturalists' Field-club.
Turin, Royal Academy of Science of.

Vienna, Geological Institute of.
——, Imperial Academy of.
——, Zoologico-Botanical Society of.

Warwickshire Natural History and Archæological Society.
Washington. Smithsonian Institution.
——. United States War Department.

II. List containing the names of the Persons from whom Donations to the Library and Museum have been received since the last Anniversary.

Adams, Dr. A. L., F.G.S.
Ansted, Prof. D. T., F.G.S.
American Journal of Mining, Editor of the.
American Journal of Science, Editor of the.
Athenæum, Editor of the.

Belt, T., Esq., F.G.S.
Billings, E., Esq., F.G.S.
Binney, E. W., Esq., F.G.S.
Black, W. T., Esq.
Blake, C. C., Esq., F.G.S.
Bland, T., Esq., F.G.S.
Blanford, H. F., Esq., F.G.S.
Boult, J., Esq.
Bowerbank, Dr. J. S., F.G.S.
Bristow, H. W., Esq., F.G.S.
Brodie, Rev. P. B., F.G.S.
Buckman, Prof. J., F.G.S.
Burmeister, Dr. G.

Canadian Journal, Editor of the.
Caton, Hon. J. D.
Chatel, M. V.
Chemical News, Editor of the.
Christy, the Executors of the late H., Esq., F.G.S.
Cialdi, Sign. A.
Clarke, Rev. W. B., F.G.S.
Colliery Guardian, Editor of the.
Croll, J., Esq.

Dahll, T., Esq., F.G.S.
Darwin, C., Esq., F.G.S.
Daubrée, Prof., For.Corr.G.S.
Davidson, T., Esq., F.G.S.
Dawson, Dr. J. W., F.G.S.

Delesse, Prof. A., For.Mem.G.S.
Deslongchamps, Prof. E. E.
Doyne, W. T., Esq.
Dresser, C. L., Esq.
Duncan, Dr. P. M., Sec. G.S.
Dupont, M. E.

Egerton, Sir P. de M. G., Bart., F.G.S.
Eichwald, Dr. E. von.
Evans, J., Esq., Sec. G.S.

Fairman, E. St. J., Esq., F.G.S.
Fisher, Rev. O., F.G.S.
Foster, Dr. C. Le N., F.G.S.
Francis, Dr. W., F.G.S.
Franke, Herr J. F. A.

Gastaldi, Sign. B., For.Corr.G.S.
Gaudry, M. A.
Geinitz, Dr. H. B., For.Mem.G.S.
Gray, J., Esq.
Gümbel, Herr Bergm., For.Corr. G.S.

Hall, T. M., Esq., F.G.S.
Hawkshaw, J. C., Esq., F.G.S.
Heaphy, C., Esq.
Hébert, Prof. E., For.Corr.G.S.
Helmersen, Gen. G. von, For. Mem.G.S.
Hochstetter, Dr. F. von.
Honeyman, Rev. Dr. D., F.G.S.
Hopkins, E. Esq., F.G.S.
Humbert, M. A.

Intellectual Observer, Editor of the.

James, Col. Sir H., F.G.S.
Jones, Prof. T. R., F.G.S.
Journal of Natural and Economic Science, Palermo, Editor of the.
Jukes, J. B., Esq., F.G.S.

Karrer, Dr. F.
Keene, W., Esq., F.G.S.
Kinder, Miss.
Kinder, Rev. T.
Kirkby, J. W., Esq.
Kjerulf, Dr. T., For.Corr.G.S.
Kner, Herr R.
Kobell, Dr. F. von.
Koenen, Baron A. von.

Lartêt, M. E., For.Mem.G.S.
Lartêt, M. L.
Laube, Dr. G. C.
Lawson, J., Esq., F.G.S.
London Review, Editor of the.
Longman and Co., Messrs.
Lowry, J. W., Esq.
Lyell, Sir C., Bart., F.G.S.

Mackie, S. J., Esq., F.G.S.
Mallet, R., Esq., F.G.S.
Marcou, M. J.
Marsh, O. C., Esq., F.G.S.
Martins, Dr. C., For.Corr.G.S.
Mingaud, Dr. P.
Montagna, Major C.
Morlot, M. A., For.Corr.G.S.
Murchison, Sir R. I., Bart., F.G.S.

Napier, C. O. G., Esq., F.G.S.
Naumann, Dr. C. F., For.Mem. G.S.
Nicol, Prof. J., F.G.S.

Packard, Dr. A. S., Jun.
Page, D., Esq., F.G.S.
——, T. Esq., F.G.S.
Peacock, R. A., Esq.
Pengelly, W., Esq., F.G.S.
Pictêt, Prof. F. J., For.Corr.G.S.
Plant, J., Esq., F.G.S.
Plomley, J., Esq.
Pumpelly, R., Esq.

Quarterly Journal of Science, Editors of the.
Quetelet, M. A.

Reader, Editor of the.
Renevier, Prof. E.
Reuss, Dr. A. E., For.Corr.G.S.
Rico y Sinobas, Don Manuel.

Schloenbach, Dr. U.
Scrope, G. P., Esq., M.P., F.G.S.
Searle, Dr. C.

Seebach, Baron K. von.
Seeley, H., Esq., F.G.S.
Sequenza, Sign. G.
Selwyn, A. R. C., Esq.
Sexe, M. S. A.
Smyth, W. W., Esq., Pres. G.S.
Spratt, Capt., T. A. B., F.G.S.
Stalsberg, M. R. F.
Stanley, W. F., Esq.
Steindachner, Dr. F.
Stratford, Dr. S.
Studer, Prof. B., For.Mem.G.S.
Suess, Prof. E., For.Corr.G.S.

Tchihatcheff, M. P. de.
Tennant, Prof. J., F.G.S.
Topley, W., Esq., F.G.S.
Trübner & Co., Messrs.

Vibraye, Marquis de, For.Corr. G.S.
Virtue Brothers & Co., Messrs.

Walker, Lieut.-Col. J. T.
Waltershausen, Baron W. S. von.
War, Secretary of State for.
Whitaker, W., Esq., F.G.S.
Whitney, Prof. J. D.
Winchell, Prof. A.
Winkler, Dr. T. C.
Woodward, the late Dr. S. P., F.G.S.
Woods, Rev. J. E. T., F.G.S.
Wynne, A. B., Esq., F.G.S.

Zeuschner, Herr L.
Zigno, Baron A. de, For.Corr.G.S.

List of PAPERS *read since the last Anniversary Meeting, February* 16*th*, 1866.

1866.

February 21st.—On the Tertiary Mollusca of Jamaica, by R. J. Lechmere Guppy, Esq.; communicated by Henry Woodward, Esq., F.G.S.

——— On the Tertiary Echinoderms from the West Indies, by R. J. Lechmere Guppy, Esq.; communicated by H. M. Jenkins, Esq., F.G.S.

——— On Tertiary Brachiopoda from Trinidad, by R. J. Lechmere Guppy, Esq.; communicated by H. M. Jenkins, Esq., F.G.S.

——— On the Affinities of *Platysomus* and Allied Genera, by John Young, M.D., F.G.S.

——— Note on the Scales of *Rhizodus*, Owen, by John Young, M.D., F.G.S.

March 7th.—Documents relating to the Formation of a New Island in the neighbourhood of the Kaimeni Islands, by St. Vincent Lloyd, Esq., A. Delenda, Esq., and M. Décigala.

——— On the Carboniferous Slate (or Devonian Rocks) of North Devon and South Ireland, by J. Beete Jukes, Esq., M.A., F.R.S., F.G.S.

March 21st.—On the Fossil British Oxen.—Part I. *Bos Urus*, Cæsar, by W. Boyd Dawkins, Esq., M.A., F.G.S.

——— Further Documents relating to the Formation of a New Island in the Neighbourhood of the Kaimeni Islands, by Commander G. Tryon.

——— Note on the Junction of the Thanet Sand and the Chalk, and of the Sandgate Beds and Kentish Rag, by T. M'Kenny Hughes, Esq., B.A., F.G.S.

1866.

March 21st.—On the "Lower London Tertiaries" of Kent, by W. Whitaker, Esq., B.A., F.G.S.

April 11th.—On the Brown Cannel or Petroleum Coal-seams at Colley Creek, Liverpool Plains, New South Wales, by William Keene, Esq., F.G.S.

——— On the Occurrence and Geological Position of Oil-bearing Deposits in New South Wales, by the Rev. W. B. Clarke, M.A., F.G.S.

——— Remarks on the Copper-mines of the State of Michigan, by H. Bauerman, Esq., F.G.S.

April 25th.—Additional Documents relating to the Volcanic Eruptions at the Kaimeni Islands, by Commander Brine.

——— Report to the Eparch of Santorino on the Eruptions at the Kaimeni Islands, by M. Fouqué.

——— Remarks upon the Interval of Time which has passed between the Formation of the Upper and Lower Valley-gravels of part of England and France, by A. Tylor, Esq., F.L.S., F.G.S.

May 9th.—On a New Species of *Acanthodes* from the Coal-shales of Longton, by Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S., F.G.S.

——— A Sketch of the Gravels and Drift of the Fenland, by Harry Seeley, Esq., F.G.S.

——— Additional Observations on the Geology of the Lake-country, by Prof. R. Harkness, F.R.S., F.G.S., and H. Nicholson, Esq.; with a Note on Two Species of *Trilobites*, by J. W. Salter, Esq., F.G.S.

——— On the Lower Silurian Rocks of the Isle of Man, by Prof. R. Harkness, F.R.S., F.G.S., and H. Nicholson, Esq.

May 23rd.—Notes on the Geology of Mount Sinai, by the Rev. F. W. Holland; communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., F.G.S.

——— On a New Genus of Phyllopodous Crustacea from the Moffat Shales (Lower Silurian), Dumfriesshire, by Henry Woodward, Esq., F.G.S.

——— On the Oldest known British Crab (*Palæinachus longipes*, Bell, sp.) from the Forest Marble of Malmesbury, Wilts, by Henry Woodward, Esq., F.G.S.

——— On the Species of the Genus *Eryon*, Desm., from the Lias and Oolite of England and Bavaria, by Henry Woodward, Esq., F.G.S.

——— Notes relating to the Discovery of Primordial Fossils in the Lingula-flags in the neighbourhood of Tyddyngwladis Silver-lead Mine, by J. Plant, Esq., F.G.S.

June 6th.—On the Metamorphic and Fossiliferous Rocks of the county of Galway, by Prof. R. Harkness, F.R.S., F.G.S.

——— On the Metamorphic Lower Silurian Rocks of Carrick, Ayrshire, by J. Geikie, Esq.; communicated by A. Geikie, Esq., F.R.S., F.G.S.

——— On a Cheirotherian Footprint from the base of the Keuper Sandstone of Daresbury, Cheshire, by Prof. W. C. Williamson, F.R.S.; communicated by the Assistant-Secretary.

1866.

June 6th.—A Description of some remarkable "Heaves" or Throws in Penhalls Mine, by J. W. Pike, Esq.; communicated by Dr. C. Le Neve Foster, F.G.S.

June 20th.—On the Structure of the Red Crag, by S. V. Wood, Esq., F.G.S.

—————— Note on Supposed Remains of the Crag on the North Downs, near Folkestone, by H. W. Bristow, Esq., F.R.S., F.G.S.

—————— On the Warp of Mr. Trimmer; its age and probable connexion with the latest geological events and changes of climate, by the Rev. O. Fisher, M.A., F.G.S.

—————— On Faults in the Drift-gravel at Hitchin, Herts, by J. W. Salter, Esq., F.G.S.

—————— On some Flint Implements lately found in the Valley of the Little Ouse River, near Thetford, by J. W. Flower, Esq., F.G.S.

—————— On some evidences of the Antiquity of Man in Ecuador, by J. S. Wilson, Esq.; communicated by Sir R. I. Murchison, Bart., K..B., F.R.S., F.G.S.

—————— On the relations of the Tertiary Formations of the West Indies, by R. J. L. Guppy, Esq., F.G.S.

—————— On the discovery of new Gold-deposits in the district of Esmeraldas, Ecuador, by Lieut.-Colonel Neale.

—————— On bones of fossil Chelonians from the Ossiferous Caves and Fissures of Malta, by A. Leith Adams, M.B., F.G.S.

—————— On the discovery of remains of *Halitherium* in the Miocene beds of Malta, by A. Leith Adams, M.B., F.G.S.

—————— On the affinities of *Chondrosteus*, Ag., by John Young, M.D., F.G.S.

—————— On new Carboniferous genera of Crossopterygian Ganoids, by John Young, M.D., F.G.S.

—————— On supposed burrows of Worms in the Laurentian Rocks of Canada, by Dr. J. W. Dawson, F.G.S.

November 7th.—On some remains of large Dinosaurian Reptiles from the Stormberg Mountains, South Africa, by Professor T. H. Huxley, LL.D., F.R.S., F.G.S.

—————— Additional Notes on the grouping of the rocks of North Devon and West Somerset, by J. Beete Jukes, Esq., M.A., F.R.S., F.G.S.

November 21st.—On marine fossiliferous deposits of Secondary Age in New South Wales, by the Rev. W. B. Clarke, M.A., F.G.S.

—————— On the Madreporaria of the Infra-lias of South Wales, by P. Martin Duncan, M.B., F.G.S.

—————— On certain points in the structure of the *Xiphosura*, having reference to their relationship with the *Eurypterida*, by Henry Woodward, Esq., F.G.S.

December 5th.—A description of some Echinodermata from the Cretaceous Rocks of Sinai, by P. Martin Duncan, M.B., Sec. G.S.

—————— Geological Description of the First Cataract, Upper Egypt, by J. C. Hawkshaw, Esq., B.A., F.G.S.

1866.

December 5th.—On the Drift of the North of England, by J. Curry, Esq.; communicated by the Assistant-Secretary.

December 19th.—On a new specimen of *Telerpeton Elginense*, by Prof. T. H. Huxley, LL.D., F.R.S., F.G.S.

——— On a section at Litcham affording evidence of Land-glaciation during the earlier part of the Glacial period in England, by Searles V. Wood, jun., Esq., F.G.S.

——— On the evidence of a third Boulder-clay in Norfolk, by F. W. Harmer, Esq.; communicated by Searles V. Wood, jun., Esq., F.G.S.

1867.

January 9th.—On the age of the Lower Brick-earths of the Thames Valley, by W. Boyd Dawkins, Esq., M.A., F.G.S.

January 23rd.—On consolidated blocks in the Drift of Suffolk, by George Maw, Esq., F.L.S., F.G.S.

——— On Chemical Analyses of variegated strata, by George Maw, Esq., F.L.S., F.G.S.

February 6th.—On the Jurassic Fauna and Flora of South Africa, by Ralph Tate, Esq., F.G.S.

——— Further remarks on the relation of the Chillesford Beds to the Norwich Crag, by the Rev. O. Fisher, M.A., F.G.S.

After the Reports had been read, it was resolved,—

That they be received and entered on the Minutes of the Meeting; and that such parts of them as the Council shall think fit be printed and distributed among the Fellows.

It was afterwards resolved,—

1. That the thanks of the Society be given to Prof. T. H. Huxley and Prof. A. C. Ramsay, retiring from the office of Vice-President.

2. That the thanks of the Society be given to W. J. Hamilton, Esq., Prof. T. H. Huxley, M. Auguste Laugel, Prof. John Morris, and Lieut.-Col. Strachey, retiring from the Council.

After the Balloting-glasses had been duly closed, and the lists examined by the Scrutineers, the following gentlemen were declared to have been duly elected as the Officers and Council for the ensuing year:—

OFFICERS.

PRESIDENT.

Warington W. Smyth, Esq., M.A., F.R.S.

VICE-PRESIDENTS.

Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
Sir Charles Lyell, Bart., D.C.L., F.R.S.
J. Carrick Moore, Esq., M.A., F.R.S.
Sir R. I. Murchison, Bart., K.C.B., F.R.S.

SECRETARIES.

P. Martin Duncan, M.B., M.R.C.S.
John Evans, Esq., F.R.S., F.S.A.

FOREIGN SECRETARY.

R. A. C. Godwin-Austen, Esq., F.R.S.

TREASURER.

Joseph Prestwich, Esq., F.R.S.

COUNCIL.

Professor D. T. Ansted, M.A., F.R.S.
H. W. Bristow, Esq., F.R.S.
P. Martin Duncan, M.B., M.R.C.S.
Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
Earl of Enniskillen, D.C.L., F.R.S.
Robert Etheridge, Esq., F.R.S.E.
John Evans, Esq., F.R.S., F.S.A.
David Forbes, Esq., F.R.S.
R. A. C. Godwin-Austen, Esq., F.R.S.
J. Gwyn Jeffreys, Esq., F.R.S.
Professor T. Rupert Jones.
Sir Charles Lyell, Bart., D.C.L., F.R.S.
Edward Meryon, M.D., M.R.C.S.
John Carrick Moore, Esq., M.A., F.R.S.
Sir R. I. Murchison, Bart., K.C.B., F.R.S.
Robert W. Mylne, Esq., F.R.S.
Joseph Prestwich, Esq., F.R.S.
Professor A. C. Ramsay, LL.D., F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.
Capt. T. A. B. Spratt, R.N., C.B., F.R.S.
Alfred Tylor, Esq., F.L.S.
Rev. Thomas Wiltshire, M.A., F.R.A.S.
Henry Woodward, Esq., F.Z.S.

LIST OF

THE FOREIGN MEMBERS

OF THE GEOLOGICAL SOCIETY OF LONDON, IN 1867.

Date of Election.

1818. Professor G. C. Gmelin, *Tübingen.*
1819. Count A. Breunner, *Vienna.*
1822. Count Vitaliano Borromeo, *Milan.*
1827. Dr. H. von Dechen, *Bonn.*
1828. M. Léonce Elie de Beaumont, Sec. Perpétuel de l'Instit. France, For. Mem. R.S., *Paris.*
1829. Dr. Ami Boué, *Vienna.*
1829. Dr. J. J. d'Omalius d'Halloy, *Halloy, Belgium.*
1839. Dr. Ch. G. Ehrenberg, For. Mem. R.S., *Berlin.*
1840. Professor Adolphe T. Brongniart, For. Mem. R.S., *Paris.*
1840. Professor Gustav Rose, *Berlin.*
1841. Dr. Louis Agassiz, For. Mem. R.S., *Cambridge, Massachusetts.*
1841. Professor G. P. Deshayes, *Paris.*
1844. William Burton Rogers, Esq., *Boston, U.S.*
1844. M. Edouard de Verneuil, For. Mem. R.S., *Paris.*
1847. M. le Vicomte B. d'Archiac, *Paris.*
1848. James Hall, Esq., *Albany, State of New York.*
1850. Professor Bernard Studer, *Berne.*
1850. Herr Hermann von Meyer, *Frankfort-on-Maine.*
1851. Professor James D. Dana, *New Haven, Connecticut.*
1851. General G. von Helmersen, *St. Petersburg.*
1851. Dr. W. K. von Haidinger, For. Mem. R.S., *Vienna.*
1851. Professor Angelo Sismonda, *Turin.*
1853. Count Alexander von Keyserling, *Dorpat.*
1853. Professor L. G. de Koninck, *Liége.*
1854. M. Joachim Barrande, *Prague.*
1854. Professor Karl Friedrich Naumann, *Leipsic.*
1856. Professor Robert W. Bunsen, For. Mem. R.S., *Heidelberg.*
1857. Professor H. R. Goeppert, *Breslau.*
1857. M. E. Lartêt, *Paris.*
1857. Professor H. B. Geinitz, *Dresden.*
1857. Dr. Hermann Abich, *Tiflis, Georgia.*
1858. Herr Arn. Escher von der Linth, *Zurich.*
1859. Professor A. Delesse, *Paris.*
1859. Dr. Ferdinand Roemer, *Breslau.*
1860. Dr. H. Milne-Edwards, For. Mem. R.S., *Paris.*
1861. Professor Gustav Bischof, *Bonn.*

1862. Baron Sartorius von Waltershausen, *Göttingen.*
1862. Professor Pierre Merian, *Basle.*
1864. Professor Paolo Savi, *Pisa.*
1865. M. Jules Desnoyers, *Paris.*
1866. Dr. Joseph Leidy, *Philadelphia.*

LIST OF

THE FOREIGN CORRESPONDENTS

OF THE GEOLOGICAL SOCIETY OF LONDON, IN 1867.

Date of Election.
1863. Professor E. Beyrich, *Berlin.*
1863. M. Boucher de Perthes, *Abbeville.*
1863. Herr Bergmeister Credner, *Gotha.*
1863. Professor Daubrée, *Paris.*
1863. M. E. Desor, *Neuchâtel.*
1863. Professor Alphonse Favre, *Geneva.*
1863. Signor B. Gastaldi, *Turin.*
1863. M. Paul Gervais, *Montpellier.*
1863. Herr Bergrath Gümbel, *Munich.*
1863. Dr. Franz Ritter von Hauer, *Vienna.*
1863. Professor E. Hébert, *The Sorbonne, Paris.*
1863. Rev. Dr. O. Heer, *Zurich.*
1863. Dr. Moritz Hörnes, *Vienna.*
1863. Dr. G. F. Jäger, *Stuttgart.*
1863. Dr. Kaup, *Darmstadt.*
1863. Dr. Theodor Kjerulf, *Christiania.*
1863. M. Nikolai von Kokscharow, *St. Petersburg.*
1863. M. Lovén, *Stockholm.*
1863. Lieut.-Gen. Count Alberto Ferrero della Marmora, *Turin.*
1863. Count A. G. Marschall, *Vienna.*
1863. Professor G. Meneghini, *Pisa.*
1863. M. Morlot, *Berne.*
1863. M. Henri Nyst, *Brussels.*
1863. Professor F. J. Pictet, *Geneva.*
1863. Signor Ponzi, *Rome.*
1863. Professor Quenstedt, *Tübingen.*
1863. Professor F. Sandberger, *Bavaria.*
1863. Signor Q. Sella, *Turin.*
1863. Dr. F. Senft, *Eisenach.*
1863. Dr. B. Shumard, *St. Louis, Missouri.*
1863. Dr. Steenstrüp, *Copenhagen.*

1863. Prof. E. Suess, *Vienna.*
1863. Marquis de Vibraye, *Paris.*
1864. M. J. Bosquet, *Maestricht.*
1864. Dr. Charles Martins, *Montpellier.*
1865. Dr. C. Nilsson, *Stockholm.*
1866. Prof. J. P. Lesley, *Philadelphia.*
1866. M. Victor Raulin, *Paris.*
1866. Prof. August Emil Reuss.
1866. Baron Achille de Zigno.

AWARDS OF THE WOLLASTON MEDAL

UNDER THE CONDITIONS OF THE "DONATION-FUND"

ESTABLISHED BY

WILLIAM HYDE WOLLASTON, M.D., F.R.S., F.G.S., &c.,

"To promote researches concerning the mineral structure of the earth, and to enable the Council of the Geological Society to reward those individuals of any country by whom such researches may hereafter be made,"—"such individual not being a Member of the Council."

1831. Mr. William Smith.
1835. Dr. G. A. Mantell.
1836. M. L. Agassiz.
1837. { Capt. P. T. Cautley. Dr. H. Falconer.
1838. Professor R. Owen.
1839. Professor C. G. Ehrenberg.
1840. Professor A. H. Dumont.
1841. M. Adolphe T. Brongniart.
1842. Baron L. von Buch.
1843. { M. E. de Beaumont. M. P. A. Dufrénoy.
1844. The Rev. W. D. Conybeare.
1845. Professor John Phillips.
1846. Mr. William Lonsdale.
1847. Dr. Ami Boué.
1848. The Rev. Dr. W. Buckland.
1849. Mr. Joseph Prestwich, jun.
1850. Mr. William Hopkins.
1851. The Rev. Prof. A. Sedgwick.
1852. Dr. W. H. Fitton.
1853. { M. le Vicomte A. d'Archiac. M. E. de Verneuil.
1854. Dr. Richard Griffith.
1855. Sir H. T. De la Beche.
1856. Sir W. E. Logan.
1857. M. Joachim Barrande.
1858. { Herr Hermann von Meyer. Mr. James Hall.
1859. Mr. Charles Darwin.
1860. Mr. Searles V. Wood.
1861. Prof. Dr. H. G. Bronn.
1862. Mr. Robert A. C. Godwin-Austen.
1863. Prof. Gustav Bischof.
1864. Sir R. I. Murchison.
1865. Mr. Thomas Davidson.
1866. Sir Charles Lyell.
1867. Mr. G. P. Scrope.

Trust-Account.

Receipts.	£	s.	d.
Balance at Banker's, January 1, 1866, on the Wollaston Donation-fund	31	16	10
Dividends on the Donation-fund for 1866 on £1084 1*s.* 1*d.* Reduced 3 per Cents.	31	19	6
	£63	16	4

Payments.	£	s.	d.
Award to Mr. Woodward	21	6	10
Cost of striking Gold Medal awarded to Sir C. Lyell	10	10	0
Balance at Banker's (Wollaston-fund)	31	19	6
	£63	16	4

Valuation of the Society's Property; 31*st December*, 1866.

Property.	£	s.	d.
Due from Longman and Co., on acc. of Journ. Vol. XXII.	53	14	7
Due from Subscribers to Journal	30	0	0
Due for Authors' Corrections in Journal	25	0	0
Balance in Banker's hands, Dec. 31, 1866	666	5	9
Balance in Clerk's hands	52	8	9
Funded Property :—			
Consols, at 95 (£ 4801* s. 3 d. 7)	4561	2	5
Arrears of Admission-fees (considered good)	75	0	0
Arrears of Annual Contributions (ditto)	225	0	0
Due from Stanford on account of Geological Map	12	13	5½
	£5701	4	11½

Debts.	£	s.	d.
Balance in favour of the Society	5701	4	11½
	£5701	4	11½

[*N.B. The value of the Mineral Collections, Library, Furniture, and stock of unsold Publications is not here included.*]

JOSEPH PRESTWICH, *Treas.*

Feb. 4, 1867.

* Including the balance of £300 remaining from the Greenough and Brown Bequest-fund.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions on Quarterly Journal (considered good)	30	0	0			
Due for Authors' Corrections	25	0	0			
Due for Arrears (See Valuation-sheet)	300	0	0			
				355	0	0
Ordinary Income.						
From Resident Fellows, &c., and Non-residents of 1859 to 1861				720	0	0
Admission-fees (supposed)				250	0	0
Compositions (supposed)				300	0	0
Dividends on Consols				141	12	8
Sale of Transactions, Proceedings, Library-catalogues, and Ormerod's Index	10	0	0			
Sale of Quarterly Journal	150	0	0			
				160	0	0
Sale of Geological Map				100	0	0
Due from Longman and Co. in June				53	14	7
Due from Stanford in June				12	13	5½
Due from the Bequest-fund on account of moneys expended on Map, Library, and Museum				322	18	5
				£2415	19	1½

JOSEPH PRESTWICH, TREAS.

Feb. 4, 1867.

the Year 1867.

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes and Insurance	100	0	0			
House-repairs	30	0	0			
Furniture	20	0	0			
Fuel	36	0	0			
Light	30	0	0			
Miscellaneous Printing, including Abstracts	40	0	0			
Tea for Meetings	20	0	0			
Miscellaneous House-expenses	80	0	0			
Stationery	30	0	0			
				386	0	0
Salaries and Wages:						
Assistant-Secretary	230	0	0			
Clerk and Accountant	85	0	0			
Assistants in Museum and Library	152	0	0			
Porter	90	0	0			
Housemaid	40	0	0			
Occasional Attendance	12	0	0			
Collector	25	0	0			
				634	0	0
Library				150	0	0
Museum				50		
Diagrams at Meetings				5	0	0
Miscellaneous Scientific Expenditure				50	0	0
Publications: Quarterly Journals	600	0	0			
" Transactions	5	0	0			
" Geological Map	50	0	0			
				655		0
				1930	0	0
Balance in favour of the Society				485	19	1½
				£2415	19	1½

Income and Expenditure during the

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance at Banker's January 1, 1866				381	18	9
Balance in Clerk's hands ditto				228	9	1
Compositions received				435	15	0
Arrears of Admission-fees				94	10	0
Arrears of Annual Contributions				151	14	6
Admission-fees, 1866				308	14	0
Annual Contributions for 1866, viz.—						
Resident Fellows	£651	9	0			
Non-Resident Fellows	40	19	0			
				692	8	0
Journal Compositions				6	0	0
Dividends on Consols				141	12	8
Publications:						
Sale of Transactions	2	7	3			
Sale of Journal, Vols. 1–6	1	13	3			
" Vols. 7–12	1	7	0			
" Vols. 13–15	2	9	6			
" Vol. 16	1	15	6			
" Vol. 17	1	5	6			
" Vol. 18	1	2	6			
" Vol. 19	2	11	0			
" Vol. 20	11	19	0			
" Vol. 21	47	14	6			
" Vol. 22*	101	4	0			
" Vol. 23	3	2	0			
				178	11	0
Longman and Co., Sale of Journal in 1865				48	12	0
Stanford and Co., Sale of Geological Map in 1865				30	8	10
Sale of Geological Map	34	7	9			
Sale of Library-catalogues	0	2	0			
Sale of Ormerod's Index	0	12	0			
				35	1	9
Taylor and Francis, Advertisements in Jour., Vols. 17–21				47	16	3
				£2781	11	10

We have compared the Books and Vouchers presented to us with these statements, and find them correct.

(Signed) J. J. BIGSBY, THOS. WILTSHIRE, } *Auditors.*

Feb. 4, 1867.

	£	s.	d.
* Due from Messrs. Longman and Co., in addition to the above, on Journal, Vol. 22, &c.	53	14	7
Due from Fellows for Journal subscription, estimated	30	0	0
Due from Messrs. Stanford on Geological Map	12	13	5½
Balance due from Bequest-fund on expenditure on Map, Library, and Museum	322	18	5
	£419	6	5½

Year ending December 31st, 1866.

EXPENDITURE.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	101	6	9			
Fire-insurance	9	0	0			
New Furniture	24	6	6			
House-repairs	2	14	0			
Fuel	36	8	0			
Light	29	11	6			
Miscellaneous House-expenses	74	2	2			
Stationery	30	17	1			
Miscellaneous Printing	67	4	10			
Tea for Meetings	19	3	4			
Diagrams for Meetings	3	3	0			
				397	17	2
Salaries and Wages:						
Assistant-Secretary	230	0	0			
Clerk	76	13	4			
Library and Museum Assistants	146	0	0			
Porter	95	0	0			
Housemaid	40	0	0			
Occasional attendants	7	15	0			
Collector's Poundage	42	19	7			
Accountants	12	12	0			
				650	19	11
Library				169	6	10
Museum				11	18	6
Miscellaneous Scientific Expenses				57	12	1
Publications:						
Geological Map	86	11	3			
Transactions	0	12	6			
Journal, Vols. 1–6	1	4	0			
„ Vols. 7–12	2	8	0			
„ Vols. 13–15	1	0	0			
„ Vol. 19	0	8	0			
„ Vol. 20	0	6	0			
„ Vol. 21	51	9	0			
„ Vol. 22	631	4	1			
				775	2	10
Balance at Banker's, Dec. 31, 1866				666	5	9
Balance in Clerk's hands, Dec. 31, 1866				52	8	9
				£2781	11	10

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

15TH FEBRUARY, 1867.

AWARD OF THE WOLLASTON MEDAL.

THE Reports of the Council and of the Committees having been read, the President, WARINGTON W. SMYTH, Esq., M.A., F.R.S., delivered the Wollaston Medal to G. POULETT SCROPE, Esq., M.P., F.R.S., F.G.S., addressing him as follows:—

Mr. POULETT SCROPE,—With great pleasure I proceed to fulfil the duty which devolves upon me of presenting to you the Wollaston Medal, which has been awarded to you by the Council of the Society in recognition of the valuable services which you have conferred on Geological Science by your researches on the Geology of Central France, and by your published works on volcanic phenomena throughout the world.

The extinct volcanos of the Auvergne had long attracted the attention of French naturalists; and the identity of their character with that of now active volcanos was recognized by Guettard as early as 1751. Dolomieu had, before the end of the last century, noticed the important fact of the derivation of their materials from a region beneath the granite of the district, and Montlosier and others had done much to explore and describe them. But no thorough and satisfactory examination had been made until you collected, with the expenditure of much time and study, those materials which, although prepared for the press in 1822, were not published until 1827.

That work, the memoir on 'The Geology of Central France, including the volcanic formations of Auvergne, the Velay, and the Vivarais,' gave at length to the world an exhaustive and a beautifully illustrated essay on that interesting region; and I am happy to record my personal testimony, which will be endorsed by many of the Fellows of the Society, to the accuracy of your descriptions and the soundness of your conclusions.

In your 'Considerations on Volcanos,' published in 1825, and in the new amplified edition of that work, entitled 'Volcanos, the Character of their Phenomena, their share in the Structure and Composition of the Surface of the Globe, and their Relation to its Internal Forces,' you have supplied geologists with a most valuable collection of facts and deductions. And however much theoretical views may change with the advance of our science, I feel assured that your name will remain linked with the study of this important class of the agencies which modify the surface of the earth.

Mr. Poulett Scrope, on receiving the Medal, replied as follows:—

Mr. President,—I cannot find words to express the mingled feelings with which I receive this honourable distinction. When a few days since I was told that it had been proposed to the Council, by yourself, Sir, I believe, that the Medal should be awarded to me, my first impression was surprise that I should be considered by any one worthy of an honour which only last year had been bestowed on my illustrious friend the author of the 'Principles of Geology,' and two years before on the equally eminent author of Siluria. But when the announcement was officially made to me by you that the Council had been pleased by a unanimous vote to select me as the medallist of the year, all feelings were merged in one of gratitude to yourself, Sir, and the other members who had taken so generous and favourable a view of the poor services to Geology, in times long past, of an old associate who might well suppose that he had faded from the recollection of the younger generation of geologists. This last consideration, however, only makes me the more indebted to the Society, of which I have been so long an unworthy member, for this superabundant recognition of my early labours in the pursuit of our science.

Award of the Wollaston Donation-fund.

The President then addressed Sir Roderick I. Murchison, Bart., K.C.B., &c., as follows:—

Sir Roderick Murchison,—In the absence of Mr. Baily, one of the geologists under your direction, who is at present occupied by his duties in Ireland, I will request you to state to him that, in voting to him the balance of the proceeds of the Wollaston-fund, the Council felt that, by aiding him to prepare a series of plates of characteristic fossils of the British formations, they would assist in the publication of a work of great utility. The industry and knowledge which Mr. Baily has manifested during many years of geological work are a sufficient guarantee for his judicious selection of the most suitable fossils, and for the fidelity of their representation; and I am confident that his book, as an addition to Morris's catalogue, will fill a gap which has been much felt, especially by students and field geologists who are deprived of access to large libraries.

Sir R. I. Murchison, replied as follows:—

Mr. President,—In receiving for Mr. Baily the award of the Council, I must say that it has been made in strict adherence to the express wishes of the eminent Wollaston himself; for by this act we help the recipient to complete a highly useful work on Palæontology on which he is engaged. I will only add that whilst my deserving friend Mr. Baily is rich in fossil lore, and, I may add, in children, he is, like too many men of science, poor in sovereigns; and hence the meeting will agree with me that this purse has been most justly bestowed.

THE ANNIVERSARY ADDRESS OF THE PRESIDENT,

WARINGTON W. SMYTH, ESQ., F.R.S.

It is now my painful task, before proceeding to other subjects, to lay before you a sketch of the life and work of the numerous eminent men whom, during the last year, death has removed from our ranks.

WILLIAM HOPKINS, M.A., LL.D., F.R.S., for many years a Fellow of the Society, and in 1851 and 1852 its President, died on the 13th October, 1866, in his seventy-third year. His early education was desultory, and his father objected to his leaving home for a public school; but at the age of fourteen he read the first book of Euclid with the interest, he afterwards said, that other boys would have felt in an exciting fiction. He was, however, for the present to apply to other pursuits, went to learn practical farming in Norfolk, and, being left a competency by his father, took an extensive farm in Suffolk. In this occupation, which lasted for some years, he was unsuccessful; and at length, collecting the remnant of his property, he entered himself at St. Peter's College, Cambridge, at the mature age of thirty. And now his mathematical talent shone out: he took his degree in 1827 as 7th wrangler, and at once became remarkable as a private tutor. He was shortly afterward elected one of the Esquire Bedells of the University, and married the daughter of the late John Boys, M.D. The success of his tuition was extraordinary: for very many years a large proportion of those who came out as high Wranglers had read with Hopkins.

On the value of this part of our deceased friend's career I cannot do better than transcribe from a letter of condolence written to Mrs. Hopkins by a mathematician of great eminence, and kindly sent by that lady for my perusal:—"If I admired Mr. Hopkins at first with the grateful feelings of a pupil, in later years I have been able to estimate better what he did for Cambridge. When he began tuition the reading, I believe, was somewhat unsystematic and in a transition state, as portions of continental works were being infused into the older style of English educational mathematics. When Mr. Hopkins therefore had for so many years the guidance of those who soon became themselves the guides and examiners of their juniors, we can appreciate what we owe to him in the method in which subjects are treated now. But he had a higher merit yet, I think—in his teaching us to read our subjects in such an honest, thorough way. He tried to raise us above the mercenary spirit of speculating on portions likely to tell in examinations, and led us to read for a more generous and honourable purpose. How effectually he thus brought his pupils to success in the Senate House I need not record; but in a moral point of view, in the formation of character, he was doing better for us than that—in holding before us higher purposes of study than the academic distinctions of the day. Thus his own noble spirit came out in his teaching, and could not fail to influence the pupils at his side."

About the year 1833 he was first smitten with a love of geology, on meeting at Barmouth with Prof. Sedgwick, and making, hammer in hand, mountain excursions with that most captivating of geological companions in parts of North Wales. The study soon deeply interested the mind of Mr. Hopkins, and he extended his excursions in successive years to Scotland, Derbyshire, the Lakes, and the north of France. His chief desire was to place the physical portion of the science on a firmer basis, to free it from unverified views, and to support its theories upon clear mathematical demonstrations.

With this object in view he commenced a series of discussions, the results of which have been published in a long list of papers in the 'Cambridge Philosophical Transactions,' in those of the Royal Society, in the 'Reports of the British Association,' and in our own Quarterly Journal.

One of the earliest and most celebrated of Mr. Hopkins's mathematical inquiries connected with geology was on the effects which an elevatory force acting from below would produce upon a portion of the earth's crust. Certain definite directions of upward-acting force being assumed, the nature of the tension upon the up-raised but still unbroken strata was determined, and it was shown what would be the direction of the resulting fissures, afterwards known to us under the various aspects of faults, lodes, and trap-dykes. After dealing with the simple case of a single fissure, he advanced to the consideration of a *system* of parallel fissures, which he concluded could not have been formed *consecutively*. Hence, although not requiring that the total elevation should have taken place at once, he stated that *the whole of any disturbed district, characterized by a continuous system of parallel dislocations, must have been elevated simultaneously*. After this, whatever tendency there might be to form a second system of fissures, it would be in a direction perpendicular to that already existing.

About 1837 Mr. Hopkins applied himself to the very difficult although promising investigation of the varying effects of the sun's and moon's attraction (especially precession and nutation) according as the earth be supposed to be solid or to be formed of a fluid interior surrounded by a rigid shell. It was a fascinating attempt to obtain from astronomical facts that evidence respecting the deep interior of the earth which is denied to the test of our senses. He found that the precession and the lunar nutation would be the same in both cases, or that the difference would be inappreciable to observation, —and that the solar nutation would remain the same, unless the thickness of shell had a certain value, something less than a quarter the earth's radius, in which case the nutation might become much greater than for the solid spheroid. In addition to these motions, the pole of the earth would have a small circular motion depending entirely on the internal fluidity, but which would for any, except the most inconsiderable thickness of the shell, be practicably inappreciable. These views were brought before the Royal Society in 1839 and 1840, and in 1847 were presented in a different form with additional discussions in the admirable Report to the British Association on the Geological Theories of Elevation and Earthquakes.

In the fourth volume of our Journal he applied his results on these subjects in a paper "On the Elevation and Denudation of the District of the Lakes of Cumberland, and Westmoreland." This was followed by a paper, in the seventh volume, "On the Geological Structure of the Wealden district, and of the Bas Boulonnais."

The Wollaston Palladium Medal was, in 1850, awarded to Mr. Hopkins, in recognition of the value of his researches on the application of mathematics and physics to geology.

In 1851 he read a paper to the British Association "On the Distribution of Granitic Blocks from Ben Cruachan," a subject which he enlarged upon before this Society (Quart. Journ. vol. viii. p. 28).

In the years 1851 and 1852 he was President of our Society. His first Address was in great part on the Drift and the phenomena of its distribution, terminated by excellent observations on the theory of *progression* in organic nature, as well as in the inorganic matter of our planet. The second Address placed before us, in a clear and fairly stated aspect, M. Élie de Beaumont's theory of the Elevation of Mountain-chains; and, by an elaborate examination into its conformity with observed facts, he showed the imperfect evidence on which it depends, and the necessity for great caution and reserve in accepting it in any degree of generality approaching that which its author would assign to it.

One of the most important physical treatises ever read before this Society was that by Mr. Hopkins in 1851, "On the Causes which may have produced Changes in the Earth's Superficial Temperature." In this treatise he considered, first, the influence of the earth's internal heat, and of the heat radiating from external bodies, on the earth's superficial temperature; and, secondly, the influence of various configurations of land and sea and of oceanic currents. The very small part ($\frac{1}{20}$ of a degree Fahrenheit) of the earth's present superficial temperature which is due to internal heat proves how in future no appreciable change of climate can result from the refrigeration of the globe, and how, looking back into the past, we shall require an enormous period to account for even a very minute difference of mean temperature. Now mathematical investigation shows that this effect of the internal heat on the superficial temperature bears a constant ratio to the rate of increase which is observed in depth. Consequently, knowing this ratio at the present time, we can ascertain the rate at which the temperature must have increased in descending at any past geological epoch at which the effect of the earth's internal heat was of any assigned amount. Thus when the superficial temperature was raised 1° F. by this means, or twenty times the present amount of this increment, the descending rate of increase must have been twenty times as great as at present, about 20° F. for every 60 feet; and if the superficial temperature were thus raised about 10° F., the temperature at the depth of 60 feet would, according to the same law, exceed 200° F., and all but surface springs would be springs of boiling water. The incompatibility of such conditions with organic life, and the improbability which seems to attach to the idea of any considerable increment of heat being derived from external sources, inclined the inquirer to look to the changes of form of sea and land, and to oceanic currents, as the probable agents of those past variations in climate which geology has made known.

Mr. Hopkins was elected President of the British Association for 1853, at the meeting in Hull, and gave an excellent philosophical address, devoted in great part to the rival views of progression and non-progression as applied to geological history.

About this time Mr. Hopkins applied himself with much zeal to experiments bearing upon various physical questions, and in 1854 he gave an account of what he had done, in company with Messrs. Fairbairn and Joule, to test the effect of pressure on the temperature of fusion of different substances.

In 1857 he followed this up by a paper to the British Association on the Conductivity of various substances for Heat, showing how, if the increment of temperature observed in mines and wells be due to heat transmitted from a central nucleus, the rate ought to be very different in different formations.

At the meeting of the Association in Leeds Mr. Hopkins was President of the Geological Section, and delivered an Address dealing chiefly with cleavage and glaciers—subjects to which he had devoted much attention, and which had received a new impulse from the experiments of Tyndall and Sorby.

Although still attending these meetings up to that of Bath in 1864, Mr. Hopkins was then evidently in declining health; and it was with a very painful feeling that his friends found he was soon afterwards retiring from the scientific circles of which he had long been an ornament.

Those who had the advantage of his private acquaintance will always remember the fine taste in art, the conversational power, and the high tone of feeling for which he was preeminent; whilst other members of the scientific world, who only knew him in his public capacity, have always highly appreciated his courteousness of manner, and the vigour and precision of thought which characterized his speeches and his writings.

The Rev. William Whewell, D.D., F.R.S., for a long series of years one of the most brilliant lights of the University of Cambridge, was taken from us in March last, at the age of seventy-two, after a few days suffering from the effects of a fall from his horse. Dr. Whewell had the merit of raising himself from a humble position in life by seconding with his industry and perseverance the efforts of friends, who enabled him to attend the Grammar School, Lancaster, his birthplace, and afterwards to enter at Trinity College, Cambridge, in 1812. His power, physical and mental, soon became apparent to his University compeers, and he was thought certain by his friends to take the highest places. But a very remarkable man, who died at an early age, Mr. Edward Jacob, was in the meanwhile working quietly at Caius College, and completely outstripped his antagonist at the degree examinations, when Whewell, to his great chagrin, came out second Wrangler and second Smith's prizeman. He at once, however, commenced a career of great usefulness to his college and the university at large. For a lengthened period he was one of the tutors of his college, associated with the late Dr. Peacock, Dean of Ely, and with Archdeacon Thorp, and during this time wrote a series of treatises and text-books on mechanics and other subjects of study required for the university examinations. An astonishing ability for work and a retentive memory made him conspicuous among the numerous eminent men, his cotemporaries, for the many-sidedness of his knowledge, and for the richness and interest of his conversation. But with a large proportion of the undergraduates, and with many of his equals in academical position, his acknowledged greatness was marred by an unfortunate brusqueness of manner and a want of respect to the feelings of other men, which he appears never to have fully mastered.

After joining our Society in 1827, Mr. Whewell was in 1828 appointed Professor of Mineralogy at Cambridge, a position which he held until the year 1832. In 1838 he accepted the Professorship of Casuistry, or Moral Philosophy, one of his favourite subjects; and this he retained until 1855. In 1841 he succeeded Dr. Wordsworth as Master of Trinity College, a dignified and responsible post which he adorned until his death. Actively engaged as he was for so long in the direction of the studies of the College and in the government of the University, his pen appears to have never lain idle. Besides the numerous works more especially devoted to academical subjects, he was the author of one of the Bridgewater Treatises, that on Astronomy, and of sundry Reports, for the British Association, on Tides and on the Mathematical Theories of Heat, Magnetism, and Electricity. Among the first to recognize the value of the revival of Gothic architecture, he published a suggestive and talented sketch, founded on his visits to the Continent, in 'Architectural Notes on Churches in France and Germany.' In 1837 he brought out the result of a long course of study in the 'History of the Inductive Sciences,' and in 1840 followed it up with the 'Philosophy of the Inductive Sciences,' a work which, although in some points perhaps too hastily completed and requiring revision, must long stand as a remarkable monument of philosophical thought and varied learning.

At the meetings of the British Association he took an active part, and in 1841 had the honour of being President of that body. In later years he published several books on topics nearly connected with his Professorship, viz. two volumes on 'Morality,' a translation of the 'Ethical Dialogues of Plato,' a volume of Sermons, and a new edition of Sir James Mackintosh's 'Introduction to Ethical Philosophy;' whilst the versatility of his genius was exemplified in his appearing as the author of 'Specimens of English Hexameters,' in association with Sir John Herschel and Archdeacon Hare.

Mr. Whewell was President of this Society in 1838, a period of great brilliancy in its annals, as witnessing some of the most remarkable results of the investigations of Mr. Darwin in South America, of Cautley and Falconer in Bengal, and of Sedgwick and Murchison in Devonshire and Siluria, together with the interesting descriptive communications of Strickland and Hamilton on Asia Minor, of Malcolmson, Grant, and Maclelland on India, and the physical inquiries of William Hopkins and Robert Were Fox. In his Presidential Addresses he sought to draw a clear line of distinction between the descriptive portion of our science and geological dynamics, to the latter of which his training, and probably his mental constitution, directed his taste. Especially was he inclined to dwell on the necessity of experimental data and of calculation. "Of late years," he said, "an opinion has taken root among us, that the dynamics of geology must invoke the aid of mathematical reasoning and calculation, as the dynamics of astronomy did at the turning-point of its splendid career. Nor can we hesitate to accept this opinion, and to look forwards to the mathematical cultivation of physical geology as one of the destined stages of our progress towards truth. But we must remember that, in order to pursue this path with advantage, we have in every instance two steps to make, each of which requires great sagacity, and may require much time and labour. These two steps are, to *propose* the proper problem and to *solve* it."

The interest with which he regarded our Society was manifold. "It had always been," he wrote, "an object of his admiration and respect, not only from the importance and range of its scientific objects, the wide and exact knowledge which it accumulates, the philosophical spirit which it calls into play, the boundless prospect of advance which it offers, but also for the manner in which its meetings and the intercourse of its members has ever been conducted;" —and, again, that as it had always been one of his most cherished occupations to trace the principles and laws by which the progress of human knowledge is regulated from age to age, he found it a permanent and most instructive lesson to have had brought familiarly under his notice, in a living form, the daily advance of a science so large and so varied as ours.

Strongly attached as was Whewell to the long-established discipline of his University in classics and in pure and mixed mathematics, he was far from objecting to the introduction of other branches of knowledge, provided they were so treated as properly to conduce to mental culture. The rules of sound reasoning, he held, ought to govern every exposition of science, however popular; and no wish to avoid wearying or perplexing the reader can set aside the obligation of the accurate use of terms and the paramount authority of logical connexion. Actuated by these views he applied himself to the modification of the studies as connected with the Cambridge Examinations, and aided materially in the establishment of the Moral and Natural Sciences Tripos.

Although he thus thoroughly appreciated the scope and bearings of geology, Dr. Whewell does not appear to have been himself an observer. His only communication to the Society was characteristic of the man. At a time, in 1847, when the power of waves of translation was widely and sometimes loosely handled, he endeavoured to work out the solution of the problem of the distribution of the drift with Scandinavian boulders over the North German area. And although few may now be inclined to attach much importance to the investigation as really accounting for the facts, the paper supplies a good example of the application of weight and measure to a problem before rather indefinite, and of the clearness of head and logical method of the late Master of Trinity.

Dr. John Lee, whose frequent appearance at the meetings of the Geological and many other scientific and literary societies will be remembered by some of our Fellows, died in February last, at his residence, Hartwell House near Aylesbury, at the advanced age of eighty-three.

As John Fiott, he was educated at St. John's College, Cambridge, and became, in 1806, fifth wrangler, afterwards, in 1816, taking the further degree of LL.D. The name of Lee was assumed, by royal license in 1815, for family reasons, and in 1827 he succeeded to the considerable properties of Sir George Lee, Bart., in Bedfordshire and Buckinghamshire. Dr. Lee had, as Travelling Bachelor from the University of Cambridge, commenced, on a journey to the Levant, the acquisition of various objects of natural history and archæology; and his taste for collecting had fuller scope when he became the owner of Hartwell. In that fine old but somewhat neglected mansion he was ever hospitably ready to show the motley contents of his museum, and, without-doors, to do the honours of his astronomical observatory and of the brick-pits and stone-quarries in his neighbourhood.

George Rennie, F.R.S., civil engineer, was born at Christchurch in Surrey in 1791, and died on the 30th of March (Good Friday), 1866. He was the eldest son of John Rennie (civil engineer), and after entering the same profession in 1811 assisted his father in designing most of the great engineering works constructed under his supervision, such as Waterloo and Southwark bridges, the improvements of Plymouth, Portsmouth, and Chatham dockyards, Plymouth, Kingston, and Holyhead breakwaters, Lincolnshire drainage works, &c. &c.

In 1818 he was appointed inspector of machinery and clerk of the irons at the Royal Mint, then recently erected on Tower Hill. The knowledge here acquired enabled him afterwards to design and construct the more perfect machinery for the Calcutta and Bombay Mints.

In 1821, John Rennie, his father, died, and left George and his brother John to complete the numerous works he had in hand before his death. The government dockyard at Sheerness, designed, but barely commenced, by his father, is due to the skill of George Rennie and his brother. The design was approved of in 1821, at an estimated cost of two and a half millions. This was by far the most complete and systematic dockyard in the kingdom, and constructed under great difficulties from the nature of the soil. Cast-iron dock-gates were here introduced, which led afterwards to the constructing of ten large iron dock-gates for Sevastopol, described in the Transactions of the Institute of Civil Engineers. Shortly before his father's death George Rennie designed London Bridge, the boldest and one of the most beautiful stone bridges in existence. He equilibrated the arches during construction, and assisted materially in completing it; but his brother John was appointed engineer, in consequence of George Rennie holding the appointment at the Mint.

Another important work erected under the Rennies' direction was the biscuit-machinery at Weovil, near Gosport; this was the first complete arrangement for making biscuit by machinery. The corn- and chocolate-mills of Deptford, as well as the more magnificent establishment called the Royal William victualling-yard at Plymouth, were also due to the skill of George Rennie; the latter was completed about 1835.

In 1828, George Rennie wrote a paper for the Royal Society "On Friction and Resistance of the Surfaces of Solids;" and the series of experiments were continued and communicated to the same Society in 1831, in a paper "On the Friction and Resistance of Fluids."

In 1832, having previously given up the appointment at the Mint, he completed the elegant stone bridge at Staines, made after his design. During hot weather certain openings were observed in the parapet of this bridge, which induced him to consider the question of the expansion of stone by heat, and resulted in his making experiments on the expansion of solid bodies by heat, published in 1834.

In the introduction of railways he played a most important part; for after the bill for the Manchester and Liverpool railway had been thrown out, in consequence of numerous defects, the line proposed by Stevenson being very circuitous in order to avoid the Chat Moss, George Rennie was called in. He made new surveys in a more direct line, and straight over the widest part of the Chat Moss, which he accomplished by making the survey in frosty weather; and instead of considering it to be an impossible matter to take railways over it, he estimated it to be about the easiest and cheapest part of the line, viz. £30,000 per four miles distance; and the actual cost for this was only £27,719. In 1836 and 1837 George Rennie laid out the railway from Birmingham to Liverpool, to cross the Mersey by a magnificent viaduct at Runcorn.

In Belgium he executed the Namur and Liége, and the Mons and Manage railways; and the beautiful bridge over the Meuse, of five arches of stone, is one of the works of good architectural taste constructed by him.

In 1834 he wrote a valuable paper for the British Association on the History, Principles, and Practice of Hydrostatics, Hydraulics, and Hydrodynamics.

In 1836 George Rennie took up the mode of propelling ships with the screw propeller, and succeeded in establishing its merits.

In 1852 he introduced the mode of propulsion with two or double screws, now much adopted.

The fine establishment for making muskets at Constantinople was carried out by him, and he was constantly engaged in the construction of a great variety of machinery, such as steam-engines on a large scale, dredging-machines, millworks, breweries, &c. &c.

In 1850 he wrote a long report on the water-bearing properties of the Bagshot district, for the purpose of supplying London with water; in 1857 a paper to the Civil Engineers, on the history and method of making béton or concrete; in 1856, a report and project for improving the entrance of the river Mersey, read at the Cheltenham meeting of the British Association.

Besides actual works carried out, George Rennie was fond of making physical experiments on the different subjects he had to consider, the results of which he communicated to the societies of which he was a member. His experiments on the strength of materials, three years before those of Morin, are most accurate, and led the way to a proper knowledge of the strain to which different bodies may be safely subjected. They referred especially to the following subjects:—On resistance of fluids, on that of solid bodies in air and water; on friction; on the expansion and contraction of iron and stone arches; on canal traction; on the resistance of trains; on the development of heat by water in motion; on the resistance of screw propellers at different depths in the water. By these and by many other experiments did George Rennie add to that kind of knowledge which is as indispensable for the practical applications of engineering as it is important to general science.

Endeared as he was to a large circle of friends by his unassuming kindly spirit, no less than for his practical intelligence, a profound feeling of sorrow was caused by the announcement of the serious accident which, after many months' illness, terminated in his death.

Henry Darwin Rogers was born at Philadelphia in 1809, the third of four brothers, who have all distinguished themselves in physical science. At an early age he undertook professional duties in Pennsylvania, and soon afterwards entered upon the long series of elaborate surveys with which his name will remain associated. It was especially in working at the great State-exploration of Pennsylvania, in union with his brother, Prof. William Rogers, who was charged with a similar task for Virginia, that his industry and breadth of view were strongly manifested. The brothers were supported by the aid of a numerous corps of assistants, and, striding in the course of a few years over an area no less extensive than full of interesting detail, were able, in 1842, to announce to a meeting of the American Association of Geologists their conclusions on the structure of the Appalachian chain, and this in a manner so lucid and vigorous as not only to charm the hearers present, but to rivet the attention of geologists in all parts of the world. Those who have enjoyed the advantage of hearing Prof. Rogers at a meeting of the British Association, or in our own rooms, or in general conversation, will long recollect the facility of expression and the occasional bursts of eloquence which would animate his treatment of favourite topics.

The great work of his life was the final Report on the Geology of Pennsylvania, a magnificent quarto filled with carefully collected details and illustrations of that great region, which embraces a great part of the most important mineral wealth of the United States. For the purpose of more readily completing his maps and plates Mr. Rogers betook himself to Edinburgh, and there established an intimate acquaintance with many members of the Scottish literary community. In 1857 he was invited to accept the Professorship of Natural History and Geology at Glasgow, which honourable post he retained until his death in May last.

For several years before his fatal attack, Prof. Rogers had been in delicate health, but had nevertheless made several journeys to America, and had continued at intervals his scientific and literary pursuits. Whilst employed in his great survey he had contributed to the Proceedings of this Society a paper entitled "Some facts in the Geology of the Central and West Portions of North America." A long series of Memoirs and Reports, published in the American scientific journals, have placed his name among the highest of the numerous excellent geologists who reflect credit on the United States. In 1856 he delivered a lecture at the Royal Institution, containing an admirable summary of the geology and physical geography of North America. In this address he dwelt specially on those great features which he had elaborated in his survey, the disturbance of the Palæozoic rocks of the Appalachian chain—"a stupendous undulation, or wave-like pulsation, the strata being elevated into permanent anticlinal and synclinal flexures, remarkable for their wave-like parallelism, and for their steady declining gradation of curvature, when they are compared in any east and west section across the corrugated zone." To the westward of the Appalachian chain, where this structure is conspicuous, he pointed out that "the crust-waves flatten out, recede from each other, and vanish into general horizontality." Coupled with these leading features, he remarked that the total thickness of the Coal-measures steadily diminishes from some 3000 feet thick in Pennsylvania to 1500 feet in the Illinois basin, and to not more than 1000 feet in the basins of Ohio and Missouri; and, similarly, the number of workable seams of coal dwindles from 25 on the Schuylkill to probably 7 in Indiana and Illinois, and but 3 or 4 in Iowa and Missouri. And when we add to this the clearly established facts of the increasing amount of sea-deposits simultaneously with the decrease of land-derived materials eastward, and the diminishing effects of metamorphism in the same direction, from the fully bituminous coals of the Western States to the hard anthracites of the most disturbed region, it must be conceded that Professor Rogers contributed a noble quota to the unravelling of some of the grandest phenomena which geologists have been called upon to investigate.

Percival Norton Johnson, F.R.S., assayer, metallurgist, and refiner, of Hatton Garden, died June 1st, 1866, aged 73. He was the eldest son of John Johnson, at one time the only commercial assayer in London; and after working with his father for some years, he established himself in Hatton Garden half a century ago.

He rapidly rose to the highest eminence as an assayer and metallurgist, and his opinion was so much sought after that he could hardly get through the work which crowded upon him.

The extreme accuracy of his assays (viz. in reporting the actual contents of gold and silver, which before had only been done approximately) soon caused them to be called in question, and to be refused by the buyers of bullion, the advantage in buying upon them being less than upon the ordinary assays. Upon this being represented to him by the merchants, he at once stated that he was willing, if required, to purchase all bars upon his own assays. And this was the origin of his taking up the refining-business, thus, as it were, compulsorily thrown upon him. In this he was so successful that it has ever since continued to be a very important branch of the Hatton Garden business, and the largest of its kind in the world. His ability in this (as in all other branches that he entered upon) was soon recognized publicly; and when the gold bars from the Brazilian "Gongo Soco" mines, which came over in very large quantities, were refused at the Mint on account of *brittleness*, he was consulted on the matter, and undertook to refine and toughen them, in which he perfectly succeeded, and the whole of the Brazilian gold was from that time worked at Hatton Garden.

It was in this gold that he discovered the existence of Palladium; and having succeeded in its separation, he introduced it commercially, at once determining and making known the best uses to which it could be applied. At one time he was able to supply this metal at 14*s*. per oz.; it is now so scarce that it sometimes realizes ten guineas per ounce.

When the Geological Society determined, in 1846, to employ this interesting and rare metal for the Wollaston medal, they applied to Mr. Johnson to supply it, and he generously responded by making it a pleasure, for many years, to present it gratuitously to the Society.

After he had been in business some years, he visited Germany, and was much interested in the mining-operations of certain districts there, to which he gave special attention. It was at this time that he met with the compound alloy called "German silver," then in a very crude and imperfect state of manufacture. He brought over with him some of the substance, analyzed it, and upon the basis of his analysis commenced its manufacture, with much profit to himself. He was the first person in England who actually made it; and he carried on its manufacture and introduced it to general use, laying the foundation of the enormous business which has since arisen in this branch of metallurgy.

At that time the rough Pottery Nickel was merely ground and ignited with nitre, the resulting oxide washed and reduced, at the same time that the fusion of the alloying metals was effected.

After a few years, owing to his many engagements and the pressure of what he considered his more legitimate work, he ceased to apply himself so diligently to the German-silver business, and it was then most energetically taken up by the Birmingham firm, Evans and Askin, who have ever since retained it almost exclusively in their hands.

It was about this time that he was much engaged in mining-pursuits, and was consulted upon, and visited professionally, nearly all the mining-districts in England and Wales, as well as many important ones abroad. He was the first to introduce in Cornwall the German shaking and washing table, with modifications of his own. Residing during a part of the year at Ward Cottage, beautifully situated on the banks of the Tamar, he was able to make frequent visits to the interesting although short-lived mines of the district of Callington, and to those of Calstock and Beer Alston. He will always be remembered throughout the mining-districts for his great kindness and consideration towards the miners, whose social condition it was his constant aim to improve. At great expense to himself he erected schools &c. in the neighbourhood of the mines, and took an active part in their supervision. He also used his utmost endeavours to alleviate the toil of the miners in ascending and descending mines: with this view, as well as for the improvement of the ventilation, he, at the Tamar mines, made the experiment of a sloping gallery, which ran for a considerable distance under the river, by which means the miners could walk up and down without the use of ladders.

Amongst his many minor chemical discoveries may be mentioned several pottery colours, amongst them the rose-pink, at a time when that colour was much wanted in the potteries, the manufacture of which he carried on for many years, at the same time as "oxide of uranium," a valuable colour much used in glass-making, of which he always maintained the monopoly.

Mr. Johnson alloyed, melted, and assayed the trial-plate of the Pyx, which is the criterion of the quality of the coin of this country, and which is still kept in the Lord Chancellor's office.

His greatest success, however, and that which has proved the most valuable to the progress of chemistry and manufacture generally, was the treatment of platinum. To him undoubtedly belongs the credit of having been the first after Dr. Wollaston who successfully refined and manufactured that metal upon a commercial scale, and introduced it for many of the valuable purposes to which it is specially adapted. The first large and perfect sheet of pure platinum ever produced was made by Mr. Johnson at 79 Hatton Garden; and seeing the immense importance of this metal, he ever afterwards made it his speciality.

As narrated by Percival Johnson, it is an interesting and perhaps not well-known fact that the discovery of the mode of refining and consolidating platinum was disputed with Dr. Wollaston by

Mr. Thomas Cock, a brother-in-law of Mr. Johnson's, a gentleman of considerable private means, and an able although comparatively unknown amateur chemist and metallurgist*. It was in William Allen's laboratories, Plough Court, that he first succeeded in working the metal; and it was at Mr. Allen's special request that he showed his experiments and their results to his friend Dr. Wollaston, then visiting him. Dr. Wollaston adopted an almost identical process for the manufacture of platinum; and to him has generally been accorded the credit of having discovered it.

Mr. Thomas Cock being much interested in the work at Hatton Garden, spent much of his time in the laboratories there. Mr. Johnson took up the platinum-manufacture, using Mr. Cock's process up to the time of his retiring from business, and always remained the only platinum-refiner in England.

His eminence as an analyst should also be noticed. So great was it, that the only other commercial assayers in London, though his rivals, used frequently to send him compounds or minerals of a difficult and complicated nature to report upon for them.

Probably no man has attained in his day greater perfection in whatever he undertook, or was more looked up to for his opinion; and few have worked with greater perseverance, or done more for the advancement of their profession.

For several years prior to his death Mr. Johnson resided in a pretty cottage, which, with an estate, picturesquely overlooking the sea, he had purchased at Stoke Fleming, near Dartmouth. Although near the scene of his former mining-adventures, and still working in his well-appointed laboratory, he was repelled from further participation in the mines by the conduct of some of his associates. His withdrawal was felt as a serious loss both by the working class whom he had befriended, and by the owners and managers of mineral property, to whom he had rendered himself remarkable, amid so much of dishonest and careless speculation, by his intelligent and honourable conduct of affairs; nor is it too much to say that enterprise in our western mines would take a much higher position if more of its leaders emulated the manly tone and liberal uprightness of Percival Johnson.

By the death of Charles Maclaren, which took place in September last, we have lost one of the veterans of geology, and a man who did much, in a persevering but unobtrusive way, to render the principles and aims of the science known to a large section of his countrymen.

He was born in the village of Ormiston, in the county of Haddington, on the 7th October, 1782, and at an early age, after some few years of parish schooling, was intended to be apprenticed to his uncle, a smith in a large way of business. But as his constitution proved to be delicate, he followed for a time the occupation of a clerk and book-keeper with some Edinburgh firms, and employed his spare hours in diligently acquiring a knowledge of Greek and

* See Aikin's 'Dictionary of Chemistry,' 1807.

French, and afterwards of algebra, chemistry, and mineralogy. The great turning-point of his life was his becoming editor of the 'Scotsman' newspaper, which was launched in January 1817; and this responsible and laborious post he held for nearly thirty years. It would be here out of place to refer to the influence which was exerted by the bold and liberal tone of that paper; but it is important to notice the leaven of scientific thought and inquiry which he so admirably infused into its pages. As early as 1824 he published a series of articles in which he upheld, contrary to the prevailing prejudice of the time, the feasibility of effecting rapid locomotion on railways. And, from a fair consideration of the mechanical conditions of the problem, he was bold enough to write, "We have spoken of vehicles travelling at twenty miles an hour, but we see no reason for thinking that, in the progress of improvement, a much higher velocity might not be found practicable; and in twenty years hence a shopkeeper or mechanic, on the most ordinary occasion, may probably travel with a speed that would leave the fleetest courser behind."

His numerous scientific articles in the columns of the 'Scotsman' contained the result not only of a vast amount of reading and reflection, but of numerous excursions made in the vicinity of Edinburgh; and in his 'Geology of Fife and the Lothians' he points out how the nature of his occupations obliged him to extend over a period of several years researches which he might otherwise have completed in a few months.

From about 1830 he devoted especial attention to the Pentland Hills; and extending his observations by degrees over the entire tract, from the Ochils on the north to the Lammermoors on the south, he published in 1839 a volume which established his reputation as a minute observer as well as an ingenious speculator. Subsequently, when glacial theories attracted the interest of geologists, and more recently when the questions on the antiquity of man came under discussion, he came boldly into the field, eager to note the real advance of the science, and to diffuse an appreciation of it among his large circle of readers.

It is perhaps somewhat singular that alongside of these studies Mr. Maclaren retained a great interest in ancient classical literature. In 1822 he had ventured on a 'Dissertation on the Topography of the Plain of Troy;' and as soon as he was released from his pressing duties, he, in 1847, visited the localities for which he had so well prepared himself, and at length, in 1863, after much further research, published a work entitled 'The Plain of Troy described, and the Identity of the Ilium of Homer with the new Ilium of Strabo proved.' Of this treatise Prof. Blackie wrote that it is "*the* book on the Plain of Troy,—the book which every scholar now must read, and which is not likely to be superseded by any other book."

After enjoying, at his suburban residence of Moreland Cottage, years of hale and active old age, Mr. Maclaren was seized in August last by paralysis, which in fourteen days terminated fatally.

All his friends (and they were many) must long retain in their memory a vivid recollection of the bright, intelligent eye, the courteous manner, the quiet humour, and the generous feeling which characterized his conversation, and the charm which modesty added to his acknowledged great merits.

Mr. George W. Featherstonhaugh.—The Society has lost one of its veteran Fellows in the person of Mr. G. W. Featherstonhaugh, who, having been born in 1780, was in his eighty-sixth year when he died, on the 27th of September last, at Havre, where he had been the British Consul since the year 1844. His friend Sir Roderick Murchison has, at my request, contributed the following sketch of his long and chequered life.

"Mr. Featherstonhaugh was born in London, and, having received a good classical education, went to France during the short peace of Amiens in 1803. Thence he travelled to Italy and other countries. In 1807 he first visited the United States, and in 1808 he married a Miss Ducane, who brought him a good estate in that country, and by whom he had three children. In 1826 he visited Europe, and it was then that, in common with Dr. Buckland and many geologists, I made his acquaintance. Attending, with myself, the lectures of the Oxford Professor, then in the zenith of his brilliant career, Mr. Featherstonhaugh, who, when he came among us was already a good mineralogist and a great traveller, seized so rapidly upon all the then recent advances in our science through palæontological discoveries, that he brought out, when he returned to the United States in 1829, an excellent review of "Geology and its Progress." This article, which developed in a masterly and clear manner the rise and progress of our science, conveyed to the American public an accurate view of the true order of succession of those formations which were marked out by William Smith, Conybeare, and others and ably tabulated by De la Beche. Nor does he omit to do full justice to M'Culloch and those who so well illustrated the power exercised by the eruption of rocks of igneous origin and the structure of such rocks. The review was also remarkable for the energy with which the writer criticised and reprobated the spurious efforts, of Mr. Granville Penn, Dr. Ure, and other writers of the day, to force all geology into a blind accordance with the Mosaic account of the Creation. Nor is it to be forgotten that he was about the first person who advocated the introduction of railways in America.

"In the years 1834–35 Mr. Featherstonhaugh made journeys through some of the remotest settlements and outposts of the United States, whether to the frontier of Mexico through the wild territory of Arkansas, or to the north-eastern countries watered by the river Saint Peter. In these excursions he acted as a Geologist of the United States, and presented two Reports, with sections, in the years 1835 and 1836. The first of these was an examination of the elevated country between the Missouri and the Red River; the second a geological reconnoissance by Green Bay and Wisconsin to the Coteau de Prairie. Being at that time in constant correspondence with myself, he became fully aware of the Silurian classification which I announced in 1835, and was one of the first to suggest its application to the formations of North America. During his long residence in the United States, Mr. Featherstonhaugh, having lost his first wife, was married in 1831 to Miss Cater (a near relative of the eminent General Robert Lee), his present widow, by whom he leaves three children:—Harry, who served in the Artillery in India; Albany, now a Lieutenant in the Royal Engineers; and Georgiana, an only daughter.

"In 1839 he returned from America, with strong recommendations from Mr. Fox, the British Minister at Washington, and the Earl Durham, the Governor of Canada, and was appointed a Commissioner to determine the boundary between the United States and British North America. Having executed this arduous duty during the following three years, associated with Alexander Baring, afterwards Lord Ashburton, and Colonel Mudge, R.E., he was rewarded in 1844 by the Earl of Aberdeen by being appointed Her Majesty's Consul at Havre. It was in that year that he published an account of one of his former travels, in two volumes, under the title of 'Excursion to the Slave States.' These volumes, which, from the lively descriptions of the scenery and the inhabitants, whether American or Indian, had a considerable sale, are even now well worthy of perusal by geologists and mineralogists, from the accounts of natural phenomena which are interspersed. Seeing the success of these volumes, Mr. Featherstonhaugh subsequently, *i. e.* in 1846, published two others, describing his north-eastern travels, entitled 'A Canoe Voyage up the Minnay Sotor, with an Account of the Lead- and Copper-deposits in Wisconsin, and of the Gold Region in the Cherokee Country.' As both these works, made up from sketches of notes taken on the spot, delineate in a lively style the popular manners of the Anglo-Americans and settlers of that day, Mr. Featherstonhaugh was well aware that they would be ill received by the masses in the United States; for he spoke with freedom of the bad effects of universal suffrage and the government of an uncontrolled democracy. Though severely handled by the adulators of their great Republic, these works were applauded by many of its enlightened inhabitants, including his intimate friend Mr. Henry Clay, as beneficial criticisms on a country of which, though he honestly indicated its defects, the author had a lively admiration.

"In the capacity of Consul at Havre, Mr. Featherstonhaugh earned the approbation of various Foreign Ministers under whom he served; and it is not to be forgotten (the Ex-Royal Family of France now in England will, I know, never forget it) that it was entirely due to the timely sagacity, zeal, and devotion of our deceased Associate that King Louis Philippe and his Queen were brought out of a very critical position and landed on our shores.

"In conclusion, let me say that those who remember Mr. Featherstonhaugh will dwell upon those genial social qualities and telling anecdotes which rendered him so agreeable and instructive a companion. He was a Fellow of the Royal Society; and, as a proof of his love of our science, he has left behind him a very instructive collection of rocks and minerals, in addition to those numerous fossils of various parts of the world with which he enriched the Museums of England and America."

Mr. ALEXANDER BRYSON, of Edinburgh, was a remarkable example of what may be done in scientific pursuits carried on simultaneously with due attention to a daily business. He was born in October 1816, and, after education at the High School, was apprenticed early to clock- and watch-making—a trade in which he continued to occupy himself until his death. Although much devoted to the other branches of science, he appears to have selected natural philosophy, mineralogy, and geology as his favourite pursuits, and on these subjects he has contributed a great number of papers to the Proceedings of various societies in the Scottish capital. In 1858 he was elected a Fellow of the Royal Society of Edinburgh, and he was an active Member, and at one time President, of the Royal Physical Society.

A visit which he made to Iceland in 1862 bore good fruit in the thermometrical observations carefully conducted by him at the Great Geyser. In 1864 he became a Fellow of this Society.

For many months before his death he appears to have been in delicate health; and its origin was ascribed to a severe cold caught whilst experimenting on the use of the electric light for fishing. In the beginning of the winter he was seized by a bronchitic affection, which terminated fatally on the 7th of December last.

Cut off in the prime of life by a terrible explosion of fire-damp, Mr. PARKIN JEFFCOCK leaves a memory which claims our admiration for the brave and generous spirit with which he volunteered to face a menacing danger. He was born in 1829, the eldest son of Mr. John Jeffcock, of Cowley Manor, near Sheffield, and was educated first at Sunderland and afterwards at the College for Civil Engineers at Putney, then flourishing under the superintendence of Mr. Cowie. In 1850 he was articled to Mr. George Hunter, a colliery viewer, and, after the death of that gentleman, to our experienced associate Mr. J. T. Woodhouse, with whom he became a partner in 1857. The disastrous results of explosions which have taken place in collieries working the Barnsley bed of coal in South Yorkshire were the occasion of Mr. Woodhouse being called in to advise upon, and in some cases to exercise a superintendence over, the methods of working. Hence Mr. Jeffcock was brought into close and frequent contact with several of the pits in that district, which are but too well known for serious loss of life. On Wednesday the 12th of December last he received a telegram stating that an explosion had occurred at the Ardsley Oaks Colliery. He immediately set off for the place, and about 11 P.M. went down the pit, and worked all night, with bands of volunteers, to extricate the living and remove the dead victims of this most destructive of all such catastrophes.

With unusual endurance and a determined resolution to meet the well-known dangers of such a position, Mr. Jeffcock laboured at the work of humanity until about nine the next morning, when a second explosion occurred, followed at ten by a third, of still more fearful violence. One man only escaped as by a miracle; Mr. Jeffcock and his brave comrades all perished.

The death of JAMES SMITH, F.R.S., of Jordan Hill, on the 17th of last month, has robbed our Society of one of its oldest veterans. Born at Glasgow, the 15th August 1782, and educated at the Grammar School and University of that city, he evinced at an early age a love of literature, of science, and of nautical adventure. He was fortunately possessed of the means and time requisite for indulging his tastes, and, making his first cruise in a yacht of his own in 1806, appears before many years were over to have paid attention to various points of archæology and natural history suggested to him in sailing about the west coast of Scotland. He became a Fellow of the Geological Society in 1836, and in that year read a paper on "Indications of Changes of Level in the West of Scotland," the substance of which was amplified in a communication read in 1838 to the Wernerian Society. Following up Lyell's account of the shells at Uddevalla in Sweden, and aided by a hint received from Dr. J. E. Gray in 1837, Mr. Smith was led to study the peculiarity of an Arctic *facies* appearing to characterize the fauna of the elevated marine beds of the Clyde; and in 1839 he brought before the Society a paper "On the Climate of the newer Pliocene Tertiary Period," and another "On the Relative Ages of the Tertiary and Post-Tertiary deposits of the Basin of the Clyde." In this latter year he took with him the then rising naturalist Edward Forbes, who afterwards wrote, of his cruise, that he felt proud to acknowledge that his "first insight into 'Newer Pliocene' Geology was acquired through the instructions of that distinguished geologist Mr. Smith of Jordan Hill, when accompanying him in one of his arduous but delightful journeys of investigation in the Clyde district and north of Ireland." Observations on changes of level at a more remote period were made by Mr. Smith in the Madeira group of islands, and he obtained evidence that a Tertiary limestone has there been elevated to the height of 2500 feet, "previous to the ejection of the overlying volcanic products" (Proc. Geol. Soc. vol. iii.).

In 1845 he read a paper on "Scratched Boulders and Rocks of the Coal-field of Scotland," in which, whilst admitting the probability of the former existence of glaciers and icebergs in Scottish latitudes, he nevertheless contended vigorously against adopting the extreme views of glacial action which had been promulgated by Agassiz. The subject was resumed in other communications at the meetings of April and May 1848, in which, although arguing against the view that the boulders in the *Till* had been furrowed and scratched by glaciers or icebergs, he was nevertheless willing to allow that ice must have assisted in the operation; and coupling these appearances with subsidence of the land and the strong zoological evidence of a glacial climate, he suggested coast-ice as the probable agent.

Mr. Smith was induced by illness in his family to visit southern climates during several years; and his activity of mind and body nowhere failed to reap a harvest of facts and conclusions. Perhaps one of the most charming results of close observation and ingenious induction is his geological account of Gibraltar (Quart. Journ. Geol. Soc. 1844), in which he traces out the numerous movements of elevation and depression to which that extraordinary peninsula has been subjected since the formation of the massive limestone beds of which it is mainly composed. Another interesting paper was that "On Recent Depressions of the Land" (February 1847), illustrated particularly by fresh observations on the temple of Serapis, at Pozzuoli, and on the coasts of Brittany and Normandy. And still more important, although not so closely connected with our own science, was his accurate investigation of the circumstances of the locality of St. Paul's shipwreck, which he published in 1848, under the title of 'The Voyage and Shipwreck of St. Paul, with Dissertations on the life and writings of St. Luke, and the Ships and Navigation of the Ancients.' For a task of this kind our late associate was admirably adapted: a good classical education in youth, supplemented by his love for natural science, might alone have been but of little avail; his acquaintance with the science of navigation and his practical experience as a yachtsman, enabled him to verify the places and thoroughly to test all the details of the narrative.

In questions of education Mr. Smith played an important part, and, as President of the Andersonian University at Glasgow, and as the chief originator and supporter of the Museum of Natural History, he contributed much towards facilitating the career of students in his native town. His liberality of thought and tolerance of the opinions of others were coupled with a heartiness and joviality that smacked of his favourite element—the salt water; and it was in part to his love of sailing and open air that he ascribed the generally excellent health which he enjoyed to an advanced age. For no less than sixty years he had sailed his own yacht. In the spring of last year he was attacked by a slight stroke of paralysis, but bore up well, with his intellect unimpaired, until near the close of the year, when the more serious stroke occurred which terminated fatally.

The Marquis Lorenzo Pareto, the scion of an old patrician family, was born in Genoa about the beginning of the present century. In early manhood he turned his attention to geological studies; and although during some portion of his life much occupied in the somewhat turbid tide of politics that affected his native city, he always returned to his favourite studies with genuine affection. His investigations were in great part limited to Liguria; but he varied his examinations of that beautiful province with excursions to other parts of Italy, and to the Islands of Pianosa, Giglio, Corsica, &c. The earliest paper by Pareto of which I find mention was "Sopra i bacini terziari delle vicinanze di Genova," in the 'Ann. des Sciences Naturelles' for 1824. Many others, on the Apennines, Alps, on the Department of the Var, &c., were published in the 'Giornale Ligustico.' At the scientific congresses of Italy he was a constant attendant, and was no less than five times President and three times Vice-President of the Geological Section, before which several of his descriptive papers were read. His last printed geological work was the account of a section through the Apennines, given to the Geological Society of France in December 1861.

The Marchese Pareto was a man of remarkable powers of memory, who wrote but little in proportion to what he knew; and his countrymen especially have to regret that many treasures of sound knowledge are buried with him. Industrious to a degree unusual in his southern clime, he laboured hard also at works of education and charity, and assisted greatly in the ordering of elementary schools, public libraries, and similar institutions, in which Genoa is unequalled by any other Italian city.

In 1864 he was attacked by pleurisy, but continued to lead a comparatively active life until a fit of apoplexy caused his death in 1865.

In Dr. Albert Oppel the geological world has prematurely lost a naturalist of extraordinary industry and of a rare devotion to a particular branch of his science. He was born in December 1831, at Hohenheim in Württemberg, received his first lessons in mineralogy and geology at Stuttgart from Professor von Kurr, and on entering the University of Tübingen became a student under Quenstedt. Although Oppel now took up a broad course of study in the whole range of the natural sciences, he soon evinced a special zeal and aptness in the examination and collection of fossils from the neighbouring localities of the Swabian Jura, and in 1852 obtained from the Philosophical Faculty of Tübingen the prize for a treatise on the Middle Lias of Swabia.

After receiving the degree of Doctor in 1853, he in the next year commenced a series of journeys to study, in France, England, and Germany, the subject which he was now determined to make the study of his life, the Jura formation.

An important turning-point in his career at this time seems to have been his becoming acquainted with D'Orbigny; for when his first great work saw the day, 'On the Jura Formation of England, France, and South-western Germany,' it was clear that he had left the camp of his old master, to take up with Quenstedt's most determined scientific opponent, the French palæontologist. The various divisions and subdivisions, however lithologically different, were to be recognized in all countries by special guide-fossils; and thus the closer the species could be defined, the more accurately would the strata be determined. Six-and-thirty zones were in this manner to be identified by certain species, generally of Ammonites.

Our former President, the late Gen. Portlock, in his Address for

1857, laid before us sound reasons for doubting the propriety of a minute classification founded on such an assumption; and Oppel himself appears, after long holding sternly to this view and all its consequences, to have passed through a remarkable ordeal on reading Darwin's work on the origin of species. Inclined as he was, at first, to take his stand on the great importance of the most minute specific differences of which his accurate study made him a master, he was nevertheless won over by the philosophical conclusions of the great naturalist, and, as we are informed by his friend Von Hochstetter, became at length a thorough Darwinian.

In 1858 he was appointed assistant to Wagner, conservator of the palæontological collection at Munich, and in 1861 succeeded him in that post, and became Professor of Palæontology. In this office he worked with untiring energy; he wrote papers on the Crustacea of the White Jura, on new Ammonites, and on the fossils collected by the Schlagintweits in the Himalaya, entered on the subject of Alpine geology, and described the Vils limestones, the Posidonomya-beds of the Alps, &c. His last work was the establishment of a "tithonian" *étage*, founded upon numerous species of Ammonites, and comprising the boundary beds between the Jura and the Chalk; and this was to be preliminary to a larger work, which, unfortunately, he did not live to complete. The Museum, which came to him in a somewhat neglected state, he worked at with indefatigable zeal, and by enriching it with the great Hohenegger Collection (from Teschen), of above 100,000 specimens, and with that of Oberndorfer, from Kelheim, raised it to the rank of one of the richest in Europe.

In private as in public life Oppel was one of the most considerate and retiring of men. At the Royal Academy of Sciences he could never be persuaded to speak; for he conceived that the gift was denied him to put into clear and popular language the substance and general results of his studies. He adhered, both in his teaching as professor and in his pursuits, to the simple, dry routine of steady work. Uncommunicative to general acquaintances, he was beloved among a small circle of friends and colleagues; and his appearance of failing health appears ,to have alarmed them in the autumn of 1865, when he attended the meeting of naturalists at Geneva. In the beginning of December he had the misfortune of losing his youngest child, and a few days after was attacked by typhoid fever, which carried him off on the 22nd of December.

The death of Oppel aroused a deep feeling of sorrow at Munich, especially among the members of the Academy and the University, who all esteemed and loved their modest colleague.

Dr. Nils von Nordenskiöld died on the 21st of February, 1866, at Frugard, near Helsingfors, in the 73rd year of his age. He was a pupil of Berzelius, and at an early age practised himself in mineralogical and geological excursions to such good purpose that he was enabled in 1820 to publish an octavo volume at Stockholm on the mineralogy of Finland. He has since been well known throughout Europe for the zeal with which he made his researches and collected minerals; and he enjoyed great facilities from the high official position with reference to the mines which he for many years held under the Russian Government.

In Professor Adolf Nils von Nordenskiöld, of Stockholm, our deceased Foreign Member has left a son devoted to the same pursuits.

Dr. Charles Théophile Gaudin was born in August 1822, at Lausanne, and received his education at the schools and academy of that town. In 1845 he came over to England, and passed several years here as tutor in the family of Lord Shaftesbury. A serious illness in 1851 obliged him to return to his father's home, and for a period of two years he devoted himself to a scientific examination of the neighbourhood. It was then that, in company with Dr. De la Harpe, he discovered the numerous Eocene animal remains, which Pictet afterwards described, and that he commenced the search for fossil plants near Lausanne and Vevey, which has been the means of bringing to notice so many new species.

Two winters after this he passed in Italy, with Madame von R., and her son, working vigorously at his favourite subject; and in the numerous contributions which he made from 1858 to 1862 to the Swiss Natural History Society, he showed that in Tuscany there exist an Upper Miocene, a Pliocene, and a Quaternary flora.

It was in consequence of a journey to England in 1860 that Madame von R. purchased a house at Lausanne, and commissioned Gaudin to arrange in it collections to illustrate arts and manufactures. It was a task which closely occupied him for years, and which remains a fine monument of his persevering industry.

Passing the winter of 1862 and 1863 at Palermo, he discovered in his excursions to the interior of Sicily a bed of Upper Miocene plants near Villafratre, and found a tooth of the dwarf elephant (*El. Melitensis*), which he transmitted to Dr. Falconer. On the way home, at Naples, he was attacked by fever, which greatly reduced him, and it soon became apparent that his lungs were affected. Yet he was able in the next winter, at Mentone, to work at the geology of the district, and to bring out, with Professor Valliemont, a little work, entitled 'Menton, son climat, sa géologie, et ses grottes.' But his disorder was constantly increasing, and he returned to his father's house only to pine away. He died on the 7th January, 1866.

Gaudin's contributions to science are mostly published in the 'Denkschriften der Schweizer naturforschenden Gesellschaft' and in the 'Bulletin de la Soc. Vaud. des Sciences Naturelles;' and they may be regarded as the work of an excellent man, whose disinterested love of science is seldom equalled. He was elected a Foreign Correspondent of this Society in 1863.

By the death of Señor Don Casiano de Prado our foreign list loses an able representative of the Spanish peninsula, and his country has to mourn the sudden removal of one of the few among her sons who have known how to combine the constant routine functions of official life with a true and persevering devotion to science. Born in the town of Santiago in August 1797, he studied in the University of that place the mathematical sciences for two years, and the natural sciences for two years more, which were barely completed before he had the misfortune to become obnoxious to the Inquisition, and was imprisoned for fifteen months, without his ever learning the reason. After applying himself for some time, under his father, to architecture, he went to Madrid in 1821, and took up the subjects of mineralogy, physics, and chemistry. In 1829 he received an appointment under the Government, in connexion with which he visited and studied the mining-districts of Almaden, Linares, Adra, Rio Tinto, and Marbella; and for several years he filled the post of superintendent of the royal mines of Almaden and of Rio Tinto with a zeal and energy which excited the admiration of his contemporaries, and enabled him at the same time to contribute valuable geological intelligence with respect to the ancient formations in which these remarkable repositories of ore occur.

In 1849 De Prado was appointed to the commission for carrying out a geological survey of Spain, and during many years he laboured hard at the production of several geological maps and descriptive memoirs, among which may be cited especially the map and "physical and geological description" of the province of Madrid, and also those of the Provinces of Segovia, Valladolid, and Palencia. The maps and notices of Zamora, Salamanca, and Leon he did not live to complete. Sundry other memoirs had proceeded from his pen, which were notable amid the general dearth of such writings in the Peninsula:—a 'Vindication of Geology,' published in 1835; a 'Discourse' on the temperatures through which the earth has passed in the succession of geological periods; papers on Almaden and a part of the Sierra Morena, and on the existence of the Primordial fauna in the Cantabrian chain, several of which appeared in the 'Bulletin' of the Geological Society of France. For some years prior to his death he had also been the director in editing the 'Revista Minera,' a periodical of a scientific and industrial character, which has done much to relieve the literary blank which formerly existed on the subject of the mineral treasures of Spain.

Don Casiano had for a long time been desirous of making a study of the Canary Islands. The near approach of the great International Exhibition of Paris roused in him a high degree of enthusiasm, and determined him to prepare a report on the old Hesperides. He laboured anxiously to arrange, as Inspector-General of Mines, that all his officials should duly contribute to make Spain assume the position to which he thought she was entitled, and, having issued his orders and laid his plans, left home in the spring of the year for the islands, which formed a part of his official district. It is said that he was too late in the season for arduous work, and that he was too unsparing of himself during his excursions. No sooner was he returned, about midsummer, to Madrid, than he was seized by an illness, which carried him off in a few hours.

The value to his countrymen of an industrious, single-hearted adherent of science like Casiano de Prado can scarcely be appreciated except by those who have visited the Peninsula. Our associates Mr. Busk and the late Dr. Falconer, little more than two years ago, visited him at Madrid, and were impressed with his many excellent qualities. And it was only last year that my predecessor in this chair, in his annual address, gave an elaborate *résumé* of the chief writings of the Spanish geologist, and concluded with a reference to the difficulties encountered by him in the isolation of his work, and with a quotation of his last words, so applicable to his approaching end:—"I always started from Madrid, with my knapsack and hammer, cheerful and full of joy; on my return I never entered its gates without a vague feeling of sadness."

Jacques Amand Eudes-Deslongchamps was born at Caen in Normandy on the 17th of January, 1794. His parents were very poor, and imposed upon themselves severe privations in order to ensure to their son a liberal education. The deep sense of duty with which he was imbued enabled him to conduct to a successful issue a series of brilliant studies, so that at a very early age he obtained his first medical degree in his native town. Unfortunately a relentless European war obliged him to become a soldier; but having already rendered himself conspicuous through his medical studies, at the age of eighteen he received the title of assistant-surgeon to the Imperial Navy, and was on the 28th of October 1812, appointed to the frigate 'La Gloire.' He was a most skilful operator. In November 1815 he became Surgeon Assistant Major to the Military Hospital of Caen, but soon afterwards left the navy and went to Paris to take his degree of Doctor of Surgery. In May 1822 he was elected Surgeon to the Board of Relief of the town of Caen; and the number of poor that followed his funeral, as well as of the wealthier classes, is a proof of the high esteem in which his arduous services were held; indeed his noble mind was wholly bent on doing good and affording relief and encouragement to those who were in need of his aid or advice.

During his sojourn in Paris, however, medicine was not his only study; for comparative anatomy, botany, and physiology had occupied much of his attention; and in these sciences he made himself eminently proficient, as well as in the art of drawing. At that period the gypsum-quarries of Montmartre were disclosing to the genius of Cuvier a multitude of extinct mammalian remains; and these wonderful discoveries had so forcibly struck the ardent young naturalist, that on his return to Caen he lost no time in exploring the quarries in its neighbourhood. Great indeed was his surprise to find them replete with fossil remains of all kinds; and the discovery of a specimen of *Teleosaurus Cadomensis* so elated him that from that time comparative anatomy and palæontology became one of the chief pursuits of his long and well-employed life. So important and varied were his researches and publications that he was universally recognized as one of the most eminent palæontologists of his day. With Cuvier, E. Geoffroy St. Hilaire, Humboldt, and other great masters of science he was upon the most intimate terms, and in constant correspondence. At Caen he met Lamouroux, and with him studied corals, and was one of the writers of the 'Encyclopédie Méthodique,' as well as of the 'Dictionnaire des Sciences Naturelles;' he was likewise one of the principal founders of the Museum of Natural History of Caen, and of the Linnean Society of Normandy, which was established in 1823. He became Honorary Curator of that Museum, which he continually augmented by personal exertions; and the Transactions of the Linnean Society are enriched with many of his most important works. In 1825 he succeeded Lamouroux as Professor of Zoology to the Faculty of Sciences of Caen, and on the 22nd of October 1847 was named Dean of the said Faculty, which chairs he retained until the day of his death. No Professor could be more popular or more respected, and he inspired his pupils with a true love of science.

Honours of all kinds were heaped upon him; he was a Corresponding Member of the Institute of France and of numerous other academies and learned societies, an officer of the Legion of Honour, and a Medallist of St. Helena, and was in March 1858 elected a Foreign Member of the Geological Society of London. In 1861 he received a silver medal from the Minister of Public Instruction. In 1863 a gold medal was presented to him as a reward for the first portion of his work on 'Teléosaurus.' In 1864 another gold medal was awarded to him by the Academy of Sciences of Rouen. About two years ago M. Deslongchamps had the great misfortune to lose the sight of one of his eyes; and the other having become much impaired, the calamity produced on his active mind a feeling of deep depression. On the 15th of November last he assisted at the inaugural opening of the Session of the Faculty of Sciences of Caen, where his worthy and distinguished son was occupying his chair as Professor of Zoology. Feeling his end fast approaching, his last few days were spent in dictating to his son what was still necessary in order to enable him to complete the great work on the Fossil Crocodilian remains of Normandy, upon which he had laboured during so many years. Remembering with satisfaction, and frequently on his death-bed recalling to his family the compliment paid to him by the Geological Society of London, he desired that his last great work should be dedicated to that Society. On the 17th of January 1867 he expired, aged 73 years and one month. In him France has lost one of her most distinguished naturalists, and science one of her ablest votaries.

In addressing you a twelvemonth ago, my predecessor in this chair placed before you an account of the general progress of geology, as indicated in a long array of publications, the contents of which, gathered with an industry worthy of all praise, he offered to the Society in so readable a form as to attract and interest all its Fellows. But if my esteemed friend thought it necessary to claim your indulgence for the selection of certain works from amid a vast body of literature, much more must I, elevated somewhat unexpectedly to the proud position of your President, crave your kind consideration in being allowed to select, as the subject of my address, only a comparatively limited district in the broad domain of our Science.

We retain, happily, among us still, perhaps the most active of our number, eminent men who joined our Society in what we may term its second generation. In their younger days geological science, although rapidly increasing in its dimensions, was not yet too extensive to forbid its entire ambit from being surveyed and explored by a single mind. But the amazing advance of the science within the last fifty years has rendered it necessary more than ever to recognize the limited power of the human intellect. Not only does the descriptive portion of physical geology carry us into a multiplicity of details culled from all parts of the earth, but the subdivision into numerous branches, all of them increasing with the growth of other conterminous sciences, has established the necessity, coupled with advantage to our progress, for working geologists to lay special stress on some particular portion of our subject.

The crowd of works which annually issue from the press of all civilized countries precludes the possibility of referring to the whole of them, except as a mere list of little more than their titles, and renders it incumbent on a President to seek out amongst them either those which may appear to be the more important, or which treat of those particular subjects with which he may happen to be most familiar.

In considering the nature and history of the rocks which form the crust of the globe, it appears to me that since Mr. Horner, a few years ago, gave a full summary of what had been recently done to elucidate the origin of the crystalline and metamorphic rocks, a number of works have appeared, some of them as contributions to our own Journal, others as independent treatises, which should excite more than a passing interest. Views of a very conflicting character have been brought forward: the Huttonian and Wernerian controversy seems almost to be revived in a modified form; and amid the results of observation and of experiment so many important facts have been elicited that I am induced to think it desirable to place before you, even if it be only as a reminder, some of the principal conclusions at which recent authors have arrived.

On looking round at the facilities offered to study by the constant multiplication and improvement of geological maps, I think it behoves me first to say a few words on the advancement of those surveys in which we are most nearly interested.

During the past year considerable progress in the field has been made by the Geological Survey of Great Britain. The mapping of the London Basin is now approaching completion, excepting on the north-east; and the last of the maps of the Wealden area, that of East Kent, is on the verge of being published. Five sheets of sections across the Weald are also being engraved, which, being on a true scale both vertically and longitudinally, may help to clear up the still vexed question of the denudation of the Weald.

The mapping of the Lancashire Coal-field and adjoining areas is so far advanced that it is expected to be finished by the close of this year; and the coal-fields of Yorkshire, Newcastle, and Durham are also being mapped, and parts of them are already published. The Survey has also begun to make some progress in the exceedingly difficult country forming part of Westmoreland and Yorkshire near Kendal and Kirkby Lonsdale—a country complicated by great contortions of the Silurian strata, by numerous large faults, and by the concealment of the Silurian Old Red Sandstone and Carboniferous rocks by drift; and it is hoped that a beginning will soon be made to the issue of the geologically coloured maps of the district.

A large tract of Ayrshire has also been surveyed, consisting of Silurian Old Red Sandstone and Carboniferous rocks; and the finished maps are now in the hands of the engravers.

By way of showing the usefulness of these documents to the public I may mention that, in his Annual Report, Sir Roderick Murchison states that during the last ten years more than 36,000 maps and sections of the Geological Survey of Great Britain have been sold, not including, of course, the large numbers given away to learned societies.

The only memoir published by the Survey during last year is that on the Geology of North Wales, by Professor Ramsay. It commences in the 1st and 2nd chapters with an historical account of the nomenclature employed in regard to the formations of which the Silurian series of Britain consists, and sketches their extent and physical relations all through Wales and Shropshire. The remainder of the descriptive geological portion of this volume is occupied with a minute analysis of the structure of the Silurian region of North Wales; and to render this as clear as possible, besides the coloured plates of a map and sections, ninety-nine woodcuts are introduced, mostly illustrative of the physical relations of the rocks all over the country; and it is thus intended that by reference to the book any one may find enough of illustrative matter to enable him to understand the geological structure of almost every hill and valley in North Wales occupied by Silurian rocks. A brief sketch of the surrounding later formations is also given. The relations to each other of the igneous and stratified rocks of this remarkable region are explained according to the views held by Professor Ramsay and his colleagues on the Survey, views in the main held by the late Sir Henry De la Beche. It is shown, in accordance with these views, by the help of numerous sections, that the felspathic rocks consist to a great extent of intrusive bosses, and of great sheets of lava and of consolidated volcanic ashes on two horizons—one at the base of the Bala beds (Llandeilo), and the other on the horizon of the Bala limestone. These have been disturbed and faulted, thrown into anticlinal and synclinal curves, and denuded on a vast scale, whence arises the present physical configuration of the country, the hard rocks generally forming hills and mountains, and the softer slaty beds being apt to lie in valleys. Certain of the terms thus employed involve an assumption as to the origin of the alleged volcanic substances, and some inquirers may dispute this nomenclature with respect to the Lower Silurian lavas and ashes; but practically it was found by the author of the book, and by his colleagues Professor Jukes, Mr. Selwyn, and Mr. Aveline, that until this conclusion was arrived at the igneous rocks could not be reduced to any systematic order, whilst as soon as it was come to the whole seemed to be intelligible, and, instead of presenting further difficulties, the interstratified igneous masses rather aided in the mapping and helped to explain the relations of all the parts to each other.

The second part of the volume consists of a description by Mr. Salter of the fossils illustrative of the memoir, accompanied by numerous plates.

On the progress of that ably conducted survey in Canada which has produced such good results, Sir William Logan informs me that the late investigations have been devoted, in the first place, to working out in more detail the structure of that region on the south side of the St. Lawrence in Eastern Canada which is occupied by the Quebec group. That group, instead of including the "calciferous" and "chazy," is now placed between them; and it has been found convenient to separate it into a lower, a middle, and an upper division, the lower comprehending nearly all the fossils by which the horizon of the group is determined, and the middle containing all the magnesian rocks and metalliferous deposits which give the Lower Silurian formations an economic value.

The geologists have also further followed out, on the westward of what was previously known, the distribution of the three great bands of limestone belonging to the Laurentian system, the upper band being that which holds *Eozoon*.

It had been already notified to us through Dr. Dawson that fragments of *Eozoon* had been found preserved in carbonate of lime. Both the large and small canals were in this case filled with calcspar. The specimens come from a micaceo-calcareous schist from the Laurentian of Madoc, where the rocks are not so much altered as they are in Grenville. This year one of the assistants, Mr. Vennor, in tracing this bed into Tudor, the next township to that of Madoc (which is north of Belleville, west of Kingston, Lake Ontario), has been so fortunate as to find a fossil whose white calcareous skeleton is preserved in a dark-coloured arenaceo-micaceous limestone, with minute grains of carbonaceous matter. The limit of the form is well preserved on one side; and although the minute structure is obscure, Dr. Dawson pronounces the fossil to be *Eozoon Canadense*. We may expect ere long to receive a further communication on this important subject from Sir William Logan himself.

The study of the numerous questions which arise from a careful examination of rocks has been much facilitated by the recent publication of several works treating specially of this branch of geology. Professor von Cotta's well-known treatise has been translated by Mr. Lawrence, one of our Fellows*, with the advantage of corrections and additions by the author, which make it, in fact, the third

* Rocks classified and described, by B. von Cotta: an English edition, by Philip Henry Lawrence, F.G.S. Longmans, 1866.

edition of the book. Containing as it does, to begin with, a full account of the minerals which form the constituents of rocks, and then giving for the rocks themselves an elaborate description, with copious references to other works, and the synonyms in the German and French languages, it forms a very complete and condensed handbook for the student. The chapters on chemical analysis, on metamorphism, and on igneous rocks, place within moderate compass and in a fair and unprejudiced light the results of the works of the numerous authors who, during the last twenty years, have so greatly added to our definite knowledge on these points. The classification and definition of the various species of rock is a notably difficult matter, in which no writer has yet succeeded in giving general satisfaction. Cotta's method will doubtless be objected to by many as starting with an hypothesis of origin which they may be indisposed to admit: the *eruptive* or igneous rocks, for example, are at once divided into Volcanic and Plutonic, a similar division applying to the basic rocks, or those poor in silica, and to the acidic rocks, or those rich in silica, the latter including, of course, granite and some varieties of gneiss. An arrangement, however, attempted on any other basis, such as composition or antiquity, must always stumble on difficulties of more or less magnitude until our knowledge is much further advanced. Not the least useful adjunct of Mr. Lawrence's translation is its very full index of localities referred to in the text.

Professor Zirkel, of Lemberg, has published during the past year, under the title of 'Lehrbuch der Petrographie,' two volumes containing a vast amount of information on the characters and occurrence of rocks. After a very full general introduction to the subject, he describes in succession all the simple crystalline rocks, or those substances occurring in mass which consist of a single mineral species, —and afterwards the compound crystalline-granular rocks, ranged according to their containing primarily one or other of the various felspars, or belonging to a group which contains neither of them. This first, the original, or the *protogenic* class of Naumann, is followed by the *clastic* or fragmentary rocks (*deuterogenic*), derived from the others by mechanical action. A valuable feature of Zirkel's work is, the abundant illustration of the peculiarities of each rock-substance by examples taken from the best chemical and geological descriptive writers, with in each case an ample series of references to the literature of that portion of the subject.

Highly valuable material on kindred matters has been brought together by our able associate, Professor Haughton, of Dublin, in his recent 'Manual of Geology.' This work, arranged in the form of fifteen lectures, with sundry appendices, may be considered in the light of a series of condensed essays, which, however useful to students, offer abundant groundwork for study and reflection to the practised geologist. The author's contributions to our Quarterly Journal have shown that his elaborate researches on the composition of rock-masses entitle him to speak with weight on the subject; and I feel that it would be very desirable to endeavour to correlate some of his conclusions with those of other inquirers.

Another remarkable book of a general character which has been recently published is Mohr's 'Geschichte der Erde.' The author takes up especially the chemical and physical side of the science, and, following the line of argument adopted by Bischof and Volger, extends it over sea and land, culling with thorough German industry a rich store of examples from observers of all parts of the earth. But the spirit of his inquiry is eminently aggressive; and whilst attacking certain commonly received views and many points of doubtful acceptation, his self-sufficiency and flippant tone in dealing with some of the greatest names in science are to be regretted, and will certainly not strengthen his position. Nor will he, I believe, find those geologists who have reviewed the history of the progress of the sciences content to refer *every* question to the undisputed arbitrement of chemistry taken at a given point in its advancing career, or inclined pedantically to limit nature to the results we have been able to accomplish in our laboratories. The author's own arguments for deriving the origin of our coals from seaweed, for making basalt from watery solutions, and for cavilling at all the recognized geological systems are alone sufficient to raise a host of opponents.

To our distinguished Foreign Member and Wollaston Medallist, Professor Gustav Bischof, belongs in great part the merit of having first worked out, by investigations extending over many years, a variety of problems on the mode of formation of the crystalline minerals in rocks, showing especially the vast number of conversions from one mineral species to another which may be explained by the action of water. Most satisfactory were the experiments and examples by which he illustrated the chemical power possessed by rain-water penetrating downwards into the rocky crust, and the crystallization of almost every well-known species of mineral from watery solution. And even though we may not see in the same light his asserted analogies, or allow ourselves always to be converted by his arguments, we cannot but recognize the justice of the main current of his reasoning, and the occasion for the warmth of the diatribes in which he attacks supporters of opposite views. No doubt hypotheses of most unwarrantable boldness had been set up by those who saw igneous action in every little vein of quartz or gypsum; and beyond all question many of the phenomena, the causation of which was formerly supposed to need a high temperature, might be better accounted for by the less heroic but more time-consuming processes suggested by Bischof. Questioning as he has done, from the year 1843 onwards, many of the palpably rash assertions of the ultra-plutonists, he has himself been followed by a goodly array of scholars, several of them contributing material of the very best order to the general geological fabric, others dashing, a little eccentrically, beyond the limits of their master's conclu-clusions, when these latter are fairly stated. For, after all, does not the Professor make very free with the statement of the opinions of authors who are more attached than himself to what he terms the Plutonic theory? and does he not sometimes fabricate an enemy in buckram in order that he may conspicuously give him the *coup de grâce*? He urges, for example*, the impossibility of an igneous rock causing by heat alone the production of crystalline minerals in the mass of an adjoining clay-slate, and cites various examples where not a single felspar crystal has been produced in a shale acted upon by fire for a great number of years. But here, and in many more instances, it would seem that he assumes the scene of action to have been at the very surface of the earth, whilst no educated geologist would dream of accounting for the crystalline alteration of rocks at their contact, except by introducing the condition, of which we so often have other ample evidences, of the deeply buried position of such rocks at the time of action. No one has more ably than Bischof proved the permeation of water through the minutest fissures and pores of rocks and minerals; and no one therefore better knows that every reasonable plutonist must necessarily infer that the stony masses, when sunk to a depth of thousands of feet beneath other strata or beneath the ocean, are more or less saturated with water. He objects, again, that *suffioni* and water vapours, in a number of instances cited, do not effect, as they ought to do by "the favourite hypothesis," the conversion of sedimentary strata into crystalline rock. But to satisfy the conditions exacted by a fair version of plutonism, these vapours ought not to escape freely, as such, from fissures at the surface, but should be pent up and closed in so as to suffuse the whole mass of the materials on which we imagine them to produce an effect. Bischof has been one of the foremost†, following Gehlen, Mitscherlich, and G. Rose, to show that many substances crystallize out of an amorphous mass without their component parts being previously thoroughly dissolved; and if this be the case at the surface and at the ordinary temperature, our author is surely not the man to doubt the increased general heat of a region some thousands of feet below the surface, nor the intenser chemical action which may be expected under such conditions of higher temperature.

Some few geologists, carrying out the views of Bischof to an extent that would have almost satisfied Werner himself, occasionally reiterate the old objection that an igneous origin is incompatible with the presence of water, either free in the rock or combined with other substances as hydrated minerals. The observer who has watched a volcano in full eruption, or even during its milder phases, is not, I believe, likely to run into this fallacy. If any one substance is erupted on a stupendous scale, it is surely water. The vast balling volumes of steam that come bursting up in quick succession through the seething lava of the crater tell at once of the great bodies of water which form a principal agent in the activity of the vent, and of the manner in which the melted stony matter below must be suffused with it in more or less notable proportions. The ingenious microscopical observations of Mr. Sorby show us how the minute pores of crystalline rocks may enclose it

* Chem. and Phys. Geol. vol. iii. p. 71.

† Lehrbuch d. chem. u. phys. Geol. (1st Germ. ed.) vol. ii. p. 332.

mechanically dispersed throughout their substance; and the researches of Daubrée, Deville, and others have proved how some of the silicated minerals composing the lavas retain for a length of time, and up to the moment of their solidification, large quantities of water, thus showing that it would remain a constituent of similar rocks until they are relieved from superincumbent pressure by actually making their appearance at the surface, when they would be subjected only to the ordinary weight of the atmosphere.

Among the foremost in applying the researches of chemical geology to the elucidation of the structure of a vast tract equal in extent to many of our European kingdoms, Sir William Logan and Mr. Sterry Hunt have in Canada arrived at remarkable conclusions. The descriptive catalogue prepared by them for their unrivalled collection of the rock-substances contributed by the Survey to the last International Exhibition, and the voluminous Report published in 1863, are fraught with facts and suggestions of great value. Among the eruptive rocks a large proportion occur with a character so like those of their European congeners, and under circumstances so similar, that no doubt is felt by the writers as to their origin. The felspathic rocks described by them under the name of trachyte occur in large masses in the mountains of Brome and Shefford, and, as dykes of a clearly intrusive character, at Chambly and near Montreal. No uncertainty appears to exist as to the similar origin of the diorites of Yamaska, Mount Johnson, and Belœil and Rigaud Mountains. More interesting are the dolerites, part of them composed chiefly of black crystalline augite, sometimes almost to the exclusion of every other mineral. These rocks, especially abundant in the county of Grenville, are referred to three different periods of eruption—one during the Silurian epoch, one before it, and another after it. The newest of them is, however, said to be traversed by, and therefore to be more ancient than, the "trachytes" of Montreal and Chambly. The dolerites are largely found, both in dykes and masses, in the mountains of Montarville, Rougemont, and Mount Royal. Occasionally, as in the former of these localities, varieties different in colour and texture are arranged in bands, "whose varying thickness and curving lines suggest the notion that they have been produced by the flow and the partial commingling of two semifluid masses." The dolerites are thus attributed to a much earlier period than has been allowed to them by observers in European regions. That of Montarville is noticeable for the large size of its imbedded crystals of augite, and for its great proportion of olivine in yellowish-brown rounded crystalline masses, from one-tenth to half an inch in diameter. Its felspar is stated to have nearly the composition of labradorite. The similar rock from the other localities contains also olivine in places, and is distinctly seen to break through the Lower Silurian strata; and when it is alleged that fragments of that mineral and of augite are found in the dolomitic conglomerates near Montreal, we have what appears to be decided evidence of the intrusion of these rocks before the close of the Silurian period. This conglomerate, however, is intersected by dykes of a finer-grained dolerite, which has a strong resemblance to the newer dolerite of Grenville, to which an exact date does not appear to have been assigned.

The observations which are thus placed before us, and which assign so great an antiquity to the outburst of some of the augitic or pyroxenic rocks, require us to receive with caution, or at all events to allow exceptions to, the views propounded by continental writers on the age of certain classes of igneous rocks. Mr. David Forbes has recently established* the true doleritic character of the so-called white-and-green rock of the Dudley coal-field—a destructive intruder, which must have made its entry, vertically and horizontally, after the consolidation of the Carboniferous strata; but there is no doubt that in a general way we have to look to still more recent periods for the chief evolution of substances so nearly akin to our modern lavas.

Certain of the bolder writers of the continental schools make no sort of difficulty in ascribing an igneous origin to many of the crystalline limestones, and especially to those which in many countries are inserted among the gnarled and contorted beds of gneiss and mica-schist. The Canadian surveyors have met with examples of this rock, appearing in a form so like that of true intrusion, filling lines of crack in the gneiss at right angles to the general direction of the strata, that they venture on an explanation differing but little from that of the most thorough plutonist. "Many of those rocks," they say, "which have hitherto been described as eruptive, are sediments, which, although altered and retaining but little evidence of their former condition, are still in the beds in which they were originally deposited. At the time of their chemical metamorphism they were impregnated with water, and by the joint action of this and of an elevated temperature were evidently reduced to a more or less plastic mass. This in some cases is found to have been displaced and, having forced its way among disrupted strata, to have assumed the form of an intrusive rock, which, becoming consolidated under sufficient pressure, retains the same mineral character as its parent bed"†. The phenomena observed in some portions of the Laurentian system lead the authors to the conclusion that "the stratified crystalline limestone of that series was at one time plastic, and when in that condition was forced into the fissures of broken siliceous strata in the vicinity, thus taking the form of an eruptive rock."

Another of the crystalline masses which in many regions form an important constituent in the structure of the solid crust of the earth is ophite or serpentine, on which the authors of Canadian geology hold very decided opinions. They assert, indeed, that, although generally described by European geologists as intrusive, the serpentines of the Laurentian and some of the overlying formations are "stratified rocks of sedimentary origin, although it is not improbable that serpentine may in certain cases, like limestone, assume the form of an eruptive rock."

It is noticeable that the serpentines of the Laurentian system

* Brit. Assoc. Report, 1865. † Geology of Canada, p. 643.

are of unusually low specific gravity, and appear to contain no ores of nickel or chromium; whilst those which belong to the altered Silurian rocks yield almost always a small percentage of nickel (rarely more than two or three thousandths of the mineral), and present in many instances deposits of chromic iron sufficiently extensive to be workable. The density of various examples of these latter serpentines is given at from 2·546 to 2·607.

Without impugning the correctness of the conclusions thus drawn for Canada, and whilst admitting that in Europe we may have interstratified masses of a very similar character, as in North Anglesey, and Glen Lochy in Perthshire, one must in passing enter a caution against adopting similar views too generally.

Various, indeed, as the colours presented to the eye by this rock (serpentine) are the opinions offered to us by geologists and chemists upon its origin and history. Downright uncompromising igneous fusion has been the explanation most readily suggested to observers who, like the Italian and many of the French writers, are familiar with the intrusive and fragmentary appearance exhibited by this substance in Italy and the Levant*. The distortion and alteration of the Tertiary strata when in contact with it appear to favour their views; and some of the Italian geologists, in describing the structure of Tuscany, even recognize several distinct epochs of serpentinous intrusion, all of them posterior to the Lower Eocene.

The idea suggested many years ago by Breithaupt, that, in analogy with a pseudomorphous mineral which he had determined, it was probable that large masses of hornblende rock had been changed to serpentine, has borne fruit in an abundant crop of speculations. Thus H. Müller, G. Rose, Bischof, and others derive many of the serpentines of Saxony and Southern Germany from the metamorphism of eklogite, of granulite, and of gabbro or euphotide. Tschermak looks upon that of Gümbelberg in Moravia† as produced by the decomposition of a rock of anorthite and augite; and Bischof suggests that the celebrated serpentine mass of Snarum, in Norway, is the result of a transformation of a mass of olivine. In fact the chemical probability of hydrated silicate of magnesia being produced by various decompositions, and the tendency of these ophiolitic rocks to appear geographically associated with diorite, granulite, gabbro, chlorite-schists, and eklogite, seem to offer a premium to the ingenious for inventing an almost infinite series of possible combinations and permutations. In the curiously patterned stripes and anastomosing veins which so many varieties of serpentine present, and in the numerous minute crystallized minerals (garnet, magnetite, chromic iron, &c.) which are disseminated in them, there appear to lie the materials for a history; and yet we may venture to express a doubt whether, when we see a mountain mass consisting at one end of serpentine and at the other of diorite, with a gradual passage in the intermediate part, we are obliged to conclude that there has been historically an actual transition from the

* *Vide* also Fiedler, 'Reise in Griechenland,' Leipzig, 1840, p. 432.

† Sitzsungsber. d. Wien. Akad. 1860, p. 132.

one to the other since the mass has occupied its present position. Such a conclusion may still be questioned, even though the change be shown to be a natural one (by the occurrence of a pseudomorphous mineral), and be confirmed as a possibility by the results of laboratory experiment.

Many of these suggested processes remove us after all by only one stage from the main question of the origin; for if we concede that the serpentine has been transmuted from a rock of labradorite and diallage (gabbro), or of anorthic felspar and hornblende (diorite), we pass back to compounds which are much more akin to the confessedly igneous rocks, and thus find it still more difficult to derive them from sedimentary strata.

Our President in 1859, Prof. Phillips, referred in his Address to this vexed question as affecting the great unstratified mass of the Lizard, in Cornwall, and gave us the two opposite hypotheses, showing how the occurrence of the diallage rock with serpentine may be made to chime in with both. But the argument in favour of the serpentine having been originally a stratified mass which has undergone metamorphism is vitiated by the incorrectness of the observations on which it is founded. It is true that on the south of the great body of the serpentine its junction with the hornblendic and micaceous slate is obscure; but on the north there are spots (not unnoticed by De la Beche), as at Pencarrock and Trenithen near St. Keverne, where the slaty strata *are* decidedly changed by the proximity of the serpentine*, and where they dip off from that rock. Moreover at Kennack Cove, on the south side, may be seen a bold example of the intrusion of a great vertical tongue of this rock, with lateral branches cutting into the black argillaceous slate. Similar, indeed, to the Italian, although on a smaller scale, we have here instances which allow no doubt that the material has been intruded in a plastic state into rocks with which it came into contact, leaving it open to us to believe either in simple fusion, like that of a deep-seated lava, or in that state of plasticity from other chemical action which is offered to us by the Canadian geologists as the more probable condition.

The gabbro or granitone (Crousa rock), which forms a fine element in this district, from St. Keverne to Coverack Cove, offers in its occurrence, as it appears to me, no support to the opinion of its chemical transformation into serpentine.

Excluding from present consideration a few somewhat far-fetched theories, in which authors have carried to an extreme the liberty of removing by percolating water those elementary substances which are not required and introducing those that are needed for the composition of serpentine, we observe that among those who demur to its igneous origin there are two very opposite views. The majority are satisfied to derive it from another and

* On my recently showing fragments of nearly adjoining clay-slate to our associate Mr. David Forbes, F.R.S., a thoroughly experienced observer in such matters, he recognized at once the characters of a killas altered by the contact.

decidedly crystalline unstratified rock, in which the constituents are augite, or hornblende, and a felspar, whilst a few investigators, chiefly, however, for a special region, term it an *indigenous* rock, as having been altered *in situ* from a sea-borne sediment.

At the risk of being tedious, I have dwelt on these variations of opinion touching the explanation of facts upon which we are most of us agreed, because the substances thus referred to have, in consequence of recent investigations, been invested with a special interest, and because it has been shown that they are connected with telluric and even cosmical phenomena on a nobler scale than had been anticipated, even by those geologists who had ascribed to them an active part in the elevation of mountain-chains.

The grandest feat of geological science within the last few years is the astounding extension of the scale of geological time consequent on the discovery of the *Eozoon Canadense*; and, *pace* the objections of the few who still doubt the organic character of those remains, one of the most curious facts connected with them is their almost universal preservation, wherever they have been found, in minerals of the augite and serpentine class, associated with carbonate of lime. The elaborate arguments of Messrs. King and Rowney (Quart. Journ. Geol. Soc. vol. xxii.) in favour of the mineral origin of "Eozoonal" structure had at one time a strong show of support in the fact that these appearances were always observed in *serpentinous* limestones (ophicalcite) only, whether in Canada, Connemara, Tyree, Bavaria (Dr. Gümbel), or Bohemia (Dr. von Hochstetter), notwithstanding great discrepancy in the age of some of the deposits. But the announcement made by Dr. Carpenter, in the Quart. Journ. Geol. Soc. for August last, of Dr. Dawson's discovery of *Eozoon* preserved in carbonate of lime pure and simple, would appear to close the discussion. Its occurrence in strata of a metamorphic character would incline, I believe, most geologists to conclude that these minerals had been formed by metamorphic action; and the undoubted evidence which we possess, that both chrysotile (a fibrous serpentine) and some varieties of augite or pyroxene have been in some cases crystallized out by the action of thermal waters, would countenance the supposition. But Prof. Sterry Hunt, who has so ably laid before us the results of his investigations on the Canadian minerals, has ventured on a bolder hypothesis. The soft portion, or *sarcode*, of the organisms has been replaced by one or other of the following silicates—a white pyroxene, a pale-green serpentine, and a dark-green alumino-magnesian mineral, allied to chlorite and pyrosklerite, and referred by him to loganite. The septa between the cells retain probably their original composition of carbonate of lime, which in some specimens is associated with carbonate of magnesia. Dr. Hunt infers, from the circumstances of their occurrence, that these silicates were directly deposited in waters in the midst of which the *Eozoon* was still growing, or had only recently perished, and that they penetrated, enclosed, and preserved the calcareous structure precisely as carbonate of lime might have done. Not that these silicates are limited by the extent of the organic structures; for whilst large quantities of them are found at each of the localities of Grenville and Calumet, in masses which are entirely destitute of remains of *Eozoon*, and yet would seem to have been deposited at the same time, other portions appear to have had the organic structure obliterated by cleavage-planes due to the crystallization of the pyroxene. In the accompanying strata, we are informed, finely crystallized pyroxene, hornblende, phlogopite, apatite, and other minerals often occur. "These observations," says Dr. Hunt, "bring the formation of siliceous minerals face to face with life, and show that their generation was not incompatible with the contemporaneous existence and the preservation of organic forms." Moreover they support a view previously put forward by him, that "these silicated minerals have been formed, not by subsequent metamorphism in deeply buried sediments, but by reactions going on at the earth's surface." And in support of this position he has reminded us that, in recent as well as ancient deposits, the most delicate forms of organic structure have been in some instances preserved by the infiltration of the mineral *glauconite*, so well known as the colouring-substance of the Greensand, and itself a hydrous combination of silica with sesqioxide and protoxide of iron, with alumina, and potash. Supposing that in the ooze at the bottom of the sea dissolved silica comes into contact with iron-oxide rendered soluble by organic matter, the resulting silicate deposits itself in the cavities of shells and other vacant spaces. "A process," Dr. Hunt suggests, "analogous to this, in its results, has filled the chambers and canals of the Laurentian Foraminifera with other silicates; but, from the comparative rarity of impurities in the silicates, it would appear that they were deposited in clear water" *.

Since Wöhler (above twenty years ago) showed how apophyllite could, as a laboratory experiment, be dissolved in water, and be reproduced from the solution in crystals, abundant proofs have been given of the power of water, especially at an elevated temperature and if saturated with carbonic acid, to destroy many silicate minerals, and also, under varied conditions, to recompose a number of familiar species, particularly among the hydrated silicates. Even the extreme feebleness of the action which carbonic-acid water, and water under great pressure †, exercises upon many of these minerals, and most notably on silicates of magnesia, must not be allowed to blind us to the numerous examples which prove the efficacy of this agent. Such are:—the green-earth, lining the interior of amygdaloidal cavities; neolite, a hydrous silicate of magnesia, which is formed at the present day in one of the iron-mines of Arendal; and meerschaum, occasionally exhibiting the form of *Helix* and several freshwater shells in the marl-beds of

* Quart. Journ. Geol. Soc. 1864, p. 71. These observations and opinions have been restated, in connexion with additional matter on the Eozoon, in the 'Report of the Geological Survey of Canada' for 1866, of which the proofs have kindly been forwarded to me by Sir William Logan.

See also the excellent paper on Glauconite, by Haushofer, in Jour. für prak. Chem. 1866, p. 361.

† Bischof, Chem. Geol. vol. i. pp. 3 and 31.

Vallecas, near Madrid, where there can be no doubt that the new mineral has been produced by silica, probably hydrated, brought into contact with carbonates of lime and magnesia held in solution in water by carbonic acid*.

But in these instances, and in many of those pseudomorphous silicates for the investigation of which we owe so much to W. von Haidinger and Dr. Blum, where no doubt can exist that the constituent elements have been dissolved in water, almost all the evidence requires that very long periods of time should be taken into account; and their mode of formation is scarcely compatible with the speculation by which Dr. Sterry Hunt would derive them from deposits in clear sea-water contemporaneously, or almost so, with the growth of the earliest known forms of organic existence. Moreover the very fact described by him, of the occurrence in the associated beds of large and well-crystallized specimens of various minerals, seems to teach that a very gradual and long-continued action after the first deposition of the sedimentary material can alone account for the phenomena.

Let it be granted, however, that, under certain conditions, watery solutions, aided probably by high temperature, have been instrumental in the production of some varieties of the silicates of magnesia, lime, alumina, and iron, it is yet to be considered whether, in dealing with the great masses of crystalline rock in which the same minerals occur, we are not still justified in referring them to the same more deeply seated and extensive agency which in so many parts of the world is giving us the clearest proofs of the reaction of the interior upon the surface of the globe.

Our Foreign Correspondent, M. Daubrée, already so distinguished for his researches on metamorphism, has recently published the results of his Synthetical Experiments on Meteorites, and has thus brought before us, from an entirely different point of view, an inquiry into the nature and origin of the silicated magnesian rocks and minerals.

It should be premised that Patrin long ago (in 1809) directed attention to the identity of composition of the meteorites with the substances ejected from terrestrial volcanos; and more recently (in 1858) Von Reichenbach boldly sketched out some of the conclusions now experimentally arrived at by Daubrée. Comparing the meteoric stones with dolerite, Reichenbach showed that the former contained very few substances which are not to be found in the latter, and that the mineral species which are met with in the meteorites occur, almost all of them, in the volcanic and plutonic rocks of the globe. Hence, he continues, we must infer that deep down under the volcanos there exist masses of the same material as the meteorites; and we may suspect that the interior of our earth

* A discussion of this case, and an elaborate account of the occurrence of another hydrated silicate, that of zinc, which appears to have been deposited in certain caverns since the time of *Elephas primigenius*, &c. will be found in the excellent 'Notes on the Geology and Mineralogy of the Spanish Provinces of Santander and Madrid,' by Dr. Sullivan and J. P. O'Reilly: Williams and Norgate, 1863.

has the same mineral composition as these bodies, or, indeed, may be nothing else than an aggregation of meteorites*.

For the purpose of comparison with reference to the substances of which they are composed, the meteorites may be divided broadly into two great classes, the irons and the stones. The former admit of three subdivisions :—1st, the metallic iron, without any stony admixture; 2nd, the iron containing grains or globules of peridote (chrysolite or olivine) ; 3rd, iron associated with silicates, pyroxene, and peridote (as that of the Sierra de Chaco).

The meteoric stones, on the other hand, for the most part contain native iron only in minute grains, disseminated in the midst of silicates, the bases of which are chiefly magnesia and protoxide of iron, bringing a large portion of them into the category of peridote. Others contain no native iron, but are formed chiefly of peridote (Chassigny), or of a less basic silicate (Bishopville, 1863)—or, again, of a granular compound of anorthite and pyroxene, like many of the lavas (Juvinas, Jonzac, and Stannern).

M. Daubrée first describes his experiments on *the imitation of the meteoric irons.* The most characteristic feature of these masses is the crystalline pattern (Widmanstätten's figures) which is brought to view on a polished surface by the action of an acid. Simple fusion of the meteorite of Caille (Var) in a *brasque* of alumina (to avoid the contact of carbon, which would have combined with the iron), was insufficient to reproduce the appearance, although the resulting substance was certainly crystalline. Further experiments, in which soft iron was associated with some of the other substances that commonly accompany meteoric iron, such as nickel and protosulphide of iron and silicon, yielded a highly crystalline result, but not yet of the true character. If, however, to the soft iron was added phosphide of iron, in the proportion of from two to five or ten per cent., and, still better, if there was introduced at the same time nickel, and if a mass of as much as two kilogrammes in weight was operated on, there appeared, when the cooled lump was polished and etched, in the midst of dendritic patterns of great regularity, lines of a brilliant material dispersed in a reticulated form.

A third mode of attempting the imitation was that of melting down certain terrestrial rock-substances, as peridote, lherzolite†, hypersthene, basalts, and melaphyres. By this means specimens of iron were obtained which, both in composition and structure, bore strong resemblance to many of the siderolites. Especially was this notable in the metal obtained from the lherzolite of Prades (Eastern Pyrenees). These artificial irons were then found, like the natural meteoric ones, to contain nickel, chromium, and phosphide of iron, the latter in long needles, recalling the appearance of the natural patterns.

Imitation of the Meteoric Stones.—Contrary to what might have been expected from the appearance of the black vitrified crust on the

* Poggendorff's 'Annalen,' vol. cv. pp. 560–562.

† Lherzolite (so called from Lherz, in the Pyrenees) is a rock composed of peridote, enstatite, and pyroxene (augite).

surface, the substance produced by the melting down of meteorites obtained from above thirty different falls, was in every case highly crystalline. Those of the common type present a group of metallic granules, disseminated in a stony mixture of peridote ($\dot{M}g^2 \dddot{S}i$) and enstatite ($\dot{M}g \ddot{S}i$), the former generally on the surface as a thin crystalline pellicle, the latter in the interior as long acicular crystals. A notable contrast was yielded by the aluminous meteorites, such as those of Juvinas, Jonzac, and Stannern, which produced, instead of a crystalline, a vitreous mass.

But perhaps the more remarkable results were those obtained synthetically by melting down pieces of rock characterized by the minerals peridote and enstatite. For this purpose peridote (olivine), from the basalt of Langeac (Haute Loire), and lherzolite, from Vicdessos and Prades, were fused in earthen crucibles. They melted easily and yielded crystalline substances, the latter especially closely resembling the original rock. The proportion of enstatite (the bisilicate of magnesia) was found to be increased by the addition of silica.

When similar mineral substances were melted in presence of a reducing agent, the iron (which in the other case remained combined in the silicate) segregated itself in grains of various sizes, separable by the magnet. Thus a perfect analogy was established between the above rocks and the meteorites, as well in their stony minerals as in the iron, which always contained nickel.

Furthermore some remarkable characters in the structure of the stony meteorites were found to have been imitated, especially the delicate parallel lines, attributable to cleavage, which are visible when a thin slice is examined under the microscope, and the globular structure where the little spherules are sometimes smooth at the surface, at others drusy, or roughened with the points of minute projecting crystals, like the meteorite of Sigena, November 17, 1773.

When hydrogen was employed as the reducing agent the results were very similar, and the reaction would take place at a temperature not exceeding red heat.

Again, another method of imitation, the reverse of the foregoing, was by oxidation. From silicide of iron, heated in a *brasque* of magnesia by the gas blowpipe, a substance was obtained extremely similar to the common type of meteorite. The iron was separated partly as native iron, partly as a silicate, forming peridote, some of it in the crystallized state. Further details of resemblance were attained by heating a mixture of silica, magnesia, nickeliferous iron, and phosphide and sulphide of iron. The stony gangue of the melted product was found to be free from the latter three substances; and instead of the simple phosphide introduced in the experiment, there was observable the triple phosphide of iron, nickel, and magnesium, first noticed by Berzelius in meteoric irons.

The preceding experiments suggest some important deductions on the condition of the planetary matter from which the meteorites have been diverted to our own globe. M. Daubrée makes no attempt to enter the lists with Von Haidinger*, Baron Reichenbach, Prof. Lawrence Smith, and others, on the questions attending the entry of these bodies into our atmosphere, and the circumstances of their fall; but, considering that their surface alone is modified by these conditions, he infers that their interior mass remains the same as when it was wandering in space, and may to a great extent be taken as a sample of the material of the planetary bodies of which they are the fragments.

Although the anhydrous silicates already so frequently named have evidently been formed at an elevated temperature, it would appear that such temperature was, at their origin, less high than that used in the experiments. The stony portion of the meteorites in their natural state is generally less perfectly crystalline than would be expected of a compound which the above experiments prove to be so ready, after full fusion, to form masses of a very pronounced crystalline character. And, again, the irregular figure of the grains of iron disseminated in the stony matrix seems to point to the material having been consolidated at a temperature below that of the fusion of soft iron—a point of view which was confirmed by experiment.

This temperature of original consolidation is a matter, of course, altogether foreign to that noted at the time of fall, and existed probably very long anterior to the meteorites coming into contact with our atmosphere; and the presence in a few cases of volatile substances in the mass proves, like a maximum thermometer, the moderate temperature of the body before it was deflected from its regular course.

Seeing how nearly the composition and structure of the meteorites are reproduced by the two methods of experiment, M. Daubrée refers by their aid to the original mode of formation of the bodies from which these meteorites come.

If they were produced from silicated minerals by reduction, in which carbon was the reducing agent, it may be objected that the iron could scarcely have remained in the metallic state; and if hydrogen be supposed to have been the reducing agent, water ought to have been formed at the surface, whence it appears more simple and reasonable to recur to the idea of an oxidizing process. Allow that silicon and the metals existed at one time in the meteorites, not combined with oxygen as they now mostly are, and this by reason either of too high a temperature to allow them to remain in combination, or of too great a separation of their particles, then, as soon as, by their cooling down or by their condensation, the oxygen was able to act upon the other elements, it would at once combine freely with those for which it had most affinity, and if not sufficient in quantity to oxidize the whole, or not enabled to act long enough, would leave a metallic residue. In fact there would be produced the silicate of magnesia and iron, peridote or olivine, and granular portions of nickeliferous iron, and of sulphides and phosphides of iron. These views, whilst applicable to a large proportion of the meteoric bodies, would require modifications for those rarer varieties which consist

* See Haidinger, 'Phil. Mag.' November and December 1861.

essentially of pyroxene and anorthite. Whilst the magnesian silicates crystallize so readily after simple fusion, these latter substances would only melt to vitreous and amorphous masses, and in order to become crystalline would have needed the presence of water.

Analogies between Meteorites and Terrestrial Rocks.—Not only are the elementary substances contained in the meteorites all of them known in our own globe, but the most abundant in both cases are iron, silicon, and oxygen. The resemblance of the meteoric stones to our eruptive rocks is especially observable in the few examples of the aluminous class (Juvinas), which are parallelled by the lava formed of anorthite and pyroxene, as that from Thjorsa in Iceland, and in the great division of the magnesian stones which so closely resemble peridote and the compound rock lherzolite*.

The most marked differences are, that, whilst protoxide of iron, whether combined with silica or with chromic acid, is a constituent in both cases, the magnetic oxide so common in our mundane rocks is, as a rule, absent from meteorites, whilst, on the other hand, the latter contain native iron, which is correspondingly wanting on the surface of the globe. Moreover the remarkable phosphide of iron and nickel so largely present in the meteoric irons is a compound not occurring in our rocks, where we may suppose it more or less represented by phosphates.

The importance of the magnesian rocks of the peridote class is witnessed by the presence of that mineral in almost the whole series of the meteorites, and by the numerous phenomena which tell of its existence in the interior of the globe. The basalts and dolerites of many and distant countries have brought to the surface fragments of that mineral, often left angular and looking as if they had been broken by force from a deeply seated and preexistent mass. Peridote or olivine forms a large portion of certain other intrusive rocks, as the lherzolite and the considerable masses of the compound termed by Hochstetter, in New Zealand, *dunite*†; and to this we have to add the family tie that closely connects it with serpentine.

No doubt it is still a disputed point whether the crystalline grains of olivine so commonly observable in basalt and in certain lavas have or have not been crystallized, *in situ*, from the elements present in the general melted *magma*. Von Buch was the first to point out several remarkable instances where it would appear that this mineral had been carried off unmelted by the lava. In the island of Lancerote, the jagged ridges of lava near Tinguaton exhibit abundant masses of crystalline olivine, which, near the origin of eruption, are often as large as a man's head, but become smaller and less noticeable where the lava-streams tail off towards Subaco‡. Similar projecting lumps of olivine had been observed at Fuen Caliente in Palma, and in the Vivarais; and more recently, our medallist of to-day, Mr. Scrope, has drawn attention, in his work on Volcanos, to the

* See Damour, 'Bull. Soc. Géol. de France,' sér. 2. vol. xix.

† This rock, formed of olivine and chromite, appears to be similar to the meteorite of Chassigny.

‡ Von Buch, 'Canarische Inseln,' pp. 303–6.

significance of similar phenomena which he had observed in the Eifel and in the Vivarais. The ordinary lavas are, as we well know, far more easily fusible than this included mineral, and especially than those paler varieties constituting the true chrysolite, which contain a larger amount of magnesia in relation to the protoxide of iron. And although it is abundantly proved that crystallized minerals very closely comparable with olivine or peridote have been produced by direct fusion in some of our blast-furnace slags, it appears certain that in many of the streams of lava and of doleritic rock this mineral had formed a solidified mass before it was broken up and floated away by the less refractory material in which we find it imbedded.

M. Daubrée proceeds to infer that, although comparatively restricted at the surface, rocks of the peridote class would at a certain depth predominate; and seeing the nature of the samples which they appear to yield us from other parts of the planetary system, he would comprise them, with the serpentines, in a special division as the *peridotic family*, or *cosmical rocks*.

A few distinguishing characters between these and other silicated rocks deserve to be noted:—

1. Peridote presents us with the most basic type known, whether in meteorites or in eruptive rocks, and must in this respect, and for its simplicity and definiteness, take precedence of the pyroxenic and other types, which have been proposed by Bunsen and Durocher.

2. The facility with which both peridote and enstatite crystallize after simple fusion contrasts remarkably with the behaviour of the aluminous silicates, and especially the felspar group.

3. The decided superiority in density of this type over that of the basalts, as of the latter over the granites &c., as seen by the following table of specific gravities:—

Granite	2·64 to 2·76.
Diabase	2·66 to 2·88.
Basalt	2·9 to 3·1.
Enstatite	3·303.
Lherzolite	3·25 to 3·33.
Peridote	3·33 to 3·44.

Hence it would seem probable that, in their origin, these different substances would have arranged themselves in the above order, and that the high density of peridote would explain the depth of its position, below the granitic covering, in the crust of the earth.

Passing to the examination of serpentine, a rock analogous in respect of its silicate of magnesia, but differing from peridote and lherzolite in being hydrated, comparatively infusible, and without distinct crystallization, specimens from several localities (Snarum in Norway, Zöblitz in Saxony, Monte Ferrato in Tuscany, &c.) were melted down. The result was in every case a more or less clearly crystalline mixture of peridote and enstatite, the former being more abundant when additional magnesia was placed in the crucible.

The serpentine of Baldissero in Piedmont gave the most characteristic product—one, indeed, identical with that obtained from lherzolite*; and although certain other silicates were formed, they are quite subordinate to the two above-named minerals.

Sundry authors have already pointed out this relationship; and it has been suggested that serpentine has been produced from peridote rock by the addition of some silica, and of water forming a hydrate. M. Daubrée suggests, however, that there is no occasion to conclude that such a change took place near the surface, for the serpentine may in many cases have been protruded, *after* acquiring at great depth the water which it still contains. The great readiness, too, with which the melted substance was transformed into less basic silicates, seems to account for the frequent association of these rocks with euphotide, with greenstones, &c.

If we now compare the fused serpentines with the meteorites, it appears on experiment that when they have been melted in a lining of carbon, grains of iron get separated which prove to contain nickel. Moreover both old analyses and abundant observations tell us that in very many and distinct regions of the earth chromium, as chromate of iron, is constantly associated with serpentine, and scarcely ever absent from meteorites. And although serpentine, on account of its hydrated condition, seems less comparable with the meteorites than peridote and lherzolite, yet it is a curious exception that certain rare carbonaceous meteorites (those of Bokkeveld at the Cape, 1838, of Kaba in Hungary, 1857, and of Orgueil) contain a hydrous silicate, referred by Wöhler to a variety akin to serpentine.

Fortified by the striking analogies which arise from his laboratory experiments, M. Daubrée has ventured to speculate on the original constitution of the crust of the earth. After recalling to us the theory of Davy, that the metals of the earths and alkalies enclosed in the interior of the globe may produce the phenomena of volcanos by oxidation in contact with water, he refers to its application by geologists to the origin of the stony crust. Our lamented friend Sir Henry De la Beche† ("dont l'esprit savait embrasser toutes les grandes questions de la Géologie," as Daubrée truly puts it) was one of the first to point out how that crust is made up in great part of oxides of the metals which have the strongest avidity for oxygen, viz. potassium, sodium, calcium, magnesium, and aluminium, and how the very water of the ocean may be considered the result of the combustion of the hydrogen in the midst of the general oxidation.

These hypothetical views appear to be supported by the synthetical experiments; for we may conclude that the peridotic rocks of our globe had an origin analogous to that of the similar substances of the meteorites, and that in fact they are the most direct products of a scorification which took place at an enormously remote epoch.

To explain the meaning of the term scorification, we are reminded that if a bath of impure iron be kept in fusion, in contact with the

* The melted substance, as in the former experiments, would sometimes take up other material, and especially silica, from the sides of the crucible.

† Researches in Theoretical Geology, 1834, chap. 7.

air, the iron oxidizes, as well as certain other bodies associated with it, and especially silicon. This oxidation gives birth to a ferruginous silicate, which forms the upper part of the metallic bath. It is a true liquid scoria, which by cooling may become pasty and then solid, and will present in the latter state a stony, crystalline structure, entirely different from the spongy, cellular substances which have been termed volcanic scoriæ. Such is the metallurgical sense in which the scorification of the globe is intended to be understood.

The materials thus affected to a considerable depth may, even at the present time, exhibit, according to their depth, masses in the three conditions above named—the solid, pasty, and fluid.

Native iron, so generally a constituent of the meteorites, is wanting, it is true, in our terrestrial rocks; but the explanation is to be found in the complete union with oxygen to which that metal is prone. And, considering the comparatively small mass of the eruptive rocks open to our investigation, it seems probable that with increasing depth a corresponding difference of composition would appear. Thus, beneath the lavas of Iceland, analogous to the meteorite of Juvinas, and beneath our peridotic rocks, like that of Chassigny, it is likely that there occur masses of lherzolite rock in which native iron similar to that which occurs in the meteorites of the common type begins to appear, and that at still greater depths we should have types more and more rich in iron, of increasing density, until they would at length only be paralleled by the native iron.

The occurrence of platinum tends to confirm these views. This metal, of extreme density, which ought upon such a supposition, until erupted, to occupy a very deep position, is commonly associated with native iron. And in the Ural it has been found encrusted with chromic iron, and even with fragments of serpentine, lending a new support to the idea of the existence at great depths of magnesian rocks of the peridote family.

Lastly, it is observable that the meteorites never contain minerals similar to the material of our stratified rocks. Haidinger has lately observed*, "The minerals composing granite, gneiss, mica-schist, and others representing the most solid basis of the terrestrial crust are wanting in them; and, to name a particularly important species, they are totally destitute of pure silica or quartz"†. Various reasons may be assigned for this remarkable fact. It is very generally allowed that the crystallization of these minerals, and particularly of the felspar group, has not been accomplished by simple fusion, but has needed the aid of other agents, and especially of water. Hence it may be suggested, either that the meteorites which impinge on the surface of our earth are fragments of the internal parts of planetary bodies formed like our own globe, or that such planetary bodies are themselves deficient in quartziferous and acid silicates, and in stratified rocks. And we might further infer that they have not witnessed the cycle of events which in our own planet have in-

* "On the original Formation of Aërolites," Phil. Mag. 1861.

† A single but notable exception is the occurrence, shown by Gustav Rose, of quartz in isolated crystals in the meteoric iron of Toluca.

troduced the cooperation of the ocean, and with it the production of granite, and afterwards of the stratified formations.

In the work already referred to, by M. Friedrich Mohr *, a chapter is devoted to the "Geology of the Heavens," and an interesting summary is given of the chief points of comparison of the meteorites with terrestrial rocks and minerals. But, although agreeing with other authors on the details of composition and on the phenomena of their occurrence, Mohr is entirely at issue with the opinions which have been above cited as to their origin. In their crystalline composition, in the mixture of different substances, and in the structure of several of them, he sees throughout the operation of watery solution. "The entire aspect of a meteorite," according to him, "speaks against fusion;" and as in the earlier portion of his work he has battled for the production by the wet way alone of all the silicates, even including olivine and augite, so in dealing with the meteoric silicates, he simply refers them to a similar origin. If, then, we lay sufficient stress on the very exceptional cases already quoted, in which carbonaceous matter has been shown to occur in meteorites, we might conclude, from the indication thus obtained of such carbo-hydrogen minerals as ozokerite, idrialite, &c., that there must have existed in the original cosmical body some such organisms as the plants of the earth, and, going a step further, that it was by their agency that the chemical reductions were effected of which we have evidence in the meteoric irons. So many, however, of Mohr's *dicta* are flatly contradicted by the results of Daubrée's experiments, that the impression which might have been produced in regard to some aspects of our science by so confident and clever a treatise as the 'Geschichte der Erde' will at once be greatly modified.

Thus, gentlemen, I have ventured to place before you some of the newest views on a limited branch of our science; and I trust that the selection of a single topic may be justified by the evidence which I have adduced of its fundamental importance, and of the connecting link which it appears to supply between the history of our own globe and that of other members of our solar system. It is not to be denied that the opinions of authors and experimenters who have recently been at work on the subject are extremely divergent. But it appears to me for that very reason the more desirable to place side by side their opposite conclusions, and thus by degrees to eliminate whatever may be one-sided, ill-founded, or not adapted to the conditions of the problem. There must always remain in geology, by the side of much that can be determined as actual fact, a large domain in which speculation will have ample scope; and it is in this latter region more especially that we have need to exercise caution, readiness to deal fairly with new views, and a deference to other men's opinions in the pursuit of that truth which it is the object of geologists to attain.

* 'Geschichte der Erde,' Bonn, 1866.

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PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 7, 1866.

The Rev. W. Gover, Saltley College, Birmingham, was elected a Fellow.

The following communications were read:—

1. *On some* Remains *of large* Dinosaurian Reptiles *from the* Stormberg Mountains, South Africa. By Professor Huxley, F.R.S., V.P.G.S.

In a box of fossils sent to Sir R. I. Murchison, Bart., by Mr. Alfred Brown of Aliwal North, South Africa, and submitted to me for examination and determination, I found certain fragmentary large reptilian bones, to which a very considerable interest attaches.

The most important of these are two femora, a right and a left. The articular ends of both of these bones are wanting; and the shaft of the left is far less complete than that of the right, to which the following remarks more particularly apply.

It is broken into four pieces; but these, when carefully fitted together, have a total length of 25·5 inches; and it may be safely assumed that the length of the entire femur exceeded 30 inches, as its distal extremity is only beginning to widen for the condyles. At 20·5 inches from the proximal end, the transverse diameter of the shaft is 5·1 inches, the antero-posterior diameter 4·2 inches. The contour of the transverse section at this point is a transversely elongated oval, the posterior face being so much more flattened than the anterior as to make it almost semilunar.

Viewed sideways, the shaft of the bone is, for the greater part of its length, nearly straight, though its dorsal contour is a little convex. But towards the proximal end it becomes widened and flattened from above downwards, while, at the same time, its longitudinal contour becomes concave above and convex below.

In its dorsal, or upper, aspect also, the greater part of the length of the shaft of the bone is nearly straight; but at nine inches from the proximal end it curves so as to have a convex outer and a concave inner contour. The latter curve takes a broad and gradual sweep. In consequence of the various curvatures and other changes of form which have been described, the broad and flattened proximal end of the femur is, as it were, twisted upon the more cylindroid shaft, the long axis of its section forming an acute angle with that of the shaft.

The outer surface of the greater part of the shaft of the bone is somewhat flattened. Just where the proximal end begins to bend inwards, the junction of the outer and the upper faces rises into an obtuse ridge, nowhere more than an inch broad and as much high, which is continued for about four inches upon the outer or convex edge of the incurved proximal part of the bone, and ends, in an obtuse summit, at 5·75 inches from the proximal end.

The surface of this outer trochanteric ridge is unbroken very nearly to its proximal end; so that if it were ever continued into a free process, this must have been comparatively short and slender.

From its inner and under side the shaft of the femur gives off a very stout process, the greater part of which is broken away. Enough remains, however, to show that one of its faces had the same direction as the tibial (or inner) face of the femur itself.

The anterior end of the fractured surface, indicating the attachment of the base of this inner trochanter, is 18·5 inches distant from the proximal end, and the surface is about 8 inches long; so that its centre must have been situated on the proximal side of the middle of the length of the uninjured bone. A broad, but very shallow, depression marks the inner face of the femur above the base of this process.

The various sections presented by the ends of the fragments of the bone show that it contained a large and distinct medullary cavity, having a diameter of from two and a half to three inches.

The peculiar form of this femur, with the characters and position of its trochanters, leave no doubt as to the Dinosaurian affinities of the animal to which it belonged.

In size it must have corresponded with *Megalosaurus* and with moderately large Iguanodons. The largest femur of an *Iguanodon* with which I am acquainted is that marked No. 1 in the British Museum. It is 44·5 inches long, the middle of its shaft having a transverse diameter of 8 inches.

The Iguanodont femur in the British Museum figured by Professor Owen in his monograph upon that Reptile, published by the Palæontographical Society (pl. 15. fig. 1), is 33 inches long, the transverse diameter of the middle of the shaft being 5 inches.

The most perfect femur of *Megalosaurus Bucklandi* in the same collection is 32 inches long, while the middle of the shaft is not more than 4 inches in diameter. The largest Megalosaurian femur in the British Museum could hardly have exceeded 33 inches in length when entire.

The femur of *Scelidosaurus* is much smaller. Thus while the thigh-bone of the African Dinosaurian was probably nearly as long as that of *Megalosaurus,* it was absolutely, and *à fortiori* relatively, stouter.

On comparing the femora of *Megalosaurus* and *Iguanodon,* I find the following to be the chief differences between the two:—

In *Megalosaurus*—

a. The shaft is more slender and proportionally deeper from before backwards.

b. The inner trochanter lies almost wholly in the proximal half of the bone, so that its central, most projecting, part is much nearer the proximal than the distal end of the bone. In *Iguanodon* the most projecting part of the inner trochanter is a sudden outgrowth from its distal end, which lies altogether in the distal half of the bone.

c. One face of the inner trochanter continues the direction of the tibial (or inner) face of the femur. In *Iguanodon* one face of the inner trochanter looks towards the dorsal side of the femur, or is at right angles with the tibial face of the shaft, and there is a fossa above the trochanter on the tibial face of the femur.

d. The proximal end of the femur is curved, flattened, and twisted on its axis, so that the long axis of its transverse section makes an acute angle with that of the shaft of the bone. In *Iguanodon* the proximal end is flattened, but almost straight and not twisted on its axis, whence the long axis of its transverse section coincides, or nearly so, with that of the shaft of the bone.

e. The concavity of the upper face and convexity of the lower face of the proximal part of the femur is strongly marked. In *Iguanodon* both faces are almost flat.

f. The inner contour of the proximal part of the femur makes a slow and gradual curve. In *Iguanodon* it makes a sharp, almost rectangular, bend.

g. The great trochanter is comparatively short, not nearly reaching the proximal end of the bone. In *Iguanodon* it is long, slender, and its summit attains the level of the proximal end.

h. There is but a shallow and wide excavation on the front face of the distal end of the femur. In *Iguanodon* there is a deep, sharply defined longitudinal furrow on this face, nearer the outer than the inner condyle.

i. The isthmus uniting the inner and outer condyles is wide from before backwards. In *Iguanodon* it is very narrow.

k. The outer condyle has a peculiar posterior ridge-like process, which appears to be absent in *Iguanodon.*

In the characters *b, c, d, e, f, g*, the femur of the African reptile approaches that of *Megalosaurus* more nearly than that of *Iguanodon*; but it differs from that of *Megalosaurus* in the proportional size and form of its trochanters, and in its much heavier proportions.

An animal the thigh-bone of which approaches three feet in length, may be fitly said to have "good legs," whence I propose the generic name of *Euskelesaurus* for this new African reptile, and the specific title of *Brownii*, after its very intelligent and energetic discoverer, who, in a letter dated the 18th of June, 1866, addressed to Sir R. I. Murchison, states that the thigh-bones now described (and the accompanying fossils numbered 1, 3, 4, 6, 9*a*, 9*b*, 20*a*, 20*b*, 21, and 49 *a, b, c, d, e*) were obtained "in the Stormberg range of mountains in the division of Aliwal North, and about thirty miles from the town of Aliwal North. The fossils were found in a compact freestone rock, which also contains other organic remains. The height of the mountains from the base is about 3500 feet, and about 9500 feet from the sea; the strata containing the fossils about 1200 feet from the base."

These additional fossils, and No. 47, of which I can find no mention in the list sent by Mr. Brown, have the same aspect, and appear to have been imbedded in the same matrix as the femora. Nos. 9*a*, 9*b*, and 49*a, b, c, d, e* are fragments of two very large flat bones, and 20*a*, 20*b* of a large metatarsal and metacarpal, which very probably belonged to *Euskelesaurus*. Nos. 4 and 21 are indeterminable.

No. 3 is a very interesting fossil, comprising nearly seven inches of the distal ends of a right tibia and fibula, with an astragalus in undisturbed position, though much mutilated. The width of the conjoined ends of the tibia and fibula is 7·8 inches, six inches being occupied by the tibia alone. The antero-posterior diameter of the tibia is 4·5 inches. The posterior surface presents a wide longitudinal groove; while the anterior appears somewhat trilobed, from the presence of two superficial longitudinal depressions. The astragalus is much damaged, but presents a general resemblance to that bone in Crocodilia and in *Scelidosaurus*, its proximal end exhibiting a concave surface, and its distal a convex pulley.

No. 47 is the proximal end of a tibia, which answers very well to the foregoing in size. It is remarkable for the great size of its *cnemial* process, the inferior edge of which (so far as it is preserved) is rounded and concave, like the *procnemial* process in the Flamingo and the Albatros. These leg-bones would answer very well to the femur of *Euskelesaurus*.

No. 1 is the broken articular end of a long bone of considerable size, as the transverse diameter of its condyles when entire could have fallen but little short of eight inches. At 7 inches from its extremity the shaft of the bone has a transverse diameter of 5·5 inches, an antero-posterior diameter of 6·6. The total length of the fragment is 10·75 inches.

The measurements of this fragment correspond pretty nearly with those of the distal end of the 33-inch *Iguanodon* femur. The two condyles are separated in front by a broad but well-marked groove, the outer boundary of which is formed by a prominent ridge, separating the front face of the bone from the flattened outer face, which is disposed at right angles to the front face. The outer condyle, in which this ridge ends, is narrower than the inner, and projects further forward, but to a less distance backward. A very deep groove separates it from the inner condyle. The posterior surface of this condyle forms a stout projecting ridge, which runs up the length of what remains of the shaft of the bone, gradually diminishing in height. The tibial, or inner, surface of the inner condyle slopes obliquely inwards and backwards, as in the femora of *Iguanodon* and *Megalosaurus*.

I cannot identify this fragment with any part of a reptilian skeleton but the distal end of a femur; and if this interpretation be correct, it must belong to some other animal than *Euskelesaurus*, so much of the commencement of the distal expansion of the femur of the latter reptile remaining as to suffice to prove that it could not have had the peculiar form presented by the present specimen. Provisionally, and while awaiting further materials, I shall apply the title of *Orosaurus* to the fossil reptile indicated by the femur. Of course, the existence of a second great Dinosaurian in the Stormberg rocks renders it, for the present, impossible to assign the tibial fragments to the one genus or to the other.

The Stormberg mountains form part of a long range which stretches north-eastward for several hundred miles, and takes the name of the Drakenberg on the north-west frontier of Natal. In Mr. Bain's map and sections illustrative of the geology of South Africa, published in the seventh volume of the Transactions of this Society, this range of mountains is seen to be formed by the southern edge of a considerable thickness of horizontal strata, piled conformably above the Karoo-beds, which have yielded the Dicynodonts and so many other remarkable true reptiles and Labyrinthodonts.

According to Mr. Bain, "these Stormberg beds," as they might be called, contain reptilian and vegetable remains; but I know of no description of any of these except that given by Professor Owen of certain fossil remains, discovered by Messrs. Orpen in the Drakenberg, 250 miles from the Stormberg, which Professor Owen has called *Massospondylus*, *Pachyspondylus*, and *Leptospondylus*, and which he considers to "indicate three or more genera or species of large extinct carnivorous reptiles, combining in their vertebræ and bones of the extremities both Crocodilian and Lacertian characters, with an indication of a structure of the sacrum like that in the Dinosauria. Their precise place in the Reptilian class cannot be determined until the cranial and dental characters are known"*.

I have carefully examined these fossil bones, which appertained to animals of much smaller dimensions than *Euskelesaurus*, and, so far as they are comparable, differ from the latter.

* Descriptive Catalogue of the fossil organic remains of Reptilia and Pisces contained in the Museum of the Royal College of Surgeons of England (1854).

The occurrence of Dinosaurian remains in the Stormberg rocks is, unfortunately, by no means decisive as to their geological relations. The Dinosaurian *Plateosaurus* has been discovered by Von Meyer in the Trias; and the affinities of the Thecodonts with the Dinosauria are so close that no one could be surprised at the occurrence of the latter reptiles in rocks of Permian age; while, on the other hand, they are continued through the Mesozoic formations to the Chalk.

In the letter from which a passage has already been cited, Mr. Brown not only expresses the belief that he will be able to procure a full suite of remains of *Euskelesaurus*; but this energetic investigator of South African geology promises shortly to forward another highly interesting fossil, the account of which I subjoin in his own words:—

"On the 24th of May last, being a holiday, I went into the country, as is my custom, and found, at a considerable distance from Aliwal, in an alluvial deposit forming the bed of an ancient valley, imbedded *in situ*, an animal which, from proofs in my possession, I believe to be a representative animal, or at least the type of a genus, which inhabited a large extent of country.

"When I send this animal I will transmit a series of fragments of teeth (belonging to this type) gathered from many parts of the district, and accompany them with a paper, with an outline sketch of the localities by the aid of a camera lucida.

"I have made already five visits to the spot. The following are the particulars:—

"*a*. The bones are completely mineralized, and very dense.

"*b*. There are about nine ribs as yet, with their vertebral ends in good preservation.

"*c*. Cranium (of which there are many pieces) very elongated. Saurian type?

"*d*. Lower jaws, very short and remarkably thick; no traces of teeth. Mammalian type?

"*e*. One large tooth in the upper jaw lying horizontally in the centre of the intermaxillary bone, and taking a curve after protruding from the muzzle. It is in such a peculiar position that I have seen nothing in nature or engravings resembling it.

"*f*. Twelve vertebræ, with their tubercles and processes complete.

"*g*. Several large bones, which I cannot define at present.

"*h*. One large bone belonging to the pelvis, possessing saurian characters."

Mr. Brown further remarks that the head must have been nearly as large as that of an ox, with lower jaws no longer than those of an average-sized dog.

It is useless to speculate when the means of arriving at certain knowledge are so near at hand; but the description is certainly more suggestive of a Dicynodont reptile than of anything else.

2. *Additional Notes on the* GROUPING *of the* ROCKS *of* NORTH DEVON *and* WEST SOMERSET. By J. Beete Jukes, Esq., M.A., F.R.S., F.G.S.

NOVEMBER 21, 1866.

The following communications were read:—

1. *On* MARINE FOSSILIFEROUS SECONDARY FORMATIONS *in* AUSTRALIA. By the Rev. W. B. CLARKE, M.A., F.G.S.

IN Australia, until the year 1860, no deposits of Secondary age had been demonstrated, although Sir T. L. Mitchell, in 1846, during his exploration of tropical Australia, had collected Belemnites and a few other fossils, which are now known to belong to a Lower Secondary formation, such as occurs on the Maranoa River, in Queensland.

During my own explorations in 1851–3, I had received a portion of an Ammonite found in the Clarence River District, in New South Wales; and in 1859, Mr. Selwyn* obtained two supposed Cretaceous fossils from the drift-gravel in Victoria.

But these were all the data that had been accumulated in Eastern Australia up to 1861, when my paper "On the position of certain plants in the Coal-bearing beds of Australia" was read before the Geological Society†. But of Oolitic fossils no species had been found in New South Wales in 1860, nor to my knowledge in any part of Australia, as stated in my book on the Gold-fields; for I was then unaware even that Mr. Gregory had discovered any Secondary fossils in Western Australia, which fact I first became acquainted with in an editorial note appended to the paper cited. In Mr. Gregory's paper‡, afterwards published, he mentions Cretaceous, but not Jurassic fossils.

Shortly after this, my friend Mr. W. P. Gordon, who then lived at Wollumbilla, north of the Condamine River, was requested by me to examine his neighbourhood, and to send me any fossils he might discover, as I was led to suspect that if Secondary rocks existed anywhere in that region, he would be within reach of them. In a few months I received the collection which is mentioned in the Quarterly Journal of the Geological Society§, under the title of "The Occurrence of Mesozoic and Permian Faunæ in Eastern Australia."

In that paper the fossils were mentioned as having been intended for the International Exhibition at London in 1862. An accident prevented their despatch in time for the Exhibition; but they have since been placed in the hands of Mr. C. Moore, of Bath, F.G.S., for description.

* Quart. Journ. Geol. Soc. vol. xvi. p. 148.
† *Ibid.* vol. xvii. pp. 359–362. ‡ *Ibid.* p. 480.
§ *Ibid.* vol. xviii. p. 244.

If my first view of some of these fossils as belonging to the Cretaceous epoch was incorrect (though the first view of Mr. Moore himself was the same), and if they belong to the very base of the Secondary formations, as has since been surmised, they become the first extensive collection of Lower Mesozoic age from a recognized locality, and are so far interesting.

Disputing the opinion that they were the marine representatives of the Coal-beds of New South Wales, I was inclined to admit that they might still be the representatives of the Wianamatta beds overlying the Hawkesbury rocks, which again overlie the Coal-beds; but Sir Philip Egerton's determination* of the Palæozoic character of the fishes in these upper beds proves that the Wollumbilla beds are far above them, and have nothing in common with the New South Wales Coal-seams.

Baron de Zigno, in his paper† "*Sopra i depositi di piante fossili dell' America Settentrionale, delle Indie e dell' Australia, che alcuni Autori riferirono all' epoca Oolitica*" (in which, I am glad to see, he arrives at a more satisfactory conclusion than in his former writings), has fallen into a mistake as to the Wollumbilla beds being connected with beds (7000 miles to the westward) containing a *Tæniopteris*, as reported by Professor M'Coy.

Mr. Gregory's paper (1861) mentions, as a Cretaceous fossil, a *Ventriculite* in flint, and as "fossils of Secondary age" specimens of *Trigonia* and *Ammonites* from the Moresby Range, an *Ammonite* from Mount Albert, and a *Pecten* from the east of Wizard Peak. These localities in Western Australia are a kind of classic ground, as they were described (though not geologically) by the late Rear-Admiral King, and afterwards by Rear-Admiral Stokes.

In 1862, a few fossils (probably from Mr. Gregory's collection) were exhibited in London, including *Trigonia costata*. In the same year I received a letter from Mr. Moore, dated 24th September, in which he mentioned that he had found accidentally in Worcestershire a collection of fossils sent from Western Australia by Mr. Clifton. Of these, between 50 and 60 species were made out, and 30 of them were in a block not larger than a sheet of note-paper. Of Oolitic forms he discovered the following:—

Ammonites (3 or 4 species).	Nautilus sinuatus?
Avicula (several species).	Nerinæa?
Astarte.	Opis.
Belemnites.	Ostrea Marshi.
Chemnitzia.	Pecten (several species).
Cucullæa (3 sp.).	Pholas australis, *Moore, MS.*
Hinnites.	Rhynchonella variabilis.
Lima proboscidea.	Serpulæ.
Lima.	Trigonia costata.
Lucina.	Turbo.

Besides these were *Ammonites radians* (a true Upper Lias form);

* Quart. Journ. Geol. Soc. vol. xx. p. 1.
† Rivista periodica della I. R. Acad. di Padova, vol. xii. 1863, p. 148.

and *A. Moorii*, Lycett, *Myacites*, and *Pholadomya*, considered Middle Lias, also occurred. The rock itself gave 56 per cent. of iron. This agrees very well with what Stokes says* of the abundance of iron diffused and in blocks about Moresby Range and Wizard Peak. Mr. Moore tells me that there is nothing in common between this collection and my Wollumbilla collection; and if so, we have a distinction of deposits; and though not far separated in point of age, yet it is so far clear that the Western and the Eastern sides of Australia are not altogether identical in age, though the Carboniferous formation below the Secondary rocks appears the same. Although Mr. Moore did not know whence the fossils came, I think they certainly came from the neighbourhood of the Moresby Range. I believe the list was published by the British Association, but I cannot now refer to the volume.

In November, 1863, I received from the Honourable F. B. Barlee, F.R.G.S., Colonial Secretary of Western Australia, a case of fossils in a ferruginous matrix, containing—

Avicula (of large size),
Astarte,
Nautilus.
Nucula,
Pecten (? vesicularis),
Pholadomya.

These came from about 15 miles north of Champion Bay, and probably from near the Moresby Range. A subsequent parcel of fossils reached me in 1864, from the same neighbourhood, and among them I find the following:—

Ammonites (4 species).
Arca (3 species).
Astarte.
Avicula Münsteri.
Belemnites canaliculatus (2 specimens).
Cardium.
Chemnitzia.
Dentalium.
Lima (2 species).
Myacites (3 species).
Mytilus.
Nautilus (2 species).
Nerinæa.
Ostrea Marshi.
Ostrea (very small species).
Pecten (4 species).
Pholadomya.
Rhynchonella (3 species).
Serpula (2 species)
Trigonia (3 species).

Taking the general aspect and association of these fossils, and the occurrence of such forms as *Avicula Münsteri*, *Ostrea Marshi*, and *Ammonites Moorii*, it is almost certain that the nearest representative of the formation is the Inferior Oolite. The *Nautilus sinuatus* and *Trigonia costata* lead to the same conclusion; but another *Nautilus* in my collection appears to be new. It appears certain, at any rate, that the Moresby Range is the headquarters of the Jurassic formations in Western Australia.

There is no necessity to enter here on any discussion as to the palpable position of these rocks with respect to the highly altered deposits of sandstone to the northwards of them, though it would seem that the Trias is represented there. But I may properly add

* Discoveries in Australia, vol. ii. p. 387.

that, although there are abundant fragments of wood mineralized by silica and iron in the deposits, no traces have been found of any plants which occur in the Wianamatta, Hawkesbury, or Newcastle beds of New South Wales.

It was my intention to redeem my promise to the Geological Society, and send the results of further investigations along the Maranoa River. Circumstances have hindered this; but I may now mention that I have ascertained that the Mesozoic formations extend over an enormous area in Tropical Eastern Australia, that from the eastward of Wollumbilla to the Maranoa, and thence to the Nive and Barcoo Rivers, and so to the Thomson, the Belyando, and the Flinders (from all which I have received collections), there are formations which appear to me to range from the Trias up to the Cretaceous; and I anticipate hereafter a development of formations or groups almost as regular in succession as those in England.

From the Barcoo I have fish-teeth imbedded in fossiliferous rocks not unlike those of Wollumbilla; and from the Branston Range on the Flinders I have Ammonites, *Avicula*, and a fragment of an *Inoceramus*, in a grey limestone highly metamorphosed, jointed, and full of calcareous spar, the joints producing a regular columnar structure.

Belemnites of various species are common on the Nive, the Belyando, and the Amby Rivers, and at Bungeeworgoraï, on Fitzroy Downs, Pentacrinites being beautifully developed in the calcareous grit of Mitchell Downs. All these last-mentioned places are in Queensland.

I hope hereafter to be able to show distinctly the order of succession in all the Australian deposits. My present object has been to give a brief *résumé* of the discovery of Secondary formations in Australia up to the present year, and I must therefore conclude it with stating that it was announced at the beginning of 1865, in the Melbourne papers, that Professor M'Coy had received from a student of the University an *Inoceramus*, and a fragment of an Ammonite from Flinders, which he considered to be Cretaceous.

I have not included the Unio (*U. Daintreei*) described by Professor M'Coy from the Western part of Victoria, because it does not come under the head of Marine fossils; but I believe it to be the only fossil animal found in the so-called Oolitic deposits of that colony; and of course it proves nothing as to comparison of them with the Wollumbilla or Moresby Range beds.

PS. As a sequel to the above, and as almost necessary to the clear understanding of the perfect separation of beds with *Glossopteris* (which Professor M'Coy so long maintained were Oolitic) from those above mentioned, I may perhaps be allowed to state that no *Glossopteris* has been found in Victoria, Queensland, Western Australia, or in New South Wales except in association with beds containing fossils of Palæozoic age, that at Stony Creek in the Hunter River-basin the Glossopteris-beds are covered by from 2000 to 3000 feet of strata full of Upper Palæozoic fossils, that similar associations exist in various other parts of that extensive basin (as proved by borings), and that Mr. Daintree, who was formerly on the Geological Survey of Victoria, but is now squatting on the Clarke River, in the Upper Kennedy district, has brought to me from the Bowen River Coal-field, fully 900 miles north of Stony Creek, the same species of shells and the same species of plants, occurring in the same order of superposition as at Stony Creek, proving that there is no anomaly in the positions I have assigned to the *Glossopteris*, and that it goes down as low as the Upper Carboniferous at least. It will be interesting to geologists to know that this is now so thoroughly determined that no doubt can remain in the mind of any honest controversialist.

I append two extracts from letters from Mr. Daintree justifying my statement:—

Bowen, Feb. 10, 1866.

"In the Bowen River Coal-field your statement as to the Palæozoic age of the Newcastle beds is, so far as I could judge, *entirely proven*, since here we have *Spirifers*, &c., similar to those in Russell's shaft* and the railway-section at Maitland overlying the coal-seams, *Glossopteris* being the most abundant fossil Fern."

After having gone to Melbourne and returned to Queensland, he writes as follows:—

Brisbane, April 11, 1866.

"I send you a copy of what Professor M'Coy addressed to me after an examination of the fossils I took him, viz.:—

"'Your brown beds No. 2, are identical with the marine beds *underlying the Coal of the Hunter* †, the *Productus brachythærus*, *Stenoporum ovatum*, *Pachydomus globosus*, *Allorisma curvatum*, &c., fixing them. The *Streptorhynchus* is new, but of clearly Carboniferous type. I have no doubt of their being Upper Palæozoic.

"'The plants are *Phyllotheca australis*, and *Glossopteris Browniana*, forms related to which in Europe are only found in Mesozoic rocks.'"

Mr. Daintree adds, "*These types are all above the Lower Coal-seams of the Bowen River*."

The section Mr. Daintree described as clear and unmistakable, presenting beds distinctly lying over each other in regular order, and having below those already described others with *Lepidodendron*, just as, in New South Wales, the marine beds *below* the Stony-Creek Coal (which, as we have seen, is covered by marine beds, which are again covered at Newcastle by Coal-beds) are succeeded

* See section by Rev. W. B. Clarke, Trans. R. Soc. Victoria, vol vi., and sections of the Newcastle Basin, by Mr. Mackenzie and Mr. Clarke.

† *I. e. overlying* the Stony Creek Coal-seams.—W.B.C.

by shales full of *Lepidodendra, Sigillariæ*, and Ferns, which are also succeeded by limestones and other rocks full of marine fossils having a Devonian or Lowest Carboniferous aspect.

We thus perceive that in North Queensland as well as in New South Wales the succession is an alternation of plant- and animal-beds ranging through many thousand feet of strata resting on granites, porphyries, or slates, &c., of Lower Palæozoic age, and covered by the Secondary formations already alluded to, which have no connexion with the Coal-seams of New South Wales, and which do not, so far as is known, occur either there or in Victoria.

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2. *On the* Madreporaria *of the* Infra-Lias *of* South Wales. By P. Martin Duncan, M.B. Lond., Sec.G.S.

Contents.

1. *Introduction.*—Towards the end of 1865, Mr. Tawney sent me a collection of fossils from the Sutton stone in South Wales, and requested me to describe the species of Madreporaria contained in it. This description appeared as an appendix to the elaborate communication "On the western limits of the Rhætic beds in South Wales, and on the position of the Sutton stone," by E. B. Tawney, Esq., F.G.S.*

The species were but few in number, they were unlike any others from British Secondary rocks, and they presented rather a St. Cassian facies.

Little could be determined, from their study, concerning the age of the Sutton stone†; and Mr. Tawney could only give a qualified opinion upon this subject after the examination of the Mollusca. Shortly after these communications were read, Mr. Charles Moore sent me a large collection of fossils from the Sutton stone and from

* Quart. Journ. Geol. Soc. vol. xxii. p. 69.

† For an admirable description of these rocks, see Mem. Geol. Survey, vol. i. p. 270, by Sir H. de la Beche.

some other Liassic beds which rest upon Carboniferous Limestone. During this autumn, the same indefatigable geologist went over the district described by Mr. Tawney, and on his return he forwarded me a magnificent collection of specimens from Sutton, Southerndown, Brocastle, Ewenny, Langan, Laleston, Cowbridge, and Shepton Mallet. He moreover gave me all the information he could obtain on the stratigraphical relations of the highly fossiliferous beds of those localities. It soon became evident that there was a very considerable number of new species of Madreporaria among the specimens*.

The objects of this communication are, to introduce to Palæontologists a new British coral-fauna from deposits of Liassic age, which rest upon Carboniferous Limestone; to correlate these beds with each other and with the Infra-Lias in Normandy, in the Côte d'Or, and in the Duchy of Luxembourg; to show the necessity of filling up the space which now exists in British classificatory geology between the zones of *Ammonites Planorbis* and of *Ammonites Bucklandi*, *Gryphæa incurva*, &c.; and to give an analysis of the species of Madreporaria of the Infra-Lias.

2. *Description of the Brocastle and Ewenny Deposits.*—Brocastle and Ewenny are localities a short distance south-west of Bridgend in Glamorganshire. Their fossiliferous deposits rest upon the Mountain-limestone, and fill up depressions on its surface. The beds have no stratigraphical succession; but at Ewenny the Sutton stone was seen by Mr. Charles Moore beneath the fossiliferous deposit. The beds are more or less conglomeratic, they are limestones with much Dolomite in their composition, and the fossils weather out amongst crystals of selenite, calc-spar, galena, and occasionally of quartz. They contain, more or less, dark chert derived from Carboniferous Limestone; and Palæozoic fossils are thus introduced. Hand specimens show a dull-grey cherty fracture or a light-brown semicrystalline lustre; but the fossils weather out of a pale yellowish brown colour. Occasionally the limestone is darker; but the fossils always appear of the same colour. Casts are frequent, and they are often filled with crystals.

* As Mr. Charles Moore is describing the Mollusca, and Mr. Tate is studying the Gasteropoda from these localities, I shall notice only those Gasteropoda and Lamellibranchiata which are common to these beds and their continental equivalents. I am under great obligations to Dr. Wright for sending me the typical specimens of the corals he has described from the zone of *Ammonites Planorbis* in England and in the island of Skye—and also to the Rev. P. B. Brodie for the loan of all his Lower-Lias Madreporaria, for sections which he has given me, and for much useful information. These gentlemen, in conjunction with Mrs. Strickland and Messrs. Tate, Burton, and Chamberlin, have given me many of the data by which I have been able to compare the coral-fauna of the Lias containing *Ammonites Bucklandi* &c. with that of the beds of which this communication more especially treats. My friend Mr. Charles Moore is the geologist to whom I am the most indebted. With a true love of science, he has furnished me with all the details I required concerning the fossiliferous beds which he has so carefully studied, although there is a difference in our opinions about their geological age; and he has spared neither time nor trouble in his endeavours to elucidate the truth.

The fossil remains in these old hollows in Mountain-limestone at the bottom of the Liassic sea are in incalculable multitudes; and on splitting blocks upon which they weather out in profusion, the fractured surfaces give indications of as many others. Some of the fossils are perfect even in their most delicate ornamentation; others are worn, having been rolled; and myriads are in fragments. The smaller fossils stud the blocks, and consist for the most part of fragments of Madreporaria and Pentacrinites, of *Cidaris* spines and plates, and of fragments of large and small Lamellibranchiata; and with these are mixed the shells of tiny Gasteropoda. The larger fossils consist of perfect spheres of *Isastræa globosa*, Dunc. (and fragments of them), of blocks more or less gibbous of another *Isastræa*, of flat or dendroid pieces of *Astrocœniæ*, and of more or less fragmentary *Thecosmiliæ* and *Montlivaltiæ*; and amidst these are more or less perfect *Cerithia*, *Turritellæ*, large *Pleurotomariæ*, *Straparolæ*, *Neritopsides*, many rugged *Ostreæ*, and more or less perfect *Limæ*. There are also Polyzoa and *Serpulæ*. All are mingled together, and here and there are some remanié species of *Syringopora*, *Amplexus*, *Cyathophyllum* and *Lithostrotion*. The profusion of perfect specimens of many species of Madreporaria is quite characteristic of the deposit. Considering that many of the fossils are found as casts, that others have suffered from a destructive fossilization, and that many kinds of stone enter into the composition of the deposit, it is very remarkable that so many species should be determinable from so many specimens.

The most common fossils are Madreporaria; and portions of some Astrocænian or other are found on every block. Specimens from Ewenny resemble those from Brocastle; and it is evident that the beds are on the same geological horizon.

Brocastle may be considered a typical deposit; and in all probability the remarks made upon it will apply to coralliferous beds near Cowbridge, which rest upon Mountain-limestone, and to a fossiliferous bed near Laleston, where vast numbers of a *Thecosmilia* are found. But further information is required before several other Liassic deposits resting upon Carboniferous limestone can be asserted to be on the same horizon as Brocastle.

The following is a list of the species of Madreporaria, from the Brocastle beds, which have not been hitherto described:—

Montlivaltia simplex, sp. nov.*
—— Walliæ, sp. nov.
—— Brodiei, sp. nov.
—— Murchisoniæ, sp. nov.
—— pedunculata, sp. nov.
—— brevis, sp. nov.
Thecosmilia irregularis, sp. nov. and 1 var.
—— Terquemi, sp. nov.
—— affinis, sp. nov.
Thecosmilia Walliæ, sp. nov.
—— dentata, sp. nov.
—— plana, sp. nov.
Isastræa globosa, sp. nov.
Latimæandra denticulata, sp. nov.
Cyathocænia dendroidea, sp. nov.
—— costata, sp. nov.
Astrocænia plana, sp. nov.
—— dendroidea, sp. nov.
—— minuta, sp. nov.

* These species, having been drawn on stone and described for the Palæontographical Society, will be published in its volume for 1866.

Astrocænia reptans, sp. nov.
—— favoidea, sp. nov.
—— spinigera, sp. nov.
—— pedunculata, sp. nov.
Astrocænia costata, sp. nov.
—— gibbosa, sp. nov.
—— insignis, sp. nov.

The following species were also found at Brocastle, but they have been previously described:—

Septastræa excavata, *de From.*
Isastræa Sinemuriensis, *d' Orb.*, sp.
Montlivaltia polymorpha, *Terquem et Piette.*
Thecosmilia Martini, *de From.*
—— Michelini, *Tqm.*

The annexed list includes the few species of Gasteropoda and bivalve Mollusca I have recognized in the Brocastle beds:—

Cerithium acuticostatum, *Tqm.*
—— gratum, *Tqm.*
—— Semele, *d' Orb.*
Turritella Zenkeni, *Dunk.*, sp.
—— Dunkeri, *Dunk.*, sp.
Phasianella Morencyana, *Piette.*
Neritopsis exigua, *Tqm.*
Gervillia acuminata, *Tqm.*
Ostræa irregularis, *Münst.*
Ostrea Liassica, *Str.* (O. multicostata, *Münst.*)
—— anomala, *Tqm.*
Lima tuberculata, *Tqm.*
—— compressa, *Tqm.*
Cucullæa Psilonoti, *Quenst.* (C. Hettangiensis, *Tqm.*)
Cardita Heberti, *Tqm.*

These lists contain a very remarkable assemblage of species; and the number of Madreporaria is very striking when it is remembered how very few species of them have been found in any Liassic formation. The species, as a whole, constitute a coral-fauna not hitherto recognized in Great Britain, and having a very decided distinction from that of the Lias containing *Ammonites Bucklandi.* The Gasteropoda associated with the Madreporaria are noteworthy, because they are grouped with some of the species of corals in those continental strata which appear to be the equivalents of the Brocastle beds.

3. *Remarks upon the Palæontology of the Sutton and Southerndown series.*—The general characteristics of the Sutton and Southerndown series have been so ably described, that it is simply necessary to refer to Mr. Tawney's essay for their relative position and lithological peculiarities. The Sutton stone, with its superimposed Southerndown beds, may be regarded as one Palæontological series. Like the Brocastle beds it rests on Carboniferous Limestone, and is conglomeratic at the base, where blocks of black chert containing Palæozoic corals of Carboniferous Limestone age are found. It is best seen on the coast; but there are quarries of it at Laleston which yield good fossils, and Mr. Charles Moore states that it may be seen beneath the Ewenny limestone. The Southerndown beds do not contain many Madreporaria, and their species are the same as those common in the Sutton stone. The uppermost beds of the Southerndown series are covered with the Lias containing *Ammonites Bucklandi, A. Conybearii, Gryphæa incurva,* &c.

The following is a list of the species of Madreporaria from the Sutton stone not hitherto described:—

Montlivaltia pedunculata, sp. nov.
—— parasitica, sp. nov.
Thecosmilia Suttonensis, sp. nov.
—— mirabilis, sp. nov.
—— serialis, sp. nov.
Cyathocœnia incrustans, sp. nov.
Astrocœnia gibbosa, sp. nov.
—— plana, sp. nov.
—— parasitica, sp. nov.
—— reptans, sp. nov.
Elysastræa Moorei, sp. nov.

The following species have been previously described from other strata:—

Montlivaltia polymorpha, *Tqm. et Piette.*
Thecosmilia rugosa, *Laube.*
Rhabdophyllia recondita, *Laube.*
Elysastræa Fischeri, *Laube.*

The species *Montlivaltia pedunculata, M. polymorpha, Astrocœnia gibbosa, A. plana,* and *A. reptans* are common to the Sutton stone and to the Brocastle beds. The small *Thecosmiliæ* have the same facies, but are specifically distinct from those of Brocastle; and the *Astrocœniæ* are all very closely allied. The species named by Laube are Triassic; and all the rest differ from those found in the Lias with *A. Bucklandi,* but clearly belong to the same general horizon as those of Brocastle, and must be referred to the continental strata which will be noticed as being its equivalents.

An analysis of the species of Mollusca described by Mr. Tawney, and an examination of some fossils he had not the opportunity of seeing, enable me to give the following list of species which had been already described from other strata:—

Southerndown Series.

Ammonites angulatus, *Schl.*
Littorina clathrata, *Desh.*

Sutton Series.

Lima exaltata, *Tqm.*
—— dentata, *Tqm.*
Cardinia regularis, *Tqm.*
—— crassissima, *Sow.*, sp.
Plicatula intusstriata, *Emm.*
Pecten Valoniensis, *Desh.*
Ostrea irregularis } *Münst.*
—— Liassica, *Strick.*
Lima tuberculata, *Tqm.*
Myophoria postera, *Quenst.*
Monotis decussata, *Münst.*
Neritopsis exigua, *Tqm.*

This small list has been introduced to demonstrate that the Mollusca and the Madreporaria belong to the same horizon elsewhere. There are in the Sutton and Brocastle beds several species of Mollusca which are known to exist in the Lias containing *Ammonites Bucklandi* in England or elsewhere. They will be considered shortly.

4. *The differences between the beds with* Ammonites Bucklandi *and* Gryphæa incurva *and those of Brocastle, Ewenny, &c.*—The Lower Lias with *Ammonites Bucklandi, Pholadomya glabra, Lima gigantea,* and *Gryphæa incurva* rests conformably on the Southerndown beds, and no unconformity has been traced between it and any lower beds of presumed Liassic age in this district. Nothing, however, can be

more distinct than the lithological and palæontological characteristics of the *Ammonites-Bucklandi* beds and of those now under consideration. The lithological characters of the Brocastle beds have just been described; and Mr. Tawney may be thus quoted with respect to those of the other series. He remarks on the lithology of the Southerndown series, "This series differs lithologically from the Sutton Stone in the beds being much harder and more irregularly bedded, and they are frequently subcrystalline and separated by thin arenaceous partings; again, the fragments of black chert are more sparingly scattered. The Sutton-Stone beds differ much in texture: some are fine-grained white limestones; others are softer and very shelly; some are yellowish-white, and at the upper part are pale grey and become gradually harder. The conglomerate at the base consists of rolled pebbles of Carboniferous Limestone, very numerously imbedded, with occasional pieces of chert in a soft fossiliferous white matrix. The beds above the conglomerate contain shattered fragments of black chert"*. The differences in the lithological composition of the Brocastle, Southerndown, and Sutton beds are appreciable; but they have those common characteristics which separate them from the Lower Lias strata with *Gryphæa incurva*. The Lima-beds, as these last are called, are earthy limestones, separated generally by argillaceous shales; they are not conglomeratic, and do not contain any fragments of black Carboniferous chert.

The palæontological differences between the beds under consideration and those containing *Ammonites Bucklandi* (the Lima-beds) are very great. Not one species of the coral-fauna of Brocastle has as yet been found in any beds of the *Ammonites-Bucklandi* zone in any part of Great Britain or elsewhere. The same holds good with regard to the Sutton Stone and the Southerndown beds. The small list of Mollusca which I have given from the Brocastle beds has not the facies of the fauna of the *Ammonites-Bucklandi* zone; the same is the case with regard to the Mollusca of the other beds. All these beds form part of the Liassic formation, and have therefore some species in common. The great bulk, however, of the Brocastle, Sutton, and Southerndown Mollusca are peculiar to a definite horizon, and but a few species pass upwards into those beds of whose lithological differences mention has already been made. Having thus shown how the beds under consideration differ lithologically and palæontologically from the beds composing the zone of *Ammonites Bucklandi*, I propose to notice shortly the Madreporaria of the other strata of the so-called Lower Lias of Great Britain.

5. *Notice of the* Madreporaria *of other British strata of the horizon of Brocastle and of the* Ammonites-planorbis *zone, &c.*—Whilst investigating the Lias of the Isle of Skye, Dr. Wright found a coral-bed at Lussay†, consisting of great blocks of a species which he has named *Isastræa Murchisoni*. Dr. Wright considered this coral-bed to be very low in the Liassic series, and, from the presence of *Cardinia concinna*, Zieten, in the strata immediately beneath, he determined

* Quart. Journ. Geol. Soc. vol. xxii. p. 74. † *Ibid.* vol. xiv. p. 35.

it to belong to his Planorbis-zone. The coral is very interesting from its peculiar calicinal gemmation, and is not allied, except generically, with any known *Isastræa*. The *Cardinia* has a great vertical range; and had it not been for the accompanying *Ostrea arietis*, no very definite age could have been assigned to the coral-bed. This *Ostrea* renders it necessary that the *Isastræa Murchisoni* should be included in the zone of *Ammonites angulatus*, and shows that, like the Madreporaria from Brocastle, it existed before the fauna of the *A. Bucklandi* or *Gryphæa-incurva* beds.

Very lately numerous Madreporaria have been found in Lincolnshire, at Marton near Gainsborough, in strata between the White Lias and the *Gryphæa-incurva* beds*. The species are not the same as those of the Brocastle and Sutton series: one of them, *Septastræa Fromenteli*, Terquem et Piette†, is found in the zone of *Ammonites planorbis* of Volfsmuhl near Mondorf; and the others are *Montlivaltiæ* of the *M. Haimei*‡ type, and rather characteristic of the Lias below the zone of *Gryphæa incurva*. The commonest of these *Montlivaltiæ*, *M. papillata*, Duncan, is also found in the Irish beds (Angulatus-zone) with *M. Haimei*, Chapuis et Dewalque§.

The *Montlivaltiæ* called by M. de Fromentel *M. tenui-septa* and *M. granigera* || are found at Balderton, near Newark¶; they cannot be considered to be anything more than varieties of *M. Haimei*, but they may be regarded as denoting a good coralliferous horizon. At Shepton Mallet, discoid *Montlivaltiæ* of the *M. Haimei* type occur; but the correct geological horizon of Balderton and the bed at Shepton requires elucidation.

In the section given by Dr. Wright of the zone of *Ammonites planorbis* at Street**, the light-coloured marly clay on the top, with Saurian bones and *Ammonites planorbis*, is succeeded by a light-coloured limestone with *Ammonites planorbis* in moulds; and immediately beneath this is a yellow shale with the same Ammonite, *Ichthyosaurus intermedius*, and a coral. Dr. Wright has sent me the specimen; and it is not *Isastræa Murchisoni* as is stated in his memoir, but a species he has named *Haimei*, which does not belong to *Isastræa*, but to *Septastræa*.

At Binton there are said to be corals in the Guinea-bed, which is covered by a succession of clays and limestones with *Modiola minima*, *Pholidophorus Stricklandi*, Ag., insect-remains, *Ammonites Johnstoni*, and Saurian remains; unfortunately I have not been able to obtain any specimens. The only Madreporarian of our *Ammonites-planorbis* zone is therefore *Septastræa Haimei*, Wright,

* The Rev. T. Chamberlin, F.G.S., and F. M. Burton, Esq., F.G.S., have afforded me information on these points, and have sent me the fossils for examination.

† Le Lias inférieur de l'est de la France, p. 129.

‡ Mr. R. Tate, F.G.S., informs me that the strata contain the fossils of the *Ammonites-angulatus* zone.

§ Mr. Tate has forwarded me specimens.

|| Paléont. Franç. livr. 10. p. 112.

¶ The Rev. Mr. Chamberlin and Rev. P. B. Brodie have forwarded specimens of these forms.

** Wright, Mon. Pal. Soc. vol. for 1863, p. 55.

sp. It is not to be found in the Sutton Stone, nor in the Southerndown or Brocastle beds, and it has not been discovered in any of the continental strata which are presumed to be the equivalents of the *Ammonites-planorbis* zone in Great Britain.

There are three species of *Montlivaltia* in the White Lias, but they are indeterminable.

The *Avicula-contorta* beds at Beer Crowcomb were found by Mr. Moore to contain a *Montlivaltia* with five cycles, but nothing more could be made of it. As far as it is possible to judge, none of these *Montivaltiæ* resemble those of the Sutton Stone or Brocastle beds. The succession of rocks from the Trias to the top of the Planorbis-series is complete; and consequently, from stratigraphical and palæontological data, the coralliferous beds at Sutton and Brocastle cannot be intercalated amongst them. It is therefore necessary to determine the continental equivalents of the beds under consideration.

6. *Strata in France and in the Duchy of Luxembourg which have the homotaxis of the Brocastle, Ewenny, Sutton, and Southerndown series.*—In Normandy there is a considerable development of beds which rest more or less upon depressions in quartzite rocks and upon the Trias, and which are covered, conformably in some places, but unconformably in others, by the Lias with *Gryphæa incurva**. These beds occupy, in the east of the Cotentin, two small basins, which are separated by the ridge of the quartzite rocks of Montebourg; and they can be traced to rest conformably on the Trias, and partly on the granitic surface. The beds have been classified in three divisions by M. Deslongchamps. The lowest are sandstones and dolomites with impressions of plants; the fossils are few in number and are badly preserved; and *Mytilus minutus* occurs, with imperfect specimens of *Avicula contorta*. The middle are marls, with *Mytilus minutus*, *Mytilus liassinus*, Tqm., *Ostrea anomala*, Tqm., *Diademopsis seriale*. The upper beds (the Calcaire de Valogne), consist of two series: the lower contains *Cardinia concinna*, *Cardinia regularis*, Tqm., *Lima Valoniensis*, Defr., *Pecten Valoniensis*, Defr., *Ostrea anomala*, *Plicatula Baylei*, Tqm., *Hettangia securiformis*, Tqm., *Pleurotomaria cœpa*, Desl.

The upper series has a lumachello with small Gasteropods at its base. The following is a list of the specific forms:—

Neritina arenacea, *Tqm.*
—— Hettangensis, *Tqm.*
Turritella Dunkeri, *Dunk.*, sp.
—— Zenkeni, *Dunk.*, sp.
Cerithium acuticostatum, *Tqm.*
—— Jobæ, *Tqm.*
Phasianella nana, *Tqm.*
—— Morencyana, *Piette.*
Plicatula Baylei, *Tqm.*
Ostrea anomala, *Tqm.*
Septastræa excavata, *de From.*
Thecosmilia, sp.
Melania unicingulata, *Tqm.*
—— usta, *Tqm.*
Ampullaria gracilis, *Tqm.*
Hettangia securiformis, *Tqm.*
Cardinia copides, *de Ryckh.*
Montlivaltia, sp.

The uppermost beds in the Calvados contain *Cardinia copides*; and their upper surface is extremely hard, and more or less

* Deslongchamps, Mem. Soc. Linnéenne de Normandie, vol. xiv., 1864.

covered with sulphide of iron. The surface is much worn and perforated, and is covered by alternations of clays and marls, which lie unconformably on it, and contain *Gryphæa incurva*, *Nautilus striatus*, and *Lima gigantea*. It will be noticed that *Septrastræa excavata*, one of the Brocastle Madreporaria, is grouped in Normandy with the Gasteropoda which are associated with the coral-fauna of the Brocastle beds. The *Thecosmilia* mentioned above has its representative species at Brocastle, and probably at Cowbridge. The Calcaire de Valogne has the homotaxis of Brocastle to a certain extent.

In the Department of the Côte d'Or*, the highest member of the Infra-Lias differs lithologically from the Gryphæa-limestone above it; this Foie de Veau, or the zone of *Ammonites Moreanus*, lying beneath the Gryphæa-limestone, has a varied mineralogical composition. In some places there are calcareous marls with grains of quartz, or black marls, schistose and brittle, and compact nodular limestone. The yellow marls of the zone are generally unfossiliferous; but the blue argillaceous limestone contains many fossils, which weather out of a yellow colour. The following species of Madreporaria are found in the Foie de Veau:—

Montlivaltia Sinemuriensis, *d'Orb.*	Isastræa Sinemuriensis, *de From.*
—— Martini, *de From.*	Stylastræa Sinemuriensis, *de From.*
Thecosmilia Martini, *de From.*	—— Martini, *de From.*
Septastræa excavata, *de From.*	Astrocænia Sinemuriensis, *d'Orb.*, sp.

The following section at Vic de Chassenay refers to the upper part of the Infra-Lias or the Foie de Veau:—

Calcaire à Gryphées arquées.	
Yellow marls without fossils.	
Blue argillaceous limestone	Littorina clathrata, *Desh.* Turritella Dunkeri, *Dunk.*, sp. —— Deshayesi, *Tqm.* Pleurotomaria Anglica, *Sow.* Cardinia sublamellosa, *d'Orb.* Lima gigantea (*var.* edule), *d'Orb.* Pecten Valoniensis, *de Fr.* Montlivaltia Sinemuriensis.
Yellow unfossiliferous marls.	
Blue-grey argillaceous limestone...	Ammonites Moreanus, *d'Orb.* Littorina clathrata, *Desh.* Turritella Deshayesi, *Tqm.* Cerithium Semele, *D'Orb.* —— gratum, *Tqm.* —— acuticostatum, *Tqm.* Thecosmilia Martini, *de From.* Stylastræa Sinemuriensis, *de From.* —— Martini, *de From.* Astrocænia Sinemuriensis, *D'Orb.*, sp.
Unfossiliferous marl.	

* Martin, Pal. strat. de l'Infra-lias, &c., 1860.

LUMACHELLO.

In the Lumachello, or the zone of *Ammonites Burgundiæ*, a large coral, in the form of a cast, has been named *Isastræa basaltiformis*. The arkose, or zone of *Avicula contorta*, beneath the Lumachello is uncoralliferous. By examining these lists the affinities between the faunæ of Brocastle and the Sutton series, and of the upper zone of the Infra-Lias of the Côte d'Or, are readily seen. The similarity of the lithological conditions is also remarkable.

In the duchy of Luxembourg the following succession of beds is seen *:—

Lias ...	1. Calcaire à Gryphées arquées.
	2. Grès calcareux.
	3. Calcaire graso-bitumineux.
	An unconformability exists here.
Keuper	4. Crystalline grits,
	5. Coloured marls.

The Grès calcareux immediately beneath the Calcaire à Gryphées arquées consist of three beds. The lowest is unfossiliferous; and the uppermost is either unfossiliferous or presents a bed full of *Lima Fisheri*, or sands with lignites. The middle bed is highly fossiliferous, and contains amongst others the following species :—

Littorina clathrata.
Turritella Dunkeri.
Turritella Zenkeni.
Phasianella nana.
Cerithium gratum.
—— acuticostatum.
Neritopsis exigua.
Cardinia regularis.
Cardita Heberti.
Gervillia acuminata.
Lima compressa.
—— tuberculata.
Spondylus liassinus, *Tqm.* (Plicatula intusstriata, *Em.*)
Ostrea irregularis.
Isastræa Sinemuriensis.

The limestone beneath, with *Lima punctata* and *Ostrea leviuscula*, Münst., rests upon the bone-bed.

The relation of this fauna to that of South Wales is very remarkable.

The Calcaire de Valogne, with the beds between it and the Trias or Granite, the Foie de Veau, the Lumachello beneath, and the Arkose above the Trias, the Grès calcareux of Luxembourg and Hettanges, with their associated bituminous limestones, lower marls, and bone-bed resting unconformably on the grits and marls of the Keuper, have much in common. They are lithologically distinct from the Trias beneath, and from the beds containing *Gryphæa incurva* above. The Calcaire de Valogne is unconformable with the Gryphæa-limestone, and the bone-bed of Luxembourg is unconformable to the Keuper. The sequence of their beds is exact, and a great number of their species are identical. They have a peculiar fauna, and, as might be anticipated, some species which have a great range; and a certain number pass upwards into the *Gryphæa-incurva* beds. These species are sufficiently numerous to connect the strata as parts of one formation; but it is very evident that the fauna of the highest beds of these series have great mutual resemblances,

* Terquem, Pal. de Hettange, 1855.

and present a distinction, both in species and genera, from those considered characteristic of the superimposed beds containing *Gryphæa incurva*, &c.

In the Brocastle conglomerate, and in the Southerndown and Sutton series, the lithological distinctions and specific resemblances of the French and Luxembourgian series are observable. The number of species common to all may be well seen in the following table:—

Table of the Distribution of the Species.

	Sutton Stone.	Southerndown.	Brocastle.	*Ammonites-planorbis* zone.	Calcaire de Valogne.	*Ammonites-Burgundiæ* zone.†	*Ammonites-angulatus* zone.†	Luxembourg Grès calcareux.	Azzarola.
Septastræa excavata *de From.*	...	...	*	...	*	...	*		
Montlivaltia polymorpha, *Terq.*	*	...	*	...	...	...	*		
—— pedunculata, *Dunc.*	*	...	*						
Isastræa Sinemuriensis	...	...	*	...	...	...	*		
Thecosmilia Martini, *de From.*	...	...	*	...	*	...	*	...	?
—— Michelini.									
Astrocænia gibbosa, *Dunc.*	*	*	*	...	...	...	*	...	*
Cerithium acuticostatum, *Terq.*	...	...	*	...	*	...	*	*	
—— gratum, *Terq.*	...	...	*	...	...	*	*	*	
—— Semele, *d'Orb.*	...	...	*	...	...	*	*		
Turritella Dunkeri, *Dunk.*, sp.	...	...	*	...	*	...	*	*	
—— Zenkeni, *Dunk.*, sp.	...	...	*	...	*	...	*	*	
Littorina clathrata, *Desh.*	...	*	*	...	...	...	*	*	
Phasianella Morencyana, *Piette*	...	...	*						
Neritopsis exigua, *Terq.*	...	...	*	...	...	...	...	*	
Gervillia acuminata, *Terq.*	...	...	*	...	...	...	*	*	
Ostræa irregularis, *Münster* (O. liassica, *Strickland*)	*	*	*	*	...	*	*	*	
—— multicostata, *Münst.*	*	*	*	...	...	...	...	...	*
—— anomala, *Terq.*	*	...	*	...	*				
Lima tuberculatata, *Terq.*	*	...	*	...	...	*	*	*	
Cucullæa Hettangiensis, *Terq.*	...	...	*	...	...	...	...	...	*
Cardita Heberti, *Terq.*	...	...	*	...	...	...	*	...	
Lima exaltata, *Terq.*	*	...	...	...	...	...	*	*	
—— dentata, *Terq.*	*	...	...	...	...	...	...	*	
Cardinia regularis, *Terq.*	*	...	...	...	*	*	*	*	
Plicatula intusstriata, *Emm.*	*	*	...	*	...	*	*	*	*
Myophoria postera, *Quenst.*	*	...	...	...	...	...	...	...	*
Monotis decussata, *Münst.*	*								
Cardinia concinna	...	...	...	*	*	*	*		

The Madreporaria, scanty in the lower strata of all the Liassic deposits immediately above the Trias, become more common in the beds just below the Gryphæa-limestone. This is a feature in Great Britain as well as elsewhere; and the coral-fauna of Sutton and Brocastle contains species in common with that of the Foie de Veau, the zone of

† Côte d'Or.

Ammonites angulatus in the east of France, and the Calcaire de Valogne, besides representative and allied species. It will have been noticed that the corals whose species are identical or common are accompanied in all these series by the same species of Gasteropoda and Bivalves. There is therefore a great general similarity of arrangement.

7. *The geological position of the Brocastle, Ewenny, Sutton, and Southerndown series.*—The similarity of arrangement noticed above justifies the correlation of the Brocastle conglomerate, the Ewenny Limestone, and the Southerndown and Sutton series with the Calcaire de Valogne, the Foie de Veau, or the zone of *Ammonites Moreanus*, and the Grès calcareux. It is well known that these continental beds form the upper part of the Infra-Lias. Since the strata just mentioned are superimposed on the equivalents of the *Ammonites-planorbis* zone of England, the Welsh fossiliferous beds resting on Mountain-limestone must be higher in the geological scale than this zone. Situated, then, without any direct stratigraphical relation with any member of the *Ammonites-planorbis* zone, the Sutton, Southerndown, and Brocastle beds form part of one province, and are the representatives and equivalents, lithologically and palæontologically, and in a positive as well as in a differential sense, of the beds included in the zones of *Ammonites angulatus* and *A. Moreanus* —the Hettangian.

Dr. Wright* remarks upon the imperfection of the zone of *Ammonites angulatus* in England as follows:—"The zone of *Ammonites angulatus*, so far as it has been exposed, appears to be imperfectly developed in the British Isles; and from the difficulty experienced in separating its beds from the Bucklandi-series, they are grouped with the latter in my memoir." He proceeds, "This zone was well exposed in the Harbury cutting near Warwick, although very few Mollusca besides *Ammonites angulatus* were obtained." He notices the zone in Yorkshire, Gloucestershire, and in the north of Ireland.

The following scheme of the succession of strata in Great Britain between the *Ammonites-Bucklandi* zone, or the true Lower Lias, and the Keuper is probably consistent with truth:—

Lower Lias.—*A. Bucklandi, A. Conybearii, Gryphæa incurva* (type).

Infra-Lias.	Upper zone.	Fossiliferous dolomitic limestones with a large fauna of Madreporaria, Gasteropoda, and Lamellibranchiata,—Brocastle, &c., Southerndown (Sutton). Astrocœnia-beds = zone of *A. Moreanus* and the Calcaire de Valogne, &c. Lincolnshire beds, zone of *A. angulatus* (Wright).	
	Middle zone.	*A.-planorbis* zone (Wright). *Septastræa Haimei* = zone of *A. Burgundiæ* of the Côte d'Or. White Lias in part.	
	Lower zone.	White Lias in part. *Avicula-contorta* beds. Marls above the Keuper (Dawkins)	Rhætic (Moore.)

Keuper.

* Mon. Pal. Soc. for 1863.

It must be admitted that the terminology is somewhat objectionable; but most of the ablest palæontologists of Europe have agreed upon the term "Infra-lias," and we cannot do better, now that the upper member of this very natural subdivision occupies the position of a great and special coral-province, than accept it. Considering that the beds which now form the upper part of the Infra-lias in Wales are full of Madreporaria, they may well be termed the *Astrocœnian* beds, on account of the predominance of specimens of that genus.

An objection may be raised, but cannot be maintained, against separating these beds from the true Lower Lias, on account of certain species being common to both. Doubtful specimens of *Gryphæa incurva* are now and then met with in the Brocastle beds, and they have been recognized in the upper beds in some sections of the Foie de Veau. One specimen from Brocastle has the laminate fossilization of the species, and a trace of the lateral groove which peculiarizes typical *Gryphæa*.

Cerithium Semele ranges from the *Avicula-contorta* zone of France through the whole of the Infra-lias, and is found in the true Lower Lias. There is no doubt that *Plicatula intusstriata* ranges upwards into the Lower Lias. The common Pentacrinite* of Ewenny and Brocastle is found also in the Lower Lias. It will of necessity be found that many species considered peculiar to, and characteristic of, strata in one locality have a greater range in others†. The relation of the bulk of the species of the Infra-lias and of those of the Lower Lias must be considered, and it is impossible to draw strict and artificial lines to serve the purposes of classificatory geology, since nature has always been progressing and has never stood still.

The subdivision of the Infra-lias forms part of the great Liassic formation, and does so because there are species which connect and link together the successive beds; but the evidences of unconformability, lithological differences, and of considerable but not perfect palæontological breaks do not permit the Infra-lias to be classified with the zone of *A. Bucklandi*‡.

* *Pentacrinus tuberculatus*, Mill. A species also found in the Middle Lias is noticed as well.

† Terquem et Piette and Martin have given very long lists of fossils from the various zones of the "Infra-lias;" and a comparison of these tabulated lists shows in the most unequivocal manner that the same species may have a different vertical range in rocks not very distant, geographically speaking. Thus *Montlivaltia Haimei* is found in the *Ammonites-planorbis* zone of Jamoigne, but has not been discovered lower than the highest beds of the *A.-angulatus* zone in the east of England. *Lima gigantea*, Desh., and *Nautilus striatus*, Sow., will be found to have a very different range from that usually admitted by palæontologists, who make them distinctive of a special horizon in Great Britain.

‡ Terquem et Piette, in their latest memoir, which is one of the most elaborate palæontological works ever produced, give the following results of their analysis of the species of the different zones they had examined (Le Lias inférieur de l'est de la France, 1865):—The Planorbis-zone contained 67 species, of which 9 were special to the zone, and 58 passed upwards. The zone of *A. angulatus* contained 325 species, of which 58 were noticed in the zone below, and two-thirds pass upwards into the zone of *A. bisulcatus* (*A. Bucklandi*). The authors state that this is the result of their own work; and they refer to the labours of other palæontologists to prove that the species "réellement caracté-

8. *Distribution of the* Madreporaria *from the Keuper to the* Ammonites-Bucklandi *beds.*—Before the discovery of the Madreporaria of the Infra-lias of Wales, it might have been very correctly asserted that the coral-fauna of the strata between the Keuper and the zone of *A. Bucklandi* was poor in the extreme, and that it bore no relation, as regards the number of its species, to the associated molluscan fauna.

The 26 new species found at Brocastle added to the 7 new species of the Sutton series form a large fauna special to the British Infra-lias. To these must be added the 5 species common to the Brocastle beds and the zone of *Ammonites Moreanus* in the Côte d'Or and its equivalent beds, and the interesting species, 3 in number, which give such a Triassic facies to part of the Sutton-Stone Madreporaria. Taken as a whole, the 40 species from these limited British beds are numerically more important than the Madreporaria of the British Upper Oolite; and no other Liassic strata yield forms sufficient for an approximative comparison. Although there are many species which are not common to the Brocastle and Sutton beds, still the facies of both collections are much alike, and the small *Montlivaltiæ* and *Thecosmiliæ* are closely allied. There is not a greater difference between the two collections of species than might be expected between those occupying the base and those of the higher parts of a very considerable and highly fossiliferous limestone. The *Astrocœniæ* are all closely allied; and the Triassic species, alone, form a ground for asserting a difference.

MM. d'Orbigny, Terquem, Piette, and de Fromentel have named species from the strata between the Trias and the zone of *Gryphæa incurva* in France; and, as has been noticed, five of the species found in the upper part of the Infra-lias have been discovered in the Brocastle conglomerate.

The following are the species of the French Infra-lias:—

1. Montlivaltia Sinemuriensis, *d'Orb.*
2. —— Martini, *de From.*
3. —— discoidea, *Tqm. et Piette.*
4. —— Haimei, *Ch. et Dew.**
5. —— polymorpha, *Tqm. et Pi.* †
6. Thecosmilia Martini, *de From.* †
7. —— Michelini, *Tqm. et Pi.* †
8. —— coronata, *Tqm. et Pi.*
9. Septastræa Fromenteli, *Tqm. et Pi.**
10. Septastræa excavata, *de From.*†
11. Isastræa basaltiformis, *de From.*
12. —— Condeana, *Ch. et Dew.*
13. —— Sinemuriensis, *de From.* † *
14. Stylastræa Sinemuriensis, *de From.*
15. —— Martini, *de From.*
16. Astrocænia Sinemuriensis, *d'Orb.*, sp. ‡
17. —— clavellata, *Tqm. et Piette.*

All these French species are rare.

Very probably *Isastræa basaltiformis* of the zone *A. Burgundiæ* in the Côte d'Or, the equivalent of the zone of *A. planorbis*, is closely

ristiques" of the zone of *A. angulatus* are very numerous. The zone of *A. bisulcatus* contained 57 special forms and 177 species found in the beds below, addition to 140 which pass upwards.

* In the *A.-angulatus* zone of England, but not in Glamorganshire.

† These species are also found in the South Wales (Glamorganshire) beds.

‡ This species is hardly sufficiently diagnosed to distinguish it from the numerous Astrocænians of the Glamorganshire beds; like *A. Oppeli*, Laube, it is too generic in its determination. I have therefore been obliged to remove these two species from the British list; but nevertheless *A. reptans*, nobis, may turn out to be *A. Sinemuriensis*, d'Orb., sp.; and *A. gibbosa*, nobis, has much in common with, but some structural distinctions of importance from, *A. Oppeli*, Laube.

allied to *Septastræa Haimei*, Wright, sp., of Street; for the genus may readily be mistaken in such a cast as that from which the species *S. basaltiformis* was determined.

Our White Lias has produced three species of stunted *Montlivaltiæ*: not one of them is accurately determinable; but the outsides of the forms are rugged and ridged.

As yet only one species has been found in the British *Avicula-contorta* zone, namely a *Montlivaltia* with five cycles of septa, but apparently indeterminable specifically; and the Rhætic beds of France and the Duchy of Luxembourg have not yielded a single form.

A very different state of things occurs in Lombardy, where the coral-fauna of the formation of Azzarola almost rivals that of Brocastle in its number of species, but far surpasses it in the extent of its area*.

Associated with a great molluscan fauna peculiar to the formation, and with many species of shells common to other strata, and situated low down in the Infra-Lias, is a very interesting series of Madreporaria, which has a decidedly Infra-liassic facies and is not very deficient in Triassic types.

The Madrepore-bed, as it is termed by Stoppani, is seen above the Azzarola beds with *Cardium Rhæticum, Myophoria inflata, Mytilus Psilonoti, Avicula contorta, Terebratula gregaria*, &c. wherever the succession of the rocks can be made out, either on the south-east slopes of the Alps, as on the Lake of Como, or on the north-west slopes to the south of the Lake of Geneva. The Madrepore bed is described, moreover, as occurring below and in the midst of the Azzarola beds, and as forming a dense layer of 8 or 10 yards in thickness. The prevailing species is a branching form called *Rhabdophyllia Langobardica*. M. Stoppani describes many species from this bed, and has had his types carefully drawn. Without any disrespect for his opinion, I have suppressed 12 of his species on account of their having been founded on casts of corals, whose generic determination even is hardly possible. It would appear that his genera *Lepiconus* and *Pyxidophyllum* are described from casts of *Montlivaltiæ* and *Thecosmiliæ*, whose original hard parts have been dissolved away. Two of his species of *Stylina* are taken from casts; and the figures of them greatly resemble the casts of *Astrocœnia gibbosa*, which are common enough in the Sutton Stone. A *Cyathophyllum* he describes is clearly a fragment of a long *Montlivaltia*, and the *Trochocyathus* has none of the essential characteristics of the genus as established by its founder. The *Rhabdophylliæ*, if they can be permitted to remain in that genus, are the most important species; they resemble in their habit of growth many *Thecosmiliæ*, and form great masses of tangle, like *Thecosmilia Martini* of the Côte d'Or and the *Thecosmiliæ* of Cowbridge and Brocastle.

The following are the species selected from M. Stoppani's studies:—

Rhabdophyllia Sellæ.	Stylina Savii.
—— Langobardica.	Thamnastræa Batarræ.
—— Menighini.	—— Escheri.
—— de Filippi.	—— Meriani.
Montlivaltia Gastaldi.	—— rectilamellosa (*Winkl.*).

* Stoppani, Monog. des. foss. de l'Azzarola.

This coral-fauna is evidently on a lower geological horizon than that of the Sutton Stone and of Brocastle, but its species have the same general facies as those of the Infra-lias of England and France; and the *Thecosmiliæ* and *Montivaltiæ* of the zone of *Ammonites Moreanus* and of the Welsh beds are the representatives of the branching and simple corals of the coral-zone of Lombardy. It is interesting to find that the Madreporaria abound at the base and at the upper part of the Infra-liassic series, that they do not appear to be associated with Ammonites, except rarely, and that as a whole the coral-fauna of the Infra-lias is more distinct from that of the true Lower Lias than the coral-fauna of any one of the Oolitic beds is from that of another.

The species are numerous, and the specimens whence they were determined are, generally speaking, plentiful; but they do not indicate such a vigorous growth as is now noticed in the tropics. The branching forms associated with solitary forms and small caliced compound Astræans denote a warm-temperate climate, and both deep water and a neighbouring shallow sea—that is to say, if the present coral-fauna can be reasonably compared with those of the past.

The Madreporaria of the Infra-lias are distributed as species in the following manner:—

Brocastle, Ewenny, Cowbridge, &c., Sutton and Southerndown, Marton, Lincolnshire, Skye	44 species.
Ammonites-angulatus zone in France and Duchy of Luxembourg...	16 species.
Ammonites-planorbis zone, England and France &c.	4 species.
White Lias	3 species.
Azzarola beds	10 species.
Avicula-contorta beds (British)	1 species.

Two of the species of the *Ammonites-planorbis* zone (*Montlivaltia Haimei* and its varieties, and *Septastræa Fromenteli*) pass upwards and are found at Marton; and five species from the foreign *A.-angulatus* zone are found in South Wales. Three Triassic species ascend to the Sutton Stone.

There would thus appear to be 39 species peculiar to the British Infra-liassic coral-fauna.

9. *Conclusion.*—It would appear, from the facts and opinions submitted in this communication, that the fossiliferous beds of Sutton, Southerndown, Brocastle, and Ewenny contain so many species of Madreporaria that they become important members of the series which, being placed between the Keuper and the Lias containing *Ammonites Bucklandi*, has been named the Infra-lias, that the Mollusca and certain well-known species of Madreporaria which are grouped together at Brocastle have similar relations to each other in the Calcaire de Valogne, in the zone of *Ammonites Moreanus* of the Côte d'Or, in the *A.-angulatus* zone of the east of France, and in the Grès de Luxembourg, and that the above-mentioned beds in Wales constituting a coralliferous horizon are the equivalents of the upper beds of the French and Luxembourgian Infra-lias; that the Madreporaria of the zone of *Ammonites planorbis* in England and those of

the equivalent zone of *A. Burgundiæ* in France are very few in number; that the Azzarola strata in Lombardy containing *Avicula contorta* have a great Madrepore-bed whose species, although differing from those of the higher members of the Infra-lias, possess the general facies of the fauna; and that the Madreporarian fauna of this period, although rich in individuals and species, does not appear to have been luxuriant.

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3. *On some* Points *in the* Structure *of the* Xiphosura, *having reference to their relationship with the* Eurypteridæ. By Henry Woodward, Esq., F.G.S., F.Z.S., of the British Museum.

[Plates I. & II.]

So long since as 1849 * Professor M'Coy made the proposition to unite in one tribe of the order Entomostraca the recent and fossil Limulidæ and the extinct species of *Pterygotus* and *Eurypterus*. "The tribe Pœcilopoda," he observes, "are to be distinguished from other Entomostraca by having crustaceous, didactyle, ambulatory thoracic feet, as well as membranous, respiratory abdominal ones." Professor M'Coy divides the Pœcilopoda into two divisions:—1. Limulidæ—*Limulus*; and 2. Eurypteridæ—*Eurypterus, Pterygotus,* and *Belinurus*. He subsequently furnished a restoration of *Pterygotus problematicus*, in illustration of his view of the anatomy of this ancient fossil remain †.

It is not surprising that Professor M'Coy should have failed to establish this order, since it was shown by Professor Huxley ‡ to be founded upon an erroneous interpretation of the fossil remains; nor can it be doubted that the arrangement was based on conjecture rather than upon any minute acquaintance with the anatomy of these extinct forms of *Pterygotus* and *Eurypterus*, then only known in England by extremely fragmentary remains.

The researches, too, of Professor Huxley § into the anatomy and affinities of the genus *Pterygotus* (in 1859) do not favour M'Coy's view of their classification under a common order or tribe with *Limulus*, although he does admit that they possess several very important points of structure in common with the latter.

"The Pœcilopoda" (*i. e.* Limulidæ), observes Professor Huxley §, "are, I believe, the only Crustacea which possess antennary organs like those of *Pterygotus*, and, like them, have the gnathites converted into locomotive organs, want the appendages to the sixth abdominal somite, and present on some parts of the body a remotely similar sculpture. In this order, however, we find but a small labrum, a rudimentary metastoma, a very differently constructed body, and a

* Ann. & Mag. Nat. Hist. 2nd ser. vol. iv. pp. 393, 394.

† Lyell's Manual of Elementary Geology, 5th. edit. 1855, p. 40. fig. 543.

‡ "On the Anatomy and Affinities of the genus *Pterygotus*," Memoirs of the Geological Survey of Great Britain, Monograph I. (1859) p. 7.

§ *Op. cit.* p. 34.

large number of appendages, both thoracic and abdominal—characters which effectually preclude the association of the extinct Crustacea under discussion with this type."

Professor Huxley adds in a foot-note*, "If the abdominal somites of the Carboniferous *Belinurus* &c. were really free, they would present a certain approximation to the *Pterygoti*. Indeed the evidence that these Carboniferous Crustacea were true Pœcilopoda is to my mind anything but conclusive."

The later researches of Professor James Hall, State Geologist to the State of New York (U. S.) †, into the structure and affinities of *Eurypterus* have led him to the conclusion that a close affinity exists between *Eurypterus*, *Pterygotus*, and *Limulus*; and he also cites the opinion of Professor Agassiz ‡, "that the *Eurypteri* are closely related to *Limulus*, belonging even to the same order." . . . . "He regards the antennal system as entirely absent. The organs of locomotion belong to the cephalic region; and while externally they perform the functions of feet, they are, at the base, organs of manducation. The central organ [Pl. II. fig. 8, *a*], indicated as a locomotive appendage [' *operculum* ' of Professor Huxley (see Med. Times & Gazette, 1857), Professor Agassiz regards as similar to the appendage attached to the membranaceous feet, behind the swimming-feet of *Limulus* [Pl. II. fig. 7, *a*], and instead of being double, is anchylosed as in young *Limulus*" §.

Professor Nieszkowski || (in Russia) appears to have arrived, about the same time as Professor Hall (1859), at somewhat similar conclusions, only that he has made out a series of *three* thoracic membranous plates *all sculptured* upon their surface. This could not be the case, however, had they *overlapped* each other as in the recent *Limulus*; for surfaces that are covered by other overlying organs are destitute of ornamentation.

Much later (*i. e.* in 1863) I made an examination of these forms, and, without being thoroughly acquainted with the foreign bibliography of the subject, I arrived independently at the same conclusion with Professors Agassiz and Hall ¶. In 1864 and 1865 I continued my researches; and some of the results have already appeared in the Journal of this Society and elsewhere **.

Having devoted some time to the examination of the (so-called) fossil Limulidæ of the Coal-measures, I think I shall be able to show that we have evidence of some, at least, of the intermediate forms that were absolutely needed in order to establish a relationship be-

* *Op. cit.* p. 34.

† Nat. Hist. New York: Palæontology (1859), vol. iii. p. 393.

‡ *Op. cit.* p. 394. § *Op. cit.*

|| Archiv für die Naturkunde Livonia, Esthonia und Kurlands, 1st series, vol. ii. p. 299, pls. 1 & 2: Dorpat, 1859.

¶ See the Intellectual Observer for 1863 (vol. iv. p. 229).

** See (*a*) Geol. Mag. vol. i. p. 196, pl. x., and p. 239. See also (*b*) Lyell's Elements of Geology, 6th edit. (1865), p. 524, fig. 591. See also (*c*) Quart. Journ. Geol. Soc. 1865, vol. xxi. p. 482, pls. xiii. & xiv. See also (*d*) British Association Reports, 1864–65, Bath and Birmingham.

tween the Limulidæ of to-day and the extinct Eurypteridæ of Palæozoic times.

In *Pterygotus*, *Eurypterus* (see Pl. I. fig. 7, *Eurypterus remipes*), &c. the animal consists of a head, bearing a pair of minute larval eyes and a larger pair of subcentral or marginal compound ones, a pair of simple or chelate antennæ (Pl. II. fig. 9), furnished with gnathites in *Eurypterus* and *Slimonia* (Pl. II. fig. 10), three pairs of more or less slender spinous pedipalps, *never chelate*, and a pair of very broad and powerful swimming-feet (Pl. I. fig. 7, *e*), whose basal joints form powerful mandibles. In *Stylonurus* the two posterior pairs of appendages are converted into long and slender rowing-organs.

Following this compound head are twelve free segments, only the first two (?) of which bear appendages (Pl. II. fig. 8), the succeeding somites being apparently destitute of any. The twelve free segments are followed by a postanal plate or "telson," broadly lanceolate or bilobed in *Pterygotus* and *Slimonia*, and ensiform in *Eurypterus* and *Stylonurus* (Pl. I. fig. 7, T).

In *Limulus* (Pl. II. figs. 1 & 2) the head is composed of a broad buckler having the larval and compound eyes upon its superior or convex surface, and the mouth, surrounded by six pairs of chelate appendages, placed beneath the head-shield (Pl. II. fig. 6). The first pair of appendages is placed in front of, and the four succeeding pairs are posterior to the mouth. These latter are furnished with spinous gnathites, the most posterior pair serving as *maxillæ*.

Next follows the *operculum* or thoracic plate (Pl. II. fig. 7), which is attached to the posterior margin of the head, and bears upon its inner and upper surface the reproductive organs or ovaries (Pl. II. fig. 7, *r*).

The six anchylosed segments which compose the posterior portion of the body bear five lamellar appendages upon their under surface, similar in shape to the operculum, but more membranous; these support the gills, and are partially hidden beneath the operculum.

The body terminates in a long ensiform "telson," or tail-spine. The anterior portion here spoken of as the head has always been regarded as representing the cephalothorax, and the posterior portion as the abdomen; this latter I propose to call the thorax (*in part*), and to give my reasons for so doing as we proceed.

The great and apparent difference between *Limulus* (Pl. II. figs. 1 & 2) and *Eurypterus* (Pl. I. fig. 7) is, that in the latter one sees fourteen free segments or divisions, whilst in the former only three are visible. But if we examine *Limulus* attentively we can still trace in the posterior portion of its shell (Pl. II. figs. 1 & 2) indications of segmentation, whilst the presence of thirteen paired appendages indicates the coalescence of numerous segments.

The points of resemblance are:—the larval eye-spots; the adult subcentral eyes; the jaw-feet, serving as the sole locomotive organs, the basal joints in the posterior pair being especially fitted for manducation, and the posterior limbs for swimming; the analogous position of the opercular plate, covering, no doubt, in the fossil

Pterygotus, as in the recent *Limulus,* the reproductive organs, and succeeded, no doubt, in both, by similarly formed membranous appendages bearing branchiæ.

This latter point, I think, is established on the evidence of specimens both in the Museum of Practical Geology and in the British Museum, showing two opercular-shaped plates associated together (Pl. II. fig. 11) and evidently belonging to the same individual. One plate also exhibits two small rounded prominences, which, there can be little doubt, were ovarian openings.

If the head in *Limulus* be composed of the cephalothorax, and the posterior portion be the abdomen, then it follows that the opercular plate is thoracic, and the succeeding branchial plates are abdominal, thus differing widely from the fossil forms, in which the head is simply the head, with one thoracic segment added to it bearing the opercular plate; the branchiæ are thoracic, and the abdomen is entirely destitute of appendages.

Let it be granted, however, that the head in *Limulus* represents the entire cephalothorax and the posterior portion the abdomen; if specimens can be shown having a "postabdominal" series of segments, I think it will be conceded by all carcinologists that in *Limulus* the abdomen is rudimentary, as is the case in *Cyclops, Daphnia, Lernæa,* &c., and in the Brachyurous Decapods.

In 1864 I exhibited at the Bath Meeting of the British Association a form which I named *Hemiaspis* (Pl. I. fig. 3; and Quart. Journ. Geol. Soc. 1865, vol. xxi. p. 490, pl. xiv. fig. 7, *a, b*)*. We have in *Hemiaspis* a limuloid crustacean, having a head-shield, six free and moveable segments forming the thorax, and three very narrow, and apparently double, segments representing the abdomen, followed by a long and slender "*telson.*"

Since describing the above remarkable form, I have lately procured a paper, published at Dorpat, by Dr. J. Nieszkowski †, by which I have become acquainted with two new forms from the Upper Silurian of the Island of Œsel, which must be added to the list of forms allied to *Hemiaspis.* They are named by Dr. Nieszkowski *Pseudoniscus aculeatus* (Pl. I. fig. 5) and *Exapinurus Schrenkii* (Pl. I. fig. 6).

Professor Eichwald has described another, which, no doubt, is related to this group of Crustacea, namely *Bunodes lunula* (Pl. I. fig. 4). All these forms have *three* well-marked divisions to their bodies, of head, thorax, and abdomen; and all, save *Bunodes,* possessed a *telson,* or tail-spine, and free articulated thoracic somites.

Having been favoured with the loan of the very beautiful series of Coal-measure *Limuli* belonging to our Treasurer, J. Prestwich, Esq., F.R.S., and also with a series from the Broseley Institute, and

* I avail myself of this opportunity to correct an error in the description of *Hemiaspis limuloides.* The portion figured as *b* on the plate referred to, and described as the centre of the glabella, is in reality that of another species, the glabella in this species being nearly smooth, as in the figure given herewith, drawn from a specimen in the late Mr. H. Wyatt-Edgell's collection.

† *Op. et loc. cit.* pp. 380, 381; and p. 384, figs. 12–15.

a third suite from the collection of John Anstice, Esq., of Madeley Wood, Wellington, Salop, together with specimens from Mr. E. J. Hollier, of Dudley, and Mr. J. Farie, of Glasgow, I have, after careful study, concluded that they are divisible into *two well-marked genera*:—

(*a*) Those having moveable thoracic segments and anchylosed abdominal ones, to be included in the genus *Belinurus*, namely—

1. *Belinurus trilobitoides*, Buckl. Coal-measures, Derry and Coalbrook Dale.
2. —— *reginæ*, Baily (Pl. I. fig. 1). Coal-measures, Ireland.
3. —— *arcuatus*, Baily. Coal-measures, Ireland.
4.?—— *Danæ*, Meek & W. Coal-measures, Illinois, U.S.

(*b*) Those in which the thoracic and abdominal segments are not divided and in which the former appear to be anchylosed, to be included in a new genus, for which I venture to propose, if Mr. Prestwich will allow me, the name of *Prestwichia*; i. e.:—

1. *Prestwichia anthrax*, Prestw., sp. Coal-measures, Coalbrook Dale.
2. —— *rotundata*, Prestw., sp. (Pl. I. fig. 2). Coal-measures, Coalbrook Dale.

In all these six species the body consists of a head-shield, five free, or anchylosed, thoracic segments, and three anchylosed abdominal ones.

Here, then, we have an intermediate group between *Limulus* proper, more nearly approaching *Hemiaspis* &c., but having the posterior (or abdominal) segments anchylosed together, and not freely articulated as they appear to have been in *Hemiaspis* and *Pseudoniscus* &c. Furthermore the six free thoracic segments are reduced to five in *Belinurus* (Pl. I. fig. 2).

In the recent *Limulus* we find thirteen paired appendages, representing an equal number of somites, behind which there is seen one or more coalesced segments destitute of appendages, to the last of which the telson is articulated (see Pl. II. figs. 1 & 2, *Ab*.).

I feel no doubt that this apodal posterior portion of the integument in *Limulus* represents the abdomen, and corresponds with the three posterior coalesced segments forming that division in *Belinurus* (Pl. I. fig. 1, *Ab*.). The fossil species well illustrate the gradual coalescence of the body-segments in this family.

Belinurus reginæ, Baily (Pl. I. fig. 1) (Ann. & Mag. Nat. Hist. 3rd ser. (1863) vol. xi. p. 107, pl. 5), is one of the best illustrations of a Crustacean with free thoracic segments, and *Prestwichia rotundata* (Pl. I. fig. 2) of one in which the segments are coalesced. All the group possess, in the trilobed aspect and general facies of the carapace, a strong resemblance to the *Trilobitæ*; but this resemblance becomes still more striking when we observe their tripartite division into head, thorax, and abdomen.

Nearly all writers agree in considering the last seven somites (counting the "telson" as the seventh) to be abdominal; the only difference of opinion, then, is as to the anterior 14 segments—how many are cephalic and how many thoracic?

Dr. Dana* considers the head and thorax in the Crustacea to be always blended in a cephalothorax; but although this view is correct as regards the Decapoda, its applicability does not hold good in all the other orders of the class.

Professor Huxley† considers that the division in the Podophthalmia is marked by the cervical fold and by the sudden change in the character of the appendages of the sixth and seventh somites, and an equally marked similarity between the latter and those of the eighth and ninth somites.

According to this view, then, we shall have six cephalic, eight thoracic, and six abdominal somites; for Professor Huxley views the telson as a median appendage, and not as a true segment. I do not find, however, that this view is generally adopted by other carcinologists.

Assuming the old view of the Crustacean type to be correct, *i.e.* seven somites for the head, seven for the thorax, and seven for the abdomen (counting the telson as a terminal segment, on which point there is no doubt some uncertainty, seeing that in *Limulus* it is developed subsequently, though this is not the case in the Decapoda), we shall find that the first thoracic somite is united to the cephalon in *Limulus* (bearing the operculum), that there are only five other appendages to the thorax, making six with the operculum, and that there are no appendages to the abdomen.

Of the appendages belonging to *Belinurus, Prestwichia, Hemiaspis, Pseudoniscus, Exapinurus,* and *Bunodes,* I cannot speak with certainty, but can only infer, from the general similarity in their bodies of the first two genera to *Limulus,* and of the last four to *Eurypterus,* that they were constructed upon those types.

Turning from *Limulus* to *Pterygotus,* we find that Professor Agassiz regards the antennary system as altogether wanting (see *ante*, p. 29); but in this we cannot but think he is mistaken. Professor Huxley regards the chelate organs on the head of *Pterygotus* as the antennæ; and this opinion agrees well with subsequent discoveries in the fossil forms on the one hand, and with the nature of these organs in the recent *Limulus.* The antennules undergo no sexual variation in the living King-crabs, it is invariably the antennæ that are modified. (See Pl. II. fig. 5, antenna of male King-crab; fig. 6, antenna of female of same.)

Assuming the antennules to be absent, and the first pair of organs after the eyes to be the antennæ, we shall find the other organs to correspond most completely with *Limulus,* and that one thoracic segment is united to the head of *Pterygotus,* as in the former, and that it also bears the reproductive organs upon its coalesced membranous appendages.

The branchiæ would, however, be fewer in *Pterygotus* than in *Limulus,* but similarly placed—resembling in this respect the immature condition of the latter. (See Pl. II. fig. 4.)

* United States Exploring Expedition, 1852: Crustacea, vol. xiii. p. 21.

† "Lectures on the Crustacea," Medical Times and Gazette, 1857, p. 507.

In the development of the embryo of any of the Crustacea, whether before or after exclusion from the egg, the segments which form the body are developed in succession from before backwards; so that when their evolution is checked, the posterior rather than the anterior rings are those that are wanting; and, in fact, it is generally easy to see in those specimens of full-grown crustaceous animals whose bodies present fewer than 21 segments, that the anomaly is due to the absence of a certain number of the most posterior rings of the body. [See Milne-Edwards on the development of Crustacea.]

So long ago as 1838, Dr. Milne-Edwards * gave an account of an examination of the young of *Limulus* at the time of its extrusion from the egg. He found that, as regards the anterior portion of their bodies, they presented little difference from the adult; but the posterior portion had only three pairs of appendages; and the long styliform telson, so remarkable in the adult, did not exist at all. [See Pl. II. figs. 3 & 4.]

It is, then, I think, reasonable to assume that the absence of the normal number of segments in *Limulus* is due to the abortion or non-development of the hindmost abdominal somites rather than of those belonging to the other divisions of the body.

As to the union of two dissimilar parts, so as to leave no indication of their blending, there are numerous cases in the Cyclopoidea, as well as in other orders. In *Cyclops* the ovarian segment is double, being formed by the coalescence of the last thoracic and the first abdominal somites. In *Corycæus crassiusculus* eight segments unite to form the head, as is the case in *Limulus*—*i. e.* seven cephalic and one thoracic somites.

Taking the Eurypterida first, we find five genera and one subgenus, having a head bearing seven paired appendages, and (adopting Professor Huxley's view, that the antennules or inner antennæ are absent) representing eight segments (*i. e.* seven cephalic and one thoracic). Add to this the twelve free body-segments and the telson, and we have twenty-one, or the normal number of somites. With the exception of the two most anterior segments (which probably had branchial appendages attached to their under surfaces, concealed beneath the operculum or thoracic plate), all the free somites are destitute of limbs of any kind; and in this respect they strongly resemble the larvæ of the Decapoda †.

In *Hemiaspis* we have the body composed of a head, six thoracic and three abdominal somites, and a telson.

In *Exapinurus* and *Pseudoniscus* of a head, five thoracic and four abdominal somites, and a telson.

In *Belinurus*, a head, five thoracic and three abdominal somites, and a telson.

In *Prestwichia*, a head, five thoracic and three abdominal somites, and a telson.

* "Sur le développement des *Limules*," Société Philomathique, Nov. 10, 1838.

† See Mr. C. Spence Bate "on the Development of Decapod Crustacea," Phil. Trans. 1858, p. 589, pl. xl. figs. A & B.

In *Limuli* from Solenhofen and in the living *Limuli*, of a head composed of eight somites (one being thoracic), followed by five coalesced thoracic somites bearing branchiæ, and one or more coalesced abdominal ones, to which is articulated a long and pointed telson.

In proposing to associate the Eurypterida and Xiphosura as two suborders of the Merostomata of Dana*, I do not for a moment overlook the fact that they form two very distinct although closely allied groups.

Notwithstanding the great difference in the form of the body, concentrated and coalesced in *Limulus*, and elongated in *Pterygotus*, the Merostomata offer perhaps even less diversity of structure than do the Decapoda, the main feature in both being the same. Thus, in the Decapoda Brachyura (Crabs) we have the cephalothoracic segments concentrated in the highest degree, and the abdomen a *mere rudiment*. In the Decapoda Macrura (Lobsters), on the contrary, the abdominal segments are not unfrequently more than twice the length of the cephalothorax, and bulky in proportion.

Such forms as *Hemiaspis*, *Pseudoniscus*, &c. may very well represent the Decapoda Anomura, being, like them, intermediate between the long-tailed Lobsters and the short-tailed Crabs.

Few classes offer so remarkable an instance of longevity as the Crustacea, and few orders can be compared to the Xiphosura for persistency. The Jurassic forms appear to differ little, if at all, from those of our own day; and even those of the Carboniferous epoch were at once recognized as belonging to the same family.

Had *Limulus* represented a higher type of Articulata, it is hardly conceivable that it could have existed so long, and apparently unchanged. But it seems to have been one of those eccentric groups that appear from time to time in the zoological series, which, branching out into a by-way of its own, is checked from further onward progress; but being possessed of tenacity of life and great power of reproduction, it holds its ground whilst higher orders have been modified or swept away.

This is one very strong argument, to my mind, in favour of the higher zoological position of *Pterygotus*—that, being extremely larval in its anatomy, it consequently possessed the capacity for further development, and so has been modified and disappeared, *Eurypterus Scouleri* of the Coal-measures being its latest representative.

It is not uninteresting to notice the appearance of Scorpionidæ in the Coal-measures of Silesia, a form of Arachnida which to this day possesses a very remarkable resemblance to *Pterygotus*, both in its general shape and also in the arrangement of its organs.

But in *Scorpio* the respiration is aërial (*i. e.* by tracheæ), whereas in *Limulus* and *Pterygotus* it was undoubtedly aquatic (*i. e.* by branchiæ).

This would, however, be a perfectly parallel case to the change

* See my 'Monograph of the British Fossil Crustacea belonging to the order Merostoma,' Part I., in the Monographs of the Palæontological Society, for 1865. 1866.

which takes place in the respiratory organs of certain Amphibia, in which the branchiæ become replaced by a lung.

The following is a diagnosis of the

Order MEROSTOMATA, Dana, 1852.

Having the mouth furnished with mandibles and maxillæ, the terminations of which become walking- or swimming-feet and organs of prehension.

I. Suborder Eurypterida, Huxley, 1859.

Crustacea with numerous free thoracico-abdominal segments, the first and second (?) of which bear one or more broad lamellar appendages upon their ventral surface, the remaining segments being devoid of appendages; the anterior rings united into a carapace bearing a pair of larval eyes (*ocelli*) near the centre, and a pair of large marginal or subcentral eyes; the mouth furnished with a broad postoral plate, or *metastoma*, and five pairs of moveable appendages, the posterior of which form great swimming-feet; the telson, or terminal segment, extremely variable in form; the integument characteristically sculptured.

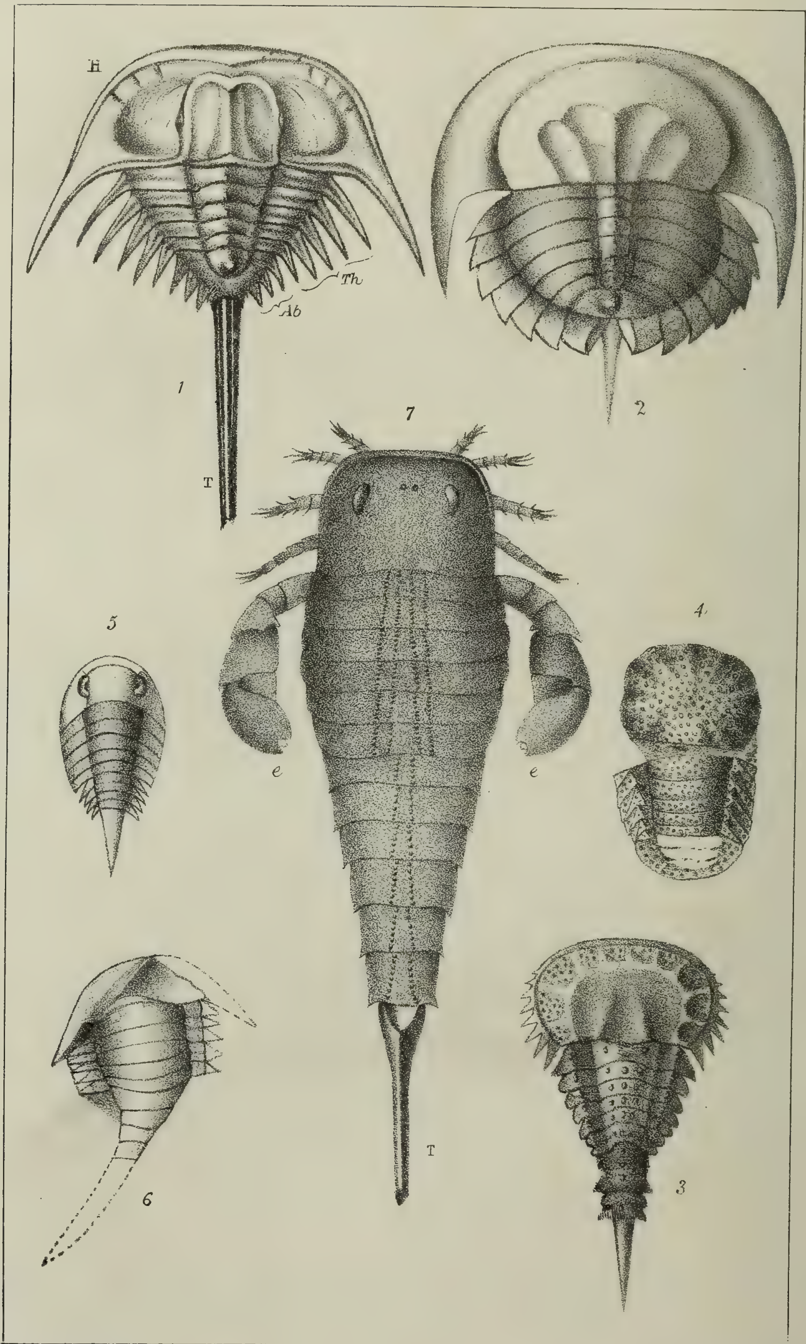
1. *Pterygotus*, Agassiz	16	species.
2. *Slimonia* (Page), H. Woodw.	3	,,
3. *Stylonurus* (Page), H. Woodw.	6	,,
4. *Eurypterus*, De Kay	22	,,
Subgenus *Dolichopterus*, Hall	1	,,
5. *Adelophthalmus*, Jordan	1	,,
6. *Bunodes*, Eichw.	2	,,
7. *Arthropleura*, Jordan	3	,,
8. *Hemiaspis*, H. Woodw.	6	,,
9. *Exapinurus*, Nieszk	1	,,
10. *Pseudoniscus*, Nieszk	1	,,
	62	

II. Suborder Xiphosura, Gronovan, 1764.

Crustacea having the anterior segments welded together to form a broad convex buckler, upon the dorsal surface of which the compound eyes and ocelli are placed, the former subcentrally, the latter in the centre in front; the mouth furnished with a small labrum, a rudimentary metastoma, and six pairs of moveable appendages. Posterior segments of the body more or less free, and bearing upon their ventral surfaces a series of broad lamellar appendages; the telson or terminal segment ensiform.

1. *Belinurus* (König), Baily	4	species.
2. *Prestwichia*, gen. nov.	2	,,
3. *Limulus*, Müller	15	,,
	21	

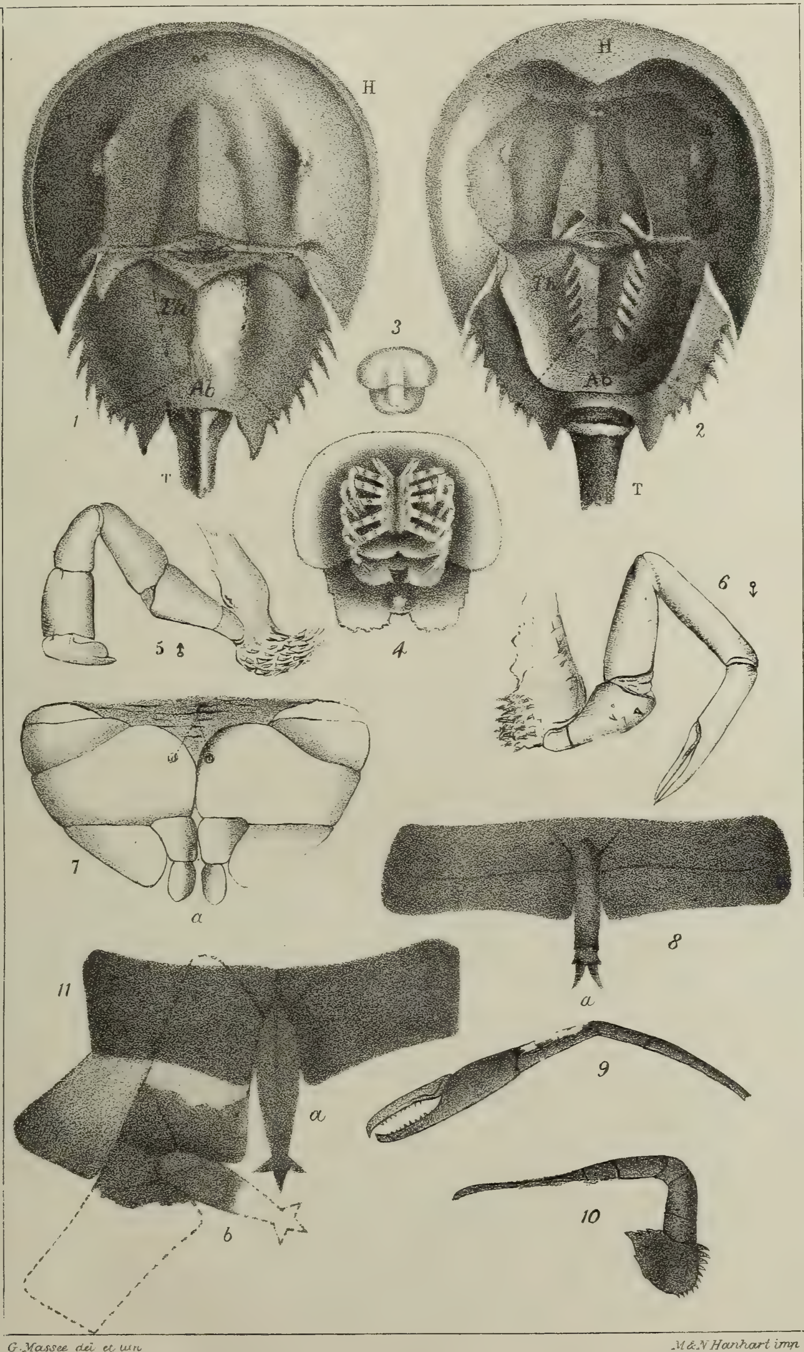
Of the Eurypterida, 49 species occur in the Upper Silurian, 18 in the Devonian, and 10 in the Carboniferous formation. Of the Xiphosura, 6 occur in the Carboniferous, 1 in the Permian, 1 in the



G Massee, del et lith

M & N Hanhart imp

PRESTWICHIA, BELINURUS, HEMIASPIS, &c.



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LIMULUS, EURYPTERUS, SLIMONIA, &c.

Trias, 7 in the Oolitic, 1 (doubtful) in the Chalk, and 1 in the Tertiary; and there are 4 recent species.

They occur living in the East Indies, in Japan, and on the east coast of North America—and fossil in North America, Great Britain and Ireland, Scandinavia, Russia, Poland, and Germany.

EXPLANATION OF PLATES I. & II.

Illustrative of the Structure of the Xiphosura *and* Eurypterida.

Plate I.

Fig. 1. *Belinurus reginæ**, Baily. Coal-measures, Queen's County, Ireland. H. = Head; Th. = Thorax; Ab. = Abdomen; T. = Telson.
2. *Prestwichia* (*Limulus*) *rotundata*, Prestw. sp. Coal-measures (Pennystone ironstone), Coalbrook Dale.
3. *Hemiaspis limuloides*, H. Woodw. Lower Ludlow shale, Leintwardine. (From the late Mr. H. Wyatt-Edgell's collection.)
4. *Bunodes limula*, Eichw. Upper Silurian, Isle of Œsel, Baltic.
5. *Pseudoniscus aculeatus*, Nieszk. Upper Silurian, Isle of Œsel, Baltic.
6. *Exapinurus Schrenkii*, Nieszk. Upper Silurian. Isle of Œsel, Baltic. (Figs. 4–6 are copied from Dr. Nieszkowski's paper in the Archiv für die Naturk. Liv-, Esth., und Kurl.-erste Serie, zweiter Bd. tab. ii. figs. 12, 13, & 15, pp. 378–382. Dorpat, 1859.)
7. *Eurypterus remipes*, Dekay. Upper Silurian, New York. (Copied from Hall's 'Palæontology of New York,' vol. iii. pl. lxxxiv. A. fig. 1.)

Plate II.

Fig. 1. Carapace of *Limulus polyphemus* (recent). East coast of North America. Showing the larval and compound eyes. H. = Head; Th. = Thorax; Ab. = Abdomen; T. = Telson.
2. Underside of same, showing indications of the coalesced thoracic and abdominal somites, and the processes for the attachment of the appendages.
3. The first stage of *Limulus* (young), dorsal aspect.
4. Underside of the same, enlarged (after Milne-Edwards).
5. Club-shaped antenna of male *Limulus*.
6. Chelate antenna of female *Limulus*.
7. Operculum of recent *Limulus*. *r*, reproductive apertures.
8. Operculum of *Eurypterus* (Hall).
9. Chelate antenna of *Pterygotus*.
10. Simple antenna of *Slimonia*.
11. Specimen from Lanarkshire in the British Museum collection (reduced to one-fourth), showing two thoracic plates of *Slimonia* associated together.

December 5, 1866.

C. J. H. Allen, Esq., F.Z.S., 4 Park Crescent, N.W.; Henry Pitts Cassidy, Esq., Engineering College, Poona; Robert Etheridge, Jun., Esq., of the Geological Survey of Victoria, Australia; Marshall Hall, Esq., 3 Cleaveland Terrace, Hyde Park, W.; Alfred Gutteres Henriques, Esq., F.Z.S., Stone Buildings, Lincoln's Inn, W.C.; Henry Lainson, Esq., Heath House, Reigate, Surrey; Dr. James Murie, 20 Regent's Park Road, N.W.; and John W. Pike, Esq., Mining Engineer, Mexico, were elected Fellows.

* Ann. & Mag. Nat. Hist. 1863 (3rd Series), vol. xi. p. 107, pl. v.

The following communications were read:—

1. A Description *of some* Echinodermata *from the* Cretaceous Rocks *of* Sinai. By P. Martin Duncan, M.B. Lond., Sec. G. S.

Contents.

1. *Introduction.*—The existence of Cretaceous rocks in the district of Sinai has been surmised for several years; but hitherto the correct geological denomination of the strata has not been ascertained. They have been simply termed Cretaceous; and, owing to the scarcity of fossils, they have not been correlated with any of the Asiatic formations.

An examination of the series of Echinodermata collected by the Rev. F. W. Holland, from the limestones of Wady Mokatteb and Wady Badera *, readily decides the geological age of the rocks, and enables them to be correlated with those red limestones in South-eastern Arabia whose fossils were described in a former communication †.

Had these Sinaitic Echinodermata been in my possession during the preparation of that communication, their study would have made it much more complete; but coming before my notice now, their examination presents several tests in reference to the correctness of my conclusions. It is satisfactory that this examination should strengthen all those conclusions, and that it should determine the presence of the same zone of Echinodermal life in Southern India, on the Nerbudda, in South-eastern Arabia, Sinai, Egypt, Algiers, and in North-western Europe. Moreover the remarks made upon the variability of the species described in the former communication receive additional strength, and the correctness of placing all the localities formerly noticed, with the Sinaitic chalk, in the Middle Cretaceous series, or in that which comprises the Cénomanien and Turonien stages, becomes apparent.

The few Echinodermata described by Desor and d'Orbigny from Sinai appear to be peculiar to that region; but all those collected by Mr. Holland are well-known forms, and are characteristic of the typical Upper Greensand of France, England, and Ireland.

The facies of the collection is that of the South-eastern Arabian and Bagh series; so that nothing can be more complete than the correspondence of the united Asiatic Echinodermata with those of the zones of *Pecten asper*, *Pygurus lampas*, *Scaphites æqualis*, *Ammonites navicularis* and *Ostrea columba* in North-western Europe.

2. *List of the species of Echinodermata.*—The following is the list of the Echinodermata from Wady Mokatteb and Wady Badera. The localities and zones of the accompanying fossils, where they are found elsewhere, are also given:—

* Quart. Journ. Geol. Soc. vol. xxii. p. 491, and note at the end of this paper.

† Quart. Journ. Geol. Soc. vol. xxi. p. 349.

1. *Pseudodiadema Rüppelli*, Desor. Egypt.
2. *Heterodiadema libycum*, Ag. & Desor, sp. Egypt. Batna in Algiers; Martigues, France. Zone of *Ostrea columba*. Martigues, France, below the zone of *Caprina adversa*.
3. *Holectypus excisus*, Desor, sp. Le Mans; Ile d'Aix. Zone of *Turrilites costatus* and *Pygurus lampas*.
4. *Periaster elatus*, d'Orb. Le Mans; Yvre l'Evêque. Zone of *Ammonites navicularis*.
5. *Hemiaster gracilis*, Cotteau. Yvre l'Evêque. Zone of *Ammonites navicularis*.
6. *Epiaster distinctus*, d'Orb. South-east Arabia, with *Hemiaster similis Cidaris cenomanensis* and *Pygaster truncatus*. Ireland; Cornes and Villiers, France. Zone of *Pecten asper* (upper part).

3. *List of the species already described from Sinai*:—

1. *Diplopodia Sinaica*, Desor, sp.
2. *Claviaster cornutus*, d'Orb.
3. *Pedina Sinaica*, Desor.

4. *List of the species from South-eastern Arabia*:—

1. *Cidaris cenomanensis*, Cotteau. Yvre l'Evêque. Zone of *Scaphites æqualis*.
2. *Pseudodiadema Roemeri*, Desor. Hildesheim.
3. *Salenia scutigera*, Gray. Warminster; Le Mans. Zone of *Scaphites æqualis*.
4. *Holectypus cenomanensis*, Guéranger. Texas; Le Mans. Zone of *Pygurus lampas*.
5. *Pygaster truncatus*, Agassiz. North Ireland; Condrécieux. Zone of *Pecten asper*.
6. *Epiaster distinctus*, d'Orb. Sinai; Ireland; Cornes. Zone of *Pecten asper*.
7. *Hemiaster similis**, d'Orb. Bagh; Le Mans. Zone of *Ammonites navicularis*.
8. *Cottaldia Carteri*, nobis.

Combining, then, the Sinaitic and south-east Arabian Echinodermata, a fauna is produced which is eminently characteristic of the middle cretaceous horizon.

5. *Remarks on the species, their persistence and variability*.—The *Holectypus* from Sinai, formerly termed a *Discoidea*, is found in three forms. One cannot be distinguished from the type of *H. excisus*; and the others are simple varieties, their size being the presumed variation.

Periaster elatus is found as a slight variety, and *Epiaster distinctus* also.

The vertical range of *Heterodiadema libycum* is worthy of notice, because it resembles that of some of the South-east Arabian Echinodermata. The species lasted during the Hippuritic chalk age, as well as during the antecedent Cénomanien.

The comparative absence of species unknown in Europe is somewha tremarkable; and so is the presence of some of the rarer Echinodermata of the well-searched French district of La Sarthe. It is very interesting to discover that the majority of these wide-wandering Echinodermata had a tendency to vary from their types, both in Europe and in Arabia, and that the rest were persistent in form.

In conclusion, I must refer to the remarks upon the diffusion and

* M. Hébert determines this species to be identical with *H. Leymeri*.

variability of the middle cretaceous Echinodermata made in my former communication.

Note.—The Rev. H. Holland informs me that in the Wady Badera the Echinodermata occurred in the bed of the Wady, having evidently been washed down from a bed of limestone which exists near the pass at its head. This pass is composed of variegated sandstone rocks resting upon gneiss. The sandstone occurs at a higher elevation than the limestone; but the exact position of the latter I did not remark. The Echinoderms from Wady Mokatteb were found in a small bed of limestone at the foot of Jebel Mokatteb, which crops out beneath a sandstone.

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2. Geological Description *of the* First Cataract, Upper Egypt. By J. C. Hawkshaw, Esq., F.G.S.

[The publication of this paper is unavoidably deferred.]

(Abstract.)

At the First Cataract the Nile flows over crystalline rocks consisting principally of quartz, felspar, and hornblende, combined in various proportions, and then appearing under the forms of syenite, greenstone, hornblende, and mica-schists, or else occurring in separate masses. In the bed of the river the surface of the harder portions of these rocks is beautifully polished. The whole district is traversed by dykes of greenstone, of which the prevailing direction is E. and W.

The crystalline rocks forming the bed of the river are overlain by a sandstone, sometimes coarse and gritty, and at other times fine-grained and compact. The prevailing colour is light yellow; but in places it is dark-purple and even black, owing to the presence of iron. As yet no organic remains have been discovered in it. This sandstone rests on the uneven surface of the syenite, in slightly inclined strata dipping N.N.E. It is nowhere altered at its junction with the syenite, nor is it anywhere penetrated by dykes.

To the eastward of the First Cataract is a wide valley, commencing opposite the Island of Philæ, and joining the Nile valley again about three miles below Assouan. Through this valley the Nile may have formerly flowed, as freshwater shells and deposits of Nile-mud are found at a considerable height above the present level of the river.

To the westward of the First Cataract the crystalline rocks disappear below the sandstone, and the country is almost entirely covered with sand of a rich yellow colour, composed of fine rounded grains of quartz.

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3. *On the* Drift *of the* North *of* England. By J. Curry, Esq.

(Communicated by the Assistant-Secretary.)

[Abstract.]

The Drift under consideration is stated to occupy certain slopes from the following mountain-eminences, namely:—Skiddaw, Saddleback, Helvellyn, Fairfield, Harter Fell, and Shap Fell, situated in and bordering the Lake-district; and Tebay Fell, Langdale Fell, Wild Boar Fell, and Kaber Fell, ranging in a curve to the south end of the Stainmore ridge on the Pennine chain; also the series of hills northward along this chain.

The author gives a geological sketch of the district, and points out that the general prevailing direction in which the drift has been carried has been from the north-west to the south-east, though much modified by the configuration of the land. He also states that from the north-western part of the Cumbrian group of mountains it has been carried, in the one case, across the slopes of the western and southern sides of the Lake-district, thence southward along the western front of the hills ranging into Derbyshire, and in the other case along the route under consideration. On the commencing part of this route the principal rocks which have yielded materials for the Drift are the Skiddaw slates, the green slates and porphyries, and the Carrock Fell and the Caldew granites. It is the waste from the granites, the green slates, and the porphyries which serves to identify and characterize the Drift on the more distant parts of its course on the Pennine chain. The waste from the various rocks of this northern area appears in the direction of Berrier, Greystoke, and Penrith. Large boulders of them are met with in the railway-excavations between Penrith and Keswick, and they continue to the north-eastern flank of Great Dod.

The Shap Fell granitic boulders are spread to the south-east of Wasdale Beck, and are probably continued in that direction across the country-side down to Tebay. Their occurrence continues for a mile or so to the east of Orton. Boulders of it lie on the western declivity from the Stainmore ridge. Among such may be noticed those at and near the following places, namely Kaber, Brough Sowerby, Church Brough, and Broughtown. They occur sparingly on both sides of the Argill Beck. Down the eastern slope of the Pennine chain, near Mickleton, and southward over the mountain-ridge into Balderdale, pebbles of indurated Silurian rock are traceable among the superficial accumulations. Lower down the valley of the Tees, Shap Fell granite and green slates and porphyry occur.

The author then offers some explanations to account for the absence of detritus from the Shap Fell granite over the sloping area of the south side of the Lune, ranging between Tebay Fell on the west, and Ravenstonedale Common on the east; and proceeds to notice the occurrence of Drift northward along the western slope of the Pennine chain.

From the neighbourhood of Brough Sowerby and Broughtown, down the east side of the Eden, as far as Appleby and Murton, the superficial accumulations are of a local character, being chiefly derived from the Permian rocks and from those in the bold escarpment contiguously situated on the east. Some Shap Fell granitic boulders are met with between Appleby and Dufton, and others near the base of Dufton Pike. In the vicinity of Melmerby the Drift is of a mixed nature, and continues so along its range by Gamblesby, Renwick, Croglin, and Newbiggin to Castle Carrock. The range of the Drift thus pointed out may be regarded as closely approximating its upper limit; but on the brow of the mountain, in the neighbourhood of Castle Carrock, the Drift-margin is a little above this place.

From the neighbourhood of Castle Carrock, across the north end of the Pennine chain, the upper reach of the Drift corresponds pretty closely with the several collieries on the north side of the Ninety-fathom Dyke, but extends a little further to the south in the valleys of the Tyne, the Allen, and the Devil's Water. On the Tyne valley it is found to occur about half a mile below Slaggyford; in the Allen, some $2\frac{1}{2}$ miles above Allen Town; and in that of the Devil's Water, a little below Lillswood. On passing somewhat direct from Midgeholme pit to Rose Hill, the Drift is seen to lie on the southern and northern sides of the mountain nearly up to its summit. To the west of a line between the last-mentioned places the drift-materials have much of a water-worn character. Small oval-shaped hills made up of these materials are very prevalent on this area, and more particularly so near the river Irthing. From the same line eastward to the Tyne the Drift occurs very abundantly. The tributaries on the west side of the Tyne, between Hartley Burn colliery and Haltwhistle, cut deep into it and expose some good sections. There is a very fine section directly down from this colliery, on the south-east side of the Blackburn, opposite Low Mill House. In the mass here presented are granites, green slates, porphyry, basalt, Mountain-limestone, shale, New Red sandstone, and some pieces of quartz. All these various rocks are confusedly mixed in a firm clay. The clay is of a reddish-brown colour and rather sandy below; but higher up it is more of a greyish blue and somewhat finer in texture. The granite occurs in small pieces, some of which are angular, and others rounded. The green slates, porphyry, and basalt are generally much rounded, and occur as pebbles and small boulders. There are some blocks of considerable size interspersed. The green slates and porphyry are very plentiful here. The blocks of Carboniferous Limestone are not much rounded, but are striated. The shale occurs in small thin pieces. Some of the fragments of New Red sandstone are angular, and others rather rounded. The clay appears to be more sandy as it increases in redness.

About halfway between the Tyne and the Allen, from an elevation corresponding with the top of the Coal-formation, the Drift spreads somewhat thinly down the side of the valley to the river. The drift-stones can be seen on the road down Plainmellar Common. Near Plainmellar are some granitic boulders, probably of the Criffle Fell granite. At Allen Town, on the east side of the water, the drift consists of a stiffish and rather blue clay, in some parts inclining to red, interspersed with angular sandstone very abundantly, and some Carboniferous Limestone, with a good deal of shale-fragments, also green slates and porphyry, and some portions of New Red sandstone. This heterogeneous mass has a thickness of 80 feet, and is overlain by sand and shingle, which probably averages 12 feet. A mile or so further up the Allen, but on the west side of the water, is another good section, which shows a blue clay interspersed with angular fragments of sandstone of a local character, and numerous thin pieces of shale, also some blocks of limestone rather striated. Green slates, porphyry, and basalt are very rare. The thickness of this mass is 50 feet; and it is overlain by a deposit of sandstone-pebbles 9 feet thick, above which is a stratum of water-washed sand 5 feet thick. This is again surmounted by shaly material 8 feet in thickness, thus making a face of section 72 feet in height. Again, to the east, at Langley, close to the turnpike road, the drift is exposed in a cutting of the Hexham and Allendale Railway. It is here of a dark-brown colour, with the usual kinds of pebbles and boulders.

For the range of the elevation of the Drift between Devil's Water and the river Wear, the following points will afford a tolerable idea —namely, the first on the ridge about a mile to the south-west of Slealey, the second a mile up the Stanhope and Tyne Railway from Waskerley, and the third on the summit of the road leading between Dean House and Witton-le-Wear. From the first of these points the outspreading area, stretching down to the Tyne, and bounded on each side by the Devil's Water and the Derwent, is for the most part covered by Drift, in greater or smaller quantities. Fine water-worn sand prevails below Minister Acres. Green slates, porphyries, and basalt are generally disseminated among the arenaceous superficial accumulations of the adjacent country. A very considerable accumulation of Drift lies in the valley of the Tyne near Stocksfield, and can be seen with advantage on the east side of Stocksfield Burn, where it is tolerably well exposed in section. The mass thickens from the Tyne across the valley to the southern bank against which it lodges. The Drift reaches up the valley of the Derwent a little above Blanchland, and up that of the Edmondbyers Burn as far as Edmondbyers. On the ridge between this burn and Icehope Burn, it extends very little to the west of Muggleswick.

From the second point the Drift covers much of the area down the south side of the Derwent. Above Waskerley, on that small area to the south-west side of the railway, it appears to be absent, but on the north-east side it occurs. It is here characterized by the scattered green slates, porphyries, &c. among the superficial accumulations. These scattered stones may be best seen on the old cart-road down the fell. The road continues down the declivity to Horseleyhope Mill, and thence by Castleside to Consett. It is on this road and adjoining parts that the various drift-stones can be advantageously observed.

In the neighbourhood of Horseleyhope Mill the Drift occurs in much abundance, consisting of clay, local detritus, and detritus from rocks many of which are situated at a great distance. The clay is stiff and compact, and of a brownish colour, but varies from that to a bluish grey. It also varies in other properties, so as in some parts to become sandy. The local detritus occurs in larger proportion, and is evidently derived, in a great measure, from the Millstone-grit series. It consists chiefly of angular fragments of coarse sandstone, and small rather thin pieces of argillaceous strata. The former range from very small sizes, through a gradation, to that of large angular blocks. The far-carried detritus comprises green slates, porphyry, and basalt, which occur in the form of pebbles, boulders, and some large blocks. The fragments of granite are only small and often angular. Among these various stones may be found the representatives of most of the rocks of the Lake-district.

South of Horseleyhope Mill and Cold Rowley, the Drift occupies the flank and summit of the hill, and from the latter place it spreads down to the Derwent. On this declivity it is of a sandy character. From Consett eastward it prevails rather partially on the higher grounds until we come to Whickham, where it would seem to be more regular. Boulders of Shap Fell granite lie on the bank below Whickham. Carrock Fell granite also occurs in the valley of the Derwent, with others which are evidently from Scottish localities. From the third point down the hill-side to Witton-le-Wear, there is apparently an absence of Drift. This may probably be the case on the slope to the Wear eastward. On the north side of the hill, from its summit to Dean House, it occurs in not a very marked character. Such it may likely continue to be on the declivity towards the river Browney. It is slightly traceable from the ridge south of Consett to near Lanchester. Thence to Durham it is apparently not traceable. At this place much sand occurs. Among this there seems to be no granite or other stones to mark it as the true drift. These sandy accumulations at Durham, and those previously noticed, have evidently resulted from the denudation of the Millstone-grit.

From Witton-le-Wear bridge, following the road by West Auckland to near Staindrop, no indications of the Drift are met with. At and near this place a few stray boulders of Shap Fell granite occur. There are others in the neighbourhood of Barnard Castle. Thus from a little north of Staindrop to Barnard Castle may probably be near the range of the Drift-elevation on the north side of the Tees. But on the south side of the river, Shap Fell granite occurs at Lartington, and is likely to be found strewn down from here to Barnard Castle. Thence down the north side of the river to Darlington the miscellaneous character of the Drift prevails. Boulders of Shap Fell granite are observable near Winston. In the North Street at Darlington lies the well-known granite Shap Fell boulder. Others of the same kind occur at Cockerton. On the road between Cockerton and West Auckland there seems to be an absence of the true Drift. Granite from Shap Fell and green slate and porphyry from the Lake-district make up a part of the drift-materials on the Tees. From what has been previously stated respecting the Drift on the Stainmore ridge and on the eastern slope to Lartington, it will now appear obvious that it has been carried over the ridge and down to the mouth of the Tees. At one time it may have lain on the Stainmore ridge in considerable quantity. From the Tees the erratic blocks of Shap Fell granite have found their way along the eastern declivity of the Pennine chain as far as the mouth of the Humber.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

On some Flint Implements *lately found in the* Valley *of the* Little Ouse River, *at* Thetford, Norfolk. By John Wickham Flower, Esq., F.G.S.

In consequence of the recent discoveries of flint implements of the St. Acheul type at Hoxne on the river Waveney, and at Icklingham on the Larke, it seemed to me probable that they would also be found in the valley of the neighbouring river known as the Little Ouse—a stream which, rising at Lopham, in the marsh in which the Waveney has also its source, flows in a direction nearly parallel with the course of the Larke (distant about nine miles), and, running from Thetford to Brandon, falls into the Great Ouse between Ely and Lynn.

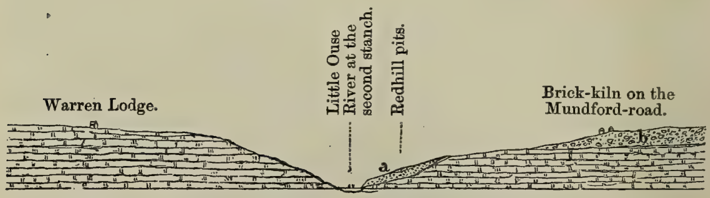
During the last two or three years I have frequently looked for these implements in the gravel-beds on the banks of this river; but my search was for some time unsuccessful, having been chiefly directed to the left bank, on which they very rarely occur. About six months since, however, several of them were found in the gravel-pits on the right bank by a labourer who had gone from Icklingham to work at Thetford. They were taken by him to Mr. Henry Prigg of Bury St. Edmunds, who at once recognized their true character and their close resemblance to those found in the valley of the Somme. In December last Mr. John Evans and Mr. Prigg found amongst the gravel several other good specimens, both of the oval and pointed forms; and within the last three months I have been able to procure upwards of fifty others. Mr. Evans and Mr. Prestwich have also obtained several; and Mr. Fitch, of Norwich, after spending some hours at the pits, procured a very good specimen, which the labourers dug up in his presence at the depth of fourteen feet. It would thus seem that this deposit is quite as productive as any hitherto examined, either in England or France.

From the accompanying plan and section it will be seen that the river here flows through a wide and shallow valley, excavated in the Chalk and Boulder-clay. The hills on either side rise to the height of about one hundred feet above the river-surface; and, when measured from the summit of Boulder-clay on the north to the Chalk-

Fig. 1.—*Geological Sketch Map of part of the Valley of the Little Ouse River.*

a. Ferruginous sands and coarse flint-gravel, 12 to 15 feet thick.
b. Boulder-clay in blue and laminated strata, 25 to 30 feet thick.
b b. Boulder-clay not laminated, 20 feet thick.
c. Chalk.

Fig. 2.—*Section across the Little Ouse Valley at the second stanch between Thetford and Santon Downham.*



Vertical scale 1 inch to 300 feet. Horizontal scale $1\frac{1}{2}$ inch to 1 mile.

summit on the south, the valley is from a mile to a mile and a half wide. On the south side, to the extent of three miles parallel with the river, and at the distance of nearly a mile from it, the hills are in several places capped with coarse flint-gravel, resembling that in which the implements are found, and containing some large nodules. On the right bank of the river a terrace of siliceous and ferruginous sands, irregularly laminated, and containing layers of flint-gravel, is found resting upon the Chalk. This terrace commences about a quarter of a mile below the town; it extends along the course of the river for about a mile and a half, and is on the average about forty yards distant from the bank, and rises about eight or ten yards above it. The base of this bed, to the extent of four or five feet in thickness, is composed of large nodules of subangular flint, with some chalk-pebbles and calcareous sand; and it is in this coarse gravel, at a spot known as Red Hill, near the second stanch in the river below Thetford, that nearly all the flint implements have been found, usually at from twelve to fifteen feet below the surface, and within a foot or less of the chalk. Some specimens (like those at Fisherton described by Dr. Blackmore) were found in pot-holes in the chalk. On the left bank the terrace does not generally rise more than twenty feet above the river, and the gravel here is deposited much more irregularly. It is of a darker colour, showing no traces of lamination, and in some other particulars differs from that on the right bank, until the river reaches a small farm at Santon Downham. At this place the ferruginous sands and gravels of the right bank reappear, and in them at least one flint implement has been found.

As regards the general form of the implements, most of them bear a close, and, indeed, almost perfect resemblance to those discovered in similar deposits in France and in other parts of England; and the accurate description which Mr. Evans has given of the St. Acheul specimens, in his paper read before the Antiquarian Society, will apply to nearly all of those found at Thetford. It would seem as if there were two predominating types, the ovoid and the pointed, examples of both of which are given in the accompanying figures. As formerly it was said that the wood which would not make a shaft might serve for a bolt, so the stone which was not sufficient for a pointed implement was doubtless worked into an oval; and occasionally it would be found convenient to fashion those intermediate varieties which are often met with.

There are one or two slight peculiarities in these implements, whether French or English, which seem to deserve notice, as they may tend to explain the uses to which they were put. Thus in several of those of the pointed form the point is seen to be slightly recurved; and in many of them we find that a flat space or surface has been left or formed, exactly adapted to receive the thumb of the right hand, which, if it had been constantly pressed upon a sharp or rugged surface, would soon have become sore and inflamed. I have never shared the opinion that these things were either weapons of war or of the chase; and the peculiarities alluded to (coupled with the circumstance that the pointed end is almost always found to be broken and blunted) tend to support the belief that they were used as hand-spades or dibbles, perhaps for digging roots.

Fig. 3.—*Flint Implement from St. Acheul.*

Fig. 4.—*Flint Implement from Thetford.*

As regards its geological relations and position, this deposit seems closely to correspond with the flint-implement-bearing beds of Amiens, as these again agree with those of Fisherton, Milford Hill, the Reculvers, Bemerton, Hoxne, Icklingham, and Biddenham. At the Reculvers they repose upon the Thanet sands; where the Boulder-clay is present, they rest in hollows or valleys of that formation; where it is absent, they are found on the eroded surface of the Chalk. In one locality, lately discovered and not yet described, they are on the surface of the Gault; and where there is neither Chalk nor Gault (as at Biddenham) they rest on the Oolite. In all cases the superincumbent beds consist of flint-gravel and siliceous and calcareous sands, more or less mixed with Tertiary boulders, and usually covered by a capping of loess. At Hoxne these beds are more argillaceous.

The close resemblance which these implements, and others like them discovered elsewhere in England, bear to those of the valley of the Somme, is a circumstance which cannot but have an important bearing upon all questions relating to their origin and history. The material from which they are made is in all the same, namely, chalk-flint—not, however, as it seems to me, as it is found *in situ*, but flint-pebbles or nodules as found on the surface of the land or in the channels or banks of rivers. In almost every specimen a part of the original coating of the flint is left at the butt or round end, showing from its battered surface and from the discoloration of the flint beneath (sometimes extending to the depth of a quarter of an inch) that before the implement was shaped the stone from which it was wrought had been long exposed to atmospheric influences, and to various mechanical and chemical changes.

In other important particulars the Thetford deposit agrees with those above alluded to—namely, in the entire absence, as well of all other works of art, as of human remains, and in the presence of bones of the Elephant. A tradesman in Thetford has part of a molar of *Elephas primigenius*, a fossil which has hitherto been invariably found with these objects. Mr. Evans has also seen bones of an ox and a horse's tooth from Redhill; and I have obtained portions of an elephant's tusk and a horse's tooth from the same spot. No traces of land or freshwater shells have yet been observed.

From these details it is evident that, so far as is known, the flint implements of the drift of France and England are the same in material, in design, and in workmanship—that the strata in which they occur are also alike in mineral character and condition, and in their geological order, and alike, also, as regards the presence of certain fossil remains, and the absence of others.

From these correspondences some additional light, as well in an ethnological as in a geological point of view, will perhaps be thrown on the much-debated question of their origin. If we are not enabled to fix their date with any degree of precision, we may yet approach it more nearly than heretofore; and thus these singular objects will be further removed from the category of casual and abnormal conditions, and approach to a distinct geological rank and order.

Consistently with the analogies drawn from other phenomena, we may reasonably conclude that deposits agreeing with each other in such various and minute particulars must be regarded as contemporaneous ; and if so, it would seem to follow that, although now separated by an arm of the sea, they at some former period (like the chalk on which several of the beds rest) extended, but with certain intervals or breaks (which were afterwards in all probability much widened), over one continuous area, ranging, as far as at present explored, from the Somme, if not from the Seine, into Kent, Hants, Wilts, Norfolk, Suffolk, and Bedfordshire. Unless we adopt this view we must suppose that each of these several deposits, although of similar date and character, is to be ascribed to a separate and independent origin. Such an hypothesis is not to be regarded as impossible, but it seems far less probable, and far less consistent with the methods of reasoning usually adopted in dealing with such topics, than that which would ascribe all the deposits to one common agency.

Another argument in support of the view here stated may be drawn from the close resemblance which is seen to exist in the form of the implements. We may reasonably assume from this that they were fashioned and used by men of the same race; and these must either have been inhabitants of one conterminous region, or if separated, as now, by an arm of the sea, then one of these nations must have had such intercourse with the other as would enable it to imitate thus closely the fashion of its implements. It seems, however, highly improbable that a people altogether destitute of metals, and so ignorant of the arts of life as to be restricted to the use of such rude instruments, could have navigated even the narrow strait which divides us from the continent: they would have no means of constructing vessels for the passage, nor any desires to tempt them to incur its dangers. And upon this assumption, it would follow that before the severance of this island from the continent (of which there are several other well known indications) both countries were adapted for the habitation of men, and were, in fact, inhabited.

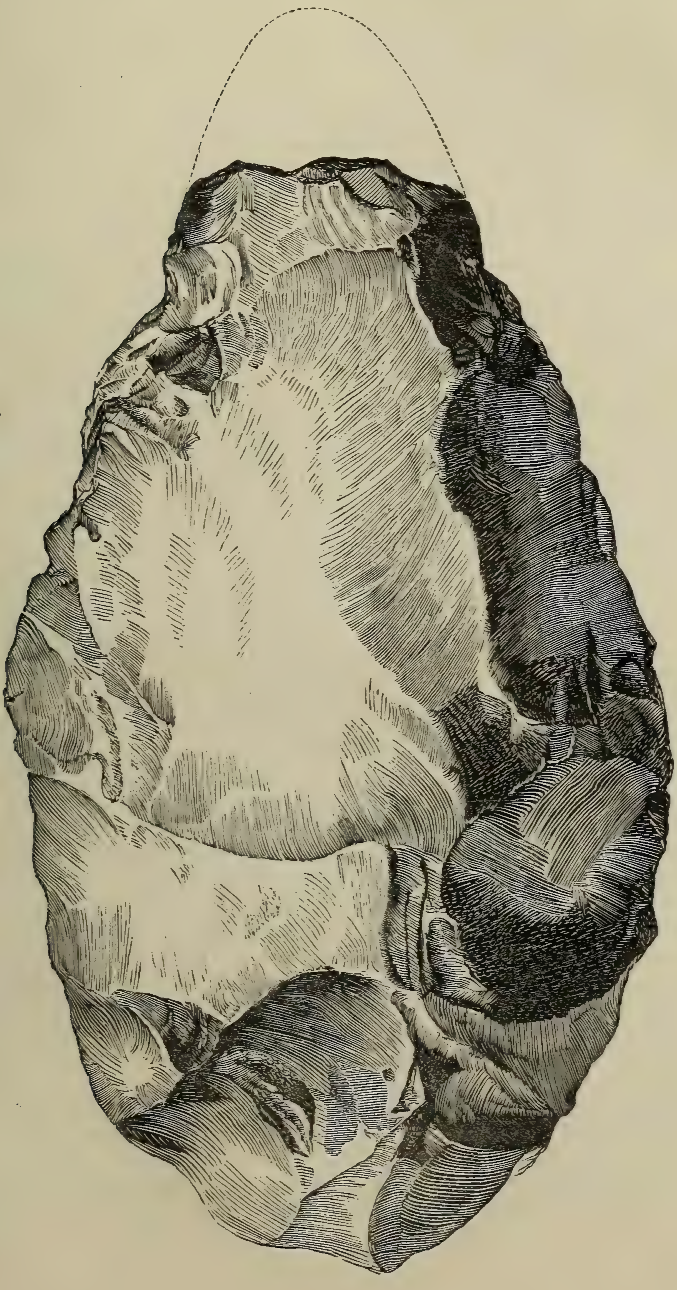
I do not propose on this occasion to consider at any length the question of the mode of transport of these objects and their attendant gravels. I shall only venture to indicate how far the opinions which have been held on that interesting and perplexing subject are borne out by the phenomena of this particular deposit and those in the immediate neighbourhood.

In the very able paper which Mr. Prestwich read before the Royal Society, he inclines to the opinion that these gravel-terraces were brought into their present position by river-action ; but as that opinion was advanced with some hesitation and with several qualifications, it seems reasonable that the subject should be reconsidered, especially with reference to this and various other recent discoveries, as well in France as in England, by means of which our knowledge of the deposits, and of their relations to other strata, has been much increased.

In the district now in question we find several deposits of implements very near to each other, but in three different valleys—namely,

Fig. 5.—*Flint Implement from St. Acheul.*

Fig. 6.—*Flint Implement from Thetford.*



at Hoxne, Icklingham, and Thetford—these places being situated at the angles of an acute-angled triangle; and if we suppose that the implements were indeed carried down by the streams near which they are found, we must conclude that not only these three rivers, but also the Somme, the Avon, the Great Ouse, and some others, in Picardy, in Hants, and in Kent, of the existence of which there are no longer the slightest traces—rivers, be it remembered, lying far apart from each other, and belonging to different water-systems—were all during one and the same geological epoch flowing through countries in which these worked flints had been fabricated, and overflowing their banks and carrying away the implements in their course.

With reference to this question it is also important to consider the position in which the implements are usually found. When they occur in profusion, as at St. Acheul and Thetford, and some other places, they are seldom found in the overlying laminated sands and gravels, but are seen to rest immediately, or almost immediately, upon the Chalk or other subjacent rock. Had they been brought down by freshets or river-floods we should expect to find them in layers, indicating alternate periods of repose and disturbance; whereas their actual position leads rather to the belief that they were all transported at one and the same time, together with the drift-gravel and sand lying loose upon the surface, into the then existing hollows and valleys. The deposits thus formed would doubtless be acted upon, and partially broken up by succeeding floods, and their materials would be redistributed; and it is to some such process that we may attribute the presence of these objects in the brick-earth and other overlying beds, in which they sometimes (although sparingly) occur.

Several other considerations may be noticed which seem to militate against the theory of river-transport as regards these beds. If, indeed, their formation is to be attributed to the rivers near which they are found, where did the people dwell who have left in so narrow a space such abundant traces of their existence? whence were derived those masses of sand and gravel in which the implements are imbedded? and by what agencies were they carried to their present position? The Waveney runs nearly east, while the Ouse and the Larke go north-west, the two former taking their rise in a marsh within a few yards of each other, and then flowing in opposite directions. It seems highly improbable that while one of these rivers was carrying the flint implements in one direction, two others, in the immediate neighbourhood, were taking them in the opposite direction, or that the population of the limited area drained by the Ouse should have been provided with such a profusion of implements, as that several hundreds of them, in addition to a great number which, doubtless, have not been noticed, should be buried in a space the dimensions of which do not exceed three or four hundred square yards.

But, further, the present rivers, even at their very highest floods, are quite inadequate in volume and velocity for the transport of the masses of gravel which now are seen resting on their banks, or for the partial denudation of the adjacent hills. The Little Ouse is formed by the confluence of three small streams, which take their rise at a short distance from Thetford, and join each other just above the gravel-terrace in question. It appears, from the map lately published under the superintendence of this Society, that during the entire course of this river, for about forty miles, from its source to the outfall at Lynn, the fall is but fifteen feet—a little over four inches in the mile. At a short distance above the gravel-terrace the river is about three feet deep and fifty wide; while in order to fill the valley only to the height of the gravel a stream of about sixtyfold greater volume would be required, and this would very far transcend the capacity of the watershed.

In the paper before referred to, Mr. Prestwich observes that it would be impossible for the present rivers, even during their greatest floods, to attain a height at all approaching to the high-level gravels, and suggests that from the melting of the snow, independently of any larger rainfall, the floods must formerly have been far greater, and have given to the river a torrential character, and that thus the ancient channels have been deepened.

But, as applied to Thetford, the phenomena in question can hardly be accounted for on this supposition. Snows do not give forth torrents of water sufficient in volume and force for the transport of such deposits as are here exhibited, unless in regions (at least to some extent) mountainous; and it is impossible to find any mountainous, or indeed any high, land in the narrow watersheds of the Waveney and the Ouse; and to affirm that some such district once existed, which has now disappeared, leaving no traces of its existence, would be a gratuitous assumption, remitting us to the region of pure conjecture.

In conclusion, I would venture to suggest that this and kindred deposits may reasonably be accounted for without having recourse to the river theory, which is attended with so many difficulties. Here not only has all the Boulder-clay on one side of the valley, and to the extent of three-quarters of a mile in breadth on the other, been carried away, together with large masses of the Chalk on which it once reposed, but vast masses of the flint-gravel which, doubtless, once covered the adjacent hills (and of which extensive traces still remain) have also been removed. It is clearly impossible to ascribe these results to the little gentle stream which finds its way in the valley below, or to any other flowing in the same course; and if the formation of the valley, and the partial denudation of the hills which bound it, must be explained in some other way than by river-action, why should not the contents of the valley come into the same category, especially as they bear unmistakeable marks of violent transport. The same law that induces water to find the lowest level operates upon all water-borne materials; and if the excavation of these wide valleys, and the partial removal of the drift from the adjoining hills, may reasonably be attributed to the passage of some great body of water over the surface of the land, the sands and gravel then upon that surface (and we know that there *were* surface-gravels before the implements were formed) would naturally be drifted into the then existing hollows; and eventually, as subaërial waters found their way into these valleys, whether filled up partially or entirely, they would, in the course of extended periods of time, form channels through their loose porous beds, and thus originate the existing rivers and streams.

On a CHEIROTHERIAN FOOTPRINT *from the* BASE *of the* KEUPER SANDSTONE *of* DARESBURY, CHESHIRE. By Prof. W. C. WILLIAMSON, F.R.S.

(Communicated by the Assistant-Secretary.)

[PLATE III.]

THE specimen figured in Plate III. was found in the Lower Keuper, at Daresbury Quarry, near Weston Point, Cheshire, a district which is rich in Cheirotherian footprints. The specimen was discovered by Mr. J. Webster Kirkham, one of my old pupils at Owens College, who has become an indefatigable worker amongst the footprints of the Cheshire district. It is obviously a reptilian footprint, but differs from all that I have hitherto seen in Great Britain in being distinctly that of a *scaly* animal. The form of the footprint differs from that of the Common Cheirotherium, which is found associated with it, in being more quadrate, and in the separated toe being less recurved, as well as approaching nearer to the other toes. In its general form it reminds us strongly of the footprints found by Dr. King in the Carboniferous beds of Pennsylvania. This resemblance is further shown in the fact that the specimen only displays four toes, as is the case with the anterior foot of the American specimens, though possibly the small projection on the left hand of the footprint opposite the thumb may be the base of a fifth toe, partly obliterated by another footprint of the same creature, which has been impressed upon it.

The arrangement of the scales corresponds very closely with that seen in the foot of the Alligator. Many of them run across the foot in oblique lines, as is common amongst living Crocodiles, leaving no room for doubt that they represent true scales, and not irregular tubercles, such as are seen on the skin of some Batrachians. The scales on the toes and at the anterior part of the foot are much smaller than those nearer the posterior region.

I have not succeeded in ascertaining all the differences that existed between the fore and hind feet. The slab, of which the specimen figured is a fragment, is paddled over with similar footprints, as if the animal had been feeding on the spot; but one footprint has disturbed the outline of another to such an extent that no continuous track can be traced. Nevertheless we have evidence that there were some differences. A little to the left of the more perfect impression will be seen an imperfect one, with much larger and more oblong scales, especially under the heel. This difference

Fig 1. Cheirotherian Footprint from Daresbury. Cheshire.

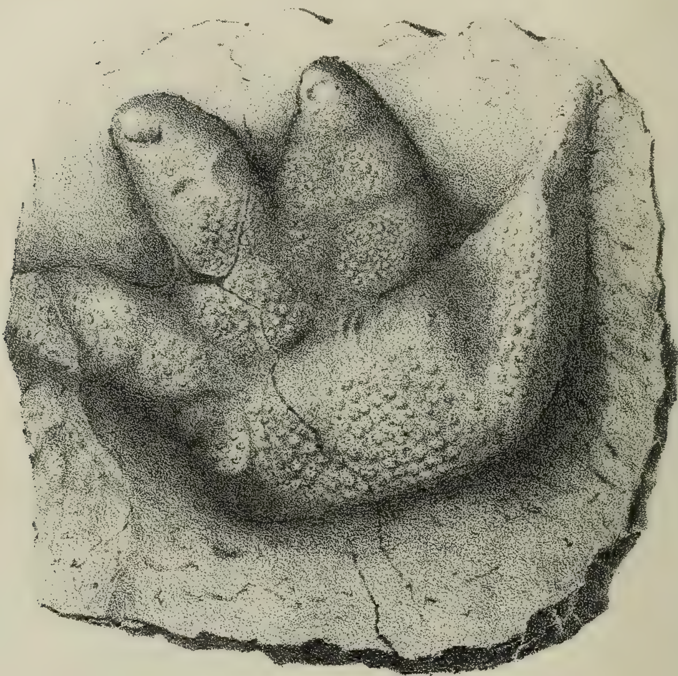
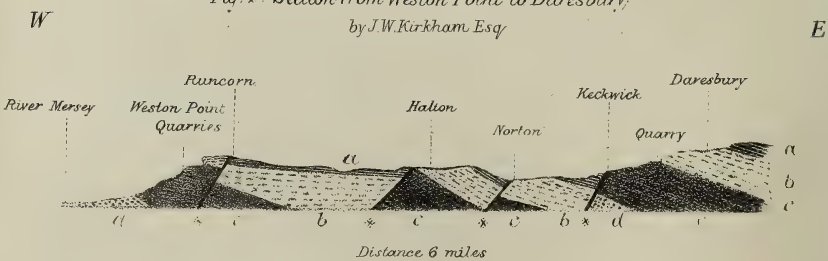


Fig. 2. Section from Weston Point to Daresbury.
by J.W.Kirkham Esq.



De Wilde. lith.
M & N Hanhart imp

is so very similar to what is seen in the fore and hind feet of many Saurians, that I have no doubt respecting its signification. The perfect impression will be that of the fore foot, and the imperfect one that of the hind foot. In the larger slab are many examples of each of these impressions, showing that they really represent the two feet. I have seen no proof that they differed materially in size. Had the impression not exhibited the scaly structure, it would probably have been described as "Cheirotherian," but I do not believe that it belonged to a Batrachian animal. It is Saurian, if not Crocodilean, in every feature, and, as such, constitutes an interesting addition to the palæontology of the English Keuper.

Accompanying this communication is Mr. Kirkham's section of the district in which the Daresbury Quarry is situated, and also a figure of the specimen, taken from a photograph by Mr. Plant of the Salford Museum.

EXPLANATION OF PLATE III.

Fig. 1. Cheirotherian Footprint from the base of the Keuper sandstone of Daresbury, Cheshire. Natural size.

Fig. 2. Section from Weston Point to Daresbury, Cheshire (about 6 miles); by J. W. Kirkham, Esq. *a.* Red Marl (Keuper); *b.* Lower Keuper sandstone; *c.* Upper mottled sandstone (Bunter); *d.* Pebble-beds (Bunter); * Faults. The whole of the line of section is covered with Drift, which conceals the rocks beneath, except at the places mentioned in the seetion.

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THE

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PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 19, 1866.

Theodore Cooke, Esq., Principal of the Engineering College, Poonah; and John Starkie Gardner, Esq., Park House, St. John's Wood, N.W., were elected Fellows.

The following communications were read:—

1. *On a* New Specimen *of* Telerpeton Elginense. By Professor Huxley, LL.D., F.R.S., F.G.S.

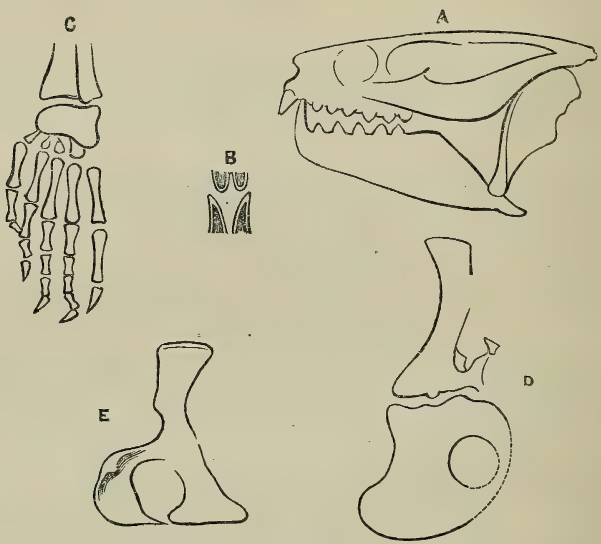
I am indebted to my friend the Rev. Dr. Gordon, of Birnie by Elgin, for the opportunity of examining the very beautiful and important specimen of *Telerpeton Elginense,* of which I propose to give a description in the present paper. It is the property of Mr. James Grant, General Assembly Teacher, in Lossiemouth, Elgin, who has been good enough to entrust it to Dr. Gordon for transmission to me; and it was obtained from the well-known reptiliferous beds of Lossiemouth, along with some highly interesting fragments of *Stagonolepis* and *Hyperodapedon.*

The fine-grained sandstone in which the fossil has been imbedded is broken irregularly into five pieces; and the several bones are represented by sharp and well-defined casts, the original osseous substance having disappeared, or being represented only by pulverulent bone-earth, or by oxide of iron. The body is curved towards the right side, and the head and neck are bent dorsad in a plane different from that of the trunk.

The length of the skull is 1·65 in., that of the vertebral column, from the atlas to the anterior margin of the sacrum, is 4·5 in. From the front margin of the sacrum to the end of the undisturbed part of the tail is 2 inches. To this total of 8·15 in. it is probable that 2 inches more, at least, must be added for the distal moiety of the tail, which would give the entire animal a length of not less than between ten and eleven inches.

The fore limb had a length of not less than 2½ inches, while the hind limb, when extended, must have measured fully 3 inches.

Figs. A–E.—*Outline-sketches of parts of the Skeleton of* Telerpeton Elginense, *Mantell.* (Natural size.)



A. A side view of the skull.
B. The anterior teeth of the upper and lower jaws.
C. The left hind foot.
D. The right scapula and coracoid.
E. The left half of the pelvis.

The skull is broad, its occipital margin measuring 1·5 in. The cranium retains this width for about half its length, and then rapidly narrows to the snout, with a contour which is at first convex, and then bcomes concave, until it terminates in the roundly truncated snout, which exhibits the remains of two cylindrical incisor teeth, placed side by side and close together (fig. A).

The posterior margin of the skull is nearly straight, but presents an obtuse angle directed backwards in the middle line. The postero-lateral, or parietal, angles of the skull are produced directly outwards, instead of backwards, into short and broad processes, which become connected with the strongly curved squamo-jugal arcades, the inner faces of which were concave and directed somewhat downwards.

The counterpart of the fragment which contains the greater part of the skull exhibits the impressions of part of the roof of the skull with the left orbit and left supratemporal fossa. It proves that the squamosal bone was large, thick, and slightly elongated posteriorly and externally, while its outer edge seems to have been undulated.

There is no evidence that any postfrontal bone separated the temporal and the orbital fossæ, the two forming one oval space about 0·7 in. long and 0·4 in. wide. The roof of the skull can be traced forwards, narrowing gradually for a distance of 0·65 in., and then seems to have suddenly contracted to form the interorbital region. Here, however, it is completely hidden by the matrix.

In the prefrontal region it widens out again; and a curious, perfectly separate, sandstone cast of the interior of this part of the skull has been formed. This cast is shaped somewhat like an ace of spades, with a truncated apex and a trilobed base, and presents a few traces of bony matter upon its upper surface. The rest of its exterior is stained, for the most part, of a reddish colour, as if by oxide of iron.

The middle basal lobe presents a truncated, uncoloured surface, where it has broken off from the matrix which lies behind it. The anterior end is similarly fractured and unstained; and there are two oval, uncoloured elevated spaces on the under surface of the cast, which answer to the posterior nares. All the rest of the cast has been enveloped in bone, which must have been furnished, at the sides, by the prefrontals and below by the vomers or the palatine bones. The impression of the upper surface of the vomers has left a strong median groove along the under surface of the cast. The surface of the matrix upon which this cast fits shows the remains of the oral faces of the facial bones, the bony matter itself appearing to be, for the most part, replaced by oxide of iron.

Each of the teeth, already mentioned, which are implanted in the præmaxillæ, is rather less than 0·1 in. wide, and rather more than 0·1 in. long. Their apices appear to have been rounded (fig. B).

The maxillæ are strong, and send up a process behind the external nostril. The roots of several teeth, placed in a single series from before backwards, occupy the alveolar surface of the thick anterior moiety of each. The palatine bones meet, and appear to be completely united in the middle line, nor does any posterior palatine space appear to be left between them and the transverse and maxillary bones. The very imperfectly preserved bony matter which remains is dotted over with rows of red spots of oxide of iron, the arrangement of which forcibly reminds me of that of the palatine teeth in *Hyperodapedon*, though I cannot make sure that these spots really represent teeth. Posteriorly the palatine bones meet the pterygoids, which diverge and pass backwards, to become connected with the quadrate bones in the ordinary way.

In the interspace between these the remains of the basi-sphenoid are visible.

The quadrate bone, 0·7 in. long, is strong; and its anterior aspect is convex forwards, and from above downwards. It consists of an outer and an inner lamella, which pass into one another along the ridge-like anterior convexity of the bone, and enclose a deep cavity posteriorly. The distal end of the bone was provided with a transversely elongated convex condyle. The angle of the ramus of the mandible, which is 1·35 in. long, projects not more than 0·15 in. behind its articular surface (fig. A).

At the articular surface, the jaw is not more than 1·5 in. thick; but in front of this point it rapidly rises, and, at 0·65 in. from the posterior extremity, forms a coronoid process, the summit of which is 0·4 in. distant from the lower edge of the ramus. It then declines in height, and, at 0·75 in. from the angular end, begins to bear teeth. Of these teeth the three posterior occupy a space of 0·25 in., and each has a conical crown 0·1 in. high. Three teeth in the upper jaw, of similar size and form, interlock with them, the hindermost maxillary tooth being posterior to the hindermost mandibular tooth. The next two teeth, forwards, in the ramus of the mandible are somewhat smaller than those just mentioned; but the most anterior tooth of all is a curved tusk, twice as long as any of the others, and having its concave side outwards, its convex side inwards and towards its fellow. These teeth bite behind the two long teeth lodged in the præmaxillæ (fig. B).

Three teeth in the upper jaw answer to the foregoing; and the anterior of these passes externally to the mandibular tusk when the mouth is closed. Thus there appear to be six teeth below, and seven teeth above, on each side of the upper and lower jaws; but it is possible that additional posterior teeth may not be visible.

I have carefully examined into the mode of implantation of those teeth, and I have been unable to satisfy myself that they are lodged in true alveoli. They appear to be anchylosed to the edges of the jaw-bones, as in many modern Lizards with a so-called "acrodont" dentition.

Each tooth contains a proportionally large pulp-cavity.

The vertebral column is broken in the middle of the dorsal region, and it is not practicable to ascertain the number of vertebræ with precision; but it may be safely assumed that the cervicodorsal series contains not fewer than twenty, and not more than twenty-two vertebræ. There are certainly not more than two sacral vertebræ. Eleven caudal vertebræ, belonging to the proximal half of the tail, lie in undisturbed relation to one another. There were probably as many more in the broken-up part of the tail.

The casts of these vertebræ show that they had completely ossified centra, very slightly concave at each end; large neural canals, and stout neural arches, running out into broad oblique processes or zygapophyses. The spines were very low narrow crests. The transverse processes must have been represented by mere tubercles.

Five long and slender vertebral ribs are visible on the right side of the anterior dorsal region, in connexion with a similar number of anterior dorsal vertebræ. The largest of these, though its distal end is not entire, measures 1·15 in. in length, but is nowhere more than

0·05 in. broad. These ribs are somewhat expanded at their proximal ends, but show no traces of a division into distinct capitula and tubercula.

On the left side the remains of several vertebral ribs, and a few slender grooves apparently produced by sternal ribs, are to be seen. The ribs of the four or five posterior dorsal vertebræ are exceedingly short; but there appear to be no proper lumbar vertebræ, in the sense of præsacral vertebræ with anchylosed or abortive ribs.

The cast of the only sacral vertebra which is visible shows it to have been possessed of a stout lateral process, 0·16 in. long, and 0·07 in. thick, which abutted against the ilium.

The ilium occupies such a position as to hide any other sacral vertebra which may have existed; but there could not have been more than one additional vertebra in this region of the spine. The eleven anterior caudal vertebræ occupy a space of 1·6 in., which gives rather more than 0·14 in. for the length of each vertebra. The anterior five or six possess slightly curved transverse processes, which taper to their extremities, and attain a length of 0·3 in.

The neural spines and subvertebral bones of the caudal vertebræ are not clearly exhibited.

Three vertebræ, following the tenth caudal, are represented by cylindroidal holes in the matrix, as much as 0·25 in. deep; and beside these lie imperfect impressions of yet two other elongated vertebral centres.

The left shoulder-girdle is displayed on the upper surfaces of the first and second fragments, the line of breakage between which has in fact passed through this system of bones (fig. D).

The scapula was 0·8 in. long; and the cast proves that its proximal, or glenoidal, end was thick and prismatic, and slightly expanded anteriorly. Distally, or dorsally, it passes into a broad and flattened blade, not more than 0·2 in. wide, which is abruptly truncated at its vertebral end.

The coracoid must have been a very stout bone, nearly 0·9 in. in antero-posterior, and 0·5 in. in transverse measurement. Of its three margins the internal presents a convex, the anterior and the posterior a concave curvature. It appears to have possessed a considerable fenestra in the inner moiety of its anterior half.

An obscure impression, leading to a triangular hole, which is the transverse section of a cavity at least 0·2 in. deep, in the matrix, I believe to represent the cast of a clavicle. There is a corresponding hole and cavity in the counterpart fragment of the fossil, whence I conclude that the clavicle must have been about half an inch long.

The impression of the head of the humerus lies in its natural relation to the scapula and coronoid. It was 0·4 in. wide, and had a strongly marked deltoid ridge, or outer tuberosity, which projected downwards. In the counterpart the rest of the cast of the humerus is preserved, and proves that bone to have had a length of about 0·85 in. The middle of its shaft is not more than 0·2 in. wide, but its distal end expands to the width of the head.

The under surface of this fragment presented two holes in the position which the radius and ulna might well occupy; and on working away the matrix, I found that they led back into cavities which are the casts of these two bones. The narrower, answering to the ulna, is 0·6 in. long by 0·05 in. wide. The radial cavity is much broader, but its exact dimensions cannot be obtained.

The forearm is disposed nearly at right angles to the arm. At its distal end four minute rounded carpal ossicles, disposed in two rows, are discernible. Then come four metacarpal bones, the longest of which is the second from the radial side, and measures 0·3 in. This is succeeded by a short hourglass-shaped phalanx, 0·15 in. long. The metacarpal on the radial side of the preceding is 0·25 in. long. Those on the ulnar side seem to have been shorter and more slender. From some obscure indications of other phalanges I conclude that the fore foot could not have been less than an inch long.

The cast of the left half of the pelvic girdle is well displayed (fig. E). The ilium was 0·5 in. long, 0·28 in. wide at its truncated end, slightly convex forwards, and concave backwards, and its long axis was apparently almost perpendicular to that of the vertebral column. The ischium and pubis were strong bones, meeting with their fellows at the symphysis; and the anterior margin of the pubis is produced downwards and forwards into a strong process. The shape of the obturator foramen is not distinctly shown. The casts of both of the femora are visible, and a part of the bony substance of the right femur is preserved. The bone is 1·1 in. long, and has a sigmoid curvature, the greater part of its anterior contour being concave, that of its posterior contour convex. There appears to have have been a prominent internal trochanter. The tibia and fibula are each 0·75 in. long; the former had a broad and expanded proximal end, and a comparatively narrow shaft, which widens again distally.

The cast of the left foot (fig. C) is very perfect, but not quite easy of interpretation. The fibula of the left leg is undisturbed; but the tibia lies obliquely across the fibula, with its femoral end on the outer, and its tarsal end on the inner side of the corresponding ends of the fibula. I conceive that while its tarsal end has remained in its proper position, the femoral end of the tibia has been dislocated; and, in this case, the cast will exhibit a dorsal view of the foot, the outer side of which will be fibular, while its inner side will be tibial. A single bone, 0·3 in. wide, and deeper on its fibular than on its tibial side, articulates with the tibia and fibula, and represents the calcaneum and astragalus. Between this bone and the three middle metatarsals three small tarsal bones, forming a distal row, appear to have been interposed. The five metatarsal bones are perfectly represented by their casts. Each is subcylindrical, and wider at its articular ends than in the middle. The two outer are respectively 0·3 in. long, while the middle metatarsal is a very little longer. The two inner are each about 0·25 in. long, and the innermost is a somewhat stouter and thicker bone than the other. Of the digits the middle and the next outermost are equal and longest, each having a length of 0·5 in. Each exhibits, very distinctly, three hourglass-shaped phalanges and a terminal pointed and slightly curved ungual phalanx. A fifth phalanx appears to be interposed between the third and the ungual phalanges, in the outermost of these two digits. The digit on the inner side of the middle one is 0·35 in. long, and contains only three phalanges, two constricted in the middle and articular at each end, and the third ungual.

The innermost digit of all has a proximal phalanx 0·15 in. long, with both ends articular, and constricted in the middle. I think I can trace the impression of a second curved ungual phalanx lying across the next digit.

The outermost digit is very extraordinary; for it presents only two phalanges, one proximal, 0·27 in. in length, or as long as the proximal two phalanges of the longest digits, and a strong terminal ungual phalanx. This is so unlike the ordinary character of the fifth digit in Lacertilian Reptiles, that I was inclined at one time to think that the foot had been turned round, and presented its plantar instead of its dorsal aspect to the eye. But its connexion with the tibia and fibula, and the numerical relations of the phalanges of the other digits, are insuperable obstacles to the adoption of this view; and I can only suppose that what I have termed the "inner" digit is the hallux, and that the two longest digits are the third and the fourth.

From the description of the organization of *Telerpeton Elginense* which has now been given, it is obvious that this animal is one of the *Reptilia* devoid of the slightest indication of affinity with the *Amphibia*. It is Saurian in all its characters; and if we inquire to what division of the Sauria *Telerpeton* belongs, there appears to me to be no doubt that it must be referred to the true *Lacertilia*, and among them to the suborder *Kionocrania* of Stannius, which contains all the modern Lizards—though I cannot make sure, from the present specimen, that it possessed a columella.

It will probably be objected that the concave articular faces of the centra of the vertebræ constitute an objection to this view, recent *Lacertilia* usually having concavo-convex vertebral centres. But, though Meckel pointed out the circumstance forty years ago, it has not always been duly remembered that biconcave vertebral centres, much more deeply excavated than those of *Telerpeton* appear to have been, are to be met with among the existing Geckos*.

I have referred to the difficulty of ascertaining the precise mode of implantation of the teeth in *Telerpeton*. If, as I believe, this Lizard is not Thecodont but Acrodont, the only other important

* See Meckel's 'System der vergleichenden Anatomie,' Theil ii. Abth. 1. p. 427 (1824):—"Andere dagegen, namentlich Gecko, verhältnissmässig doch nur eine geringe Anzahl, verhalten sich wie die Säugethiere oder noch richtiger den Fischen ähnlich; indem der Körper vorn und hinten eine beträchtliche, mit einer Knorpelbandmasse angefüllte, trichterförmige Höhle hat, wodurch er aus zwei Kegeln zusammengesetzt erscheint."

character by which it differs from existing *Lacertilia* is the structure of the fifth digit of the hind foot, in which, however, it departs from all known Lacertilian reptiles, whether recent or fossil.

It is most interesting to observe that *Telerpeton* presents not a single character approximating it towards the type of the Permian *Protosauria*, nor to the Triassic *Rhynchosaurus* and other (probably Triassic) African and Asiatic allies of that genus *, nor to the Mesozoic *Dinosauria*; still less can it be considered a "generalized" form, or as, in any sense, a less perfectly organized creature than the Gecko, whose swift and noiseless run over walls and ceilings surprises the modern traveller in warmer climates than our own †. And whether the age of the deposit in which it occurs be Triassic or Devonian, *Telerpeton* is one of the most astonishing examples within my knowledge of a *persistent type* of animal organization.

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2. *On a* Section *at* Litcham *affording evidence of* Land-Glaciation *during the earlier part of the* Glacial Period *in* England. By S. V. Wood, Jun., Esq., F.G.S.

The structure of the Lower Drift, and the limited area to which it is confined, conspire to show that this country first encountered, and for a long period sustained, the glacial conditions while principally in the state of land; for not only do the limited superficial extent of the formation and its rapid attenuation in all directions, from its great development on the Cromer coast, necessitate an inference that only a small part of England was under water at the time of the deposition of the Lower Drift, but the great masses of chalk and chalky débris that were carried into the marine sediment require us to admit the presence, near at hand, of some terrestrial chalk-area from which these masses were detached; and I imagine that it does not require any illustration here to satisfy geologists of the fact, so obvious from the appearance of the Cromer Cliffs, that much of the chalk of Norfolk was, at the time these masses were imbedded, occupied by a great glacier, from whose seaward termination they were carried and dropped into the marine sediment.

In such a state of things we should naturally look for some evidences inland of the terrestrial glaciation which this structure involves.

The beds in section on the Cromer Coast, forming the Lower Drift, although of so great a thickness there, alter, as I have elsewhere shown, both in their appearance and thickness inland.

* The anterior tusk-like teeth are comparable to the anterior teeth of *Rhynchosaurus* and *Dicynodon*, only so far as these are comparable to the like teeth of many existing Lizards, e. g. *Uromastrix* and *Hatteria*.

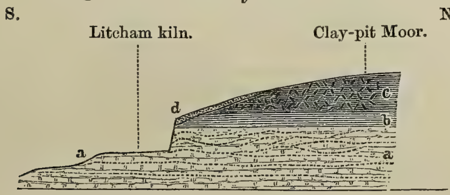
† Dr. Mantell suggested that, should the lacertian relations of *Telerpeton* be established, it probably differed but little in its physiognomy and economy from the small existing terrestrial Lizards.

South-eastwards, in the direction of Norwich and the Yare Valley, the Lower Drift, or at least the upper or contorted part of it, passes into a fine brickearth, which exhibits no evidence of anything like terrestrial conditions; but westwards and southwestwards, it rapidly assumes the condition of chalky loam, often very finely stratified or laminated. In both directions it attenuates to less than a tenth of the thickness which it possesses on the coast, and, in both, passes under the thick formation of the Middle-Drift sand, appearing only where the valleys cut down to it.

Proceeding in the direction of Litcham, we lose sight of it altogether under the Middle Drift, that formation also eventually disappearing in this direction under the Upper Drift, or wide-spread Boulder-clay.

On encountering the Lower Drift, in its form of chalky loam, again at Litcham town, we find that the Middle Drift has disappeared in the interval, the Upper Drift resting directly on the laminated loam, as is the case also towards Weasenham and Swaffham, although a small tongue of it runs in again immediately on the south of Litcham. Fig. 1 shows the manner in which the Lower Drift recurs at Litcham town.

Fig. 1.—*Section of Litcham Hill.*

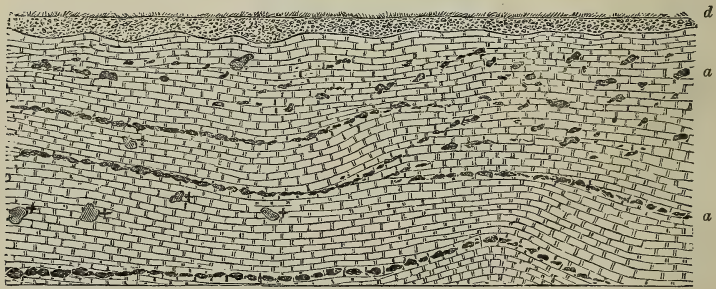


a. Chalk. *b.* Laminated chalky loam, forming the inland attenuated prolongation of the Contorted Drift of the Cromer Coast (6 feet exposed under *d*). *c.* Upper Drift (Boulder-clay). *d.* Coarse Postglacial gravel, 5 feet.

Now the condition of the Chalk over which this attenuated representative of the thick beds of the Cromer Coast occurs, is one of much interest, as it seems to afford clear indications of the passage over it of a glacier, and to connect itself with the phenomena of the transported chalk-masses of the coast.

I should premise that over much of Norfolk, under the Drift-beds, and even, in some degree, under the Fluvio-marine Crag itself, the chalk presents an appearance quite dissimilar to that exhibited by it in the south of England (where it was protected during the Glacial period by its covering of Lower Tertiaries), and for some 15 or 20 feet from its surface is in the impure condition which gives rise to the local term of "Marl" given to it in Norfolk. This condition seems to indicate that a churning up of the surface of the chalk has been effected by some action which permitted it again to subside without any considerable intermixture of foreign ingredients; and it is very dissimilar to anything we know to result, or can by geological phenomena gather to have resulted, from water-action. Now not only is the condition of the upper 15 or 20 feet of the chalk in the section at Litcham, upon which the Lower Drift rests, such as this, but the state of the flint bands there indicates that great disturbance has taken place by a force acting *downwards from the surface*, and becoming less powerful the deeper the section descends. This is best displayed in a part of the quarry where the Lower Drift has, by the postglacial denudation which gave rise to the gravel (*d*), been removed; but although such is the case, it is sufficiently clear from similar although less striking features in the adjoining quarry, where the Lower Drift occurs, that this force was exerted before that formation was spread over the chalk. By the section (fig. 2) it will be seen that, of the bands of flint, only the lowest is perfect in its continuity, the others having been ruptured by some force not exerted from below, and whose intensity diminished downwards; and that this lowest band, although not ruptured, indicates, by its upward curvature under the spot where the bands which overlie it are ruptured and destroyed, that it has sustained in a less degree that dragging towards the surface which has been powerful enough to shatter altogether the bands above it. In the body of the chalk also are galls or cavities filled with dark-brown clay. These galls are not sections cutting obliquely across pipes or potholes, which are so common where the chalk or other soft limestone strata have been subjected to the Postglacial denudation, and into which the bed immediately over them commonly descends, but are cavities filled with some material quite foreign to the present superincumbent strata. Pipes, or potholes, of the well-known kind do, in fact, occur in the adjoining quarry, and are of great dimensions, passing completely through the thin bed of Lower Drift exposed there, and thence through some 20 feet of chalk. These, as is usual in similar cases, are filled with the gravel (*d*); but to them the galls of clay shown in the section have no relation.

Fig. 2.—*Section at Litcham Lime-kiln.*



a. Chalk with flint bands, becoming gradually more impure upwards, and the flints becoming detached and scattered in the upper part, about 20 feet. *d.* Coarse red Postglacial gravel. + Galls of dark-brown clay.

N.B. The lines of shading indicating the chalk in the *upper part* of the section are not to be regarded as lines of stratification.

Closely resembling the chalk in this section, are several of the transported masses imbedded in the contorted Drift of the Cromer coast, especially that in which the limekiln is worked under Cromer Lighthouse,—galls of dark sand occurring in it there, as those of clay do here.

To what precise action these galls are due, or what the clay is that fills them, it is difficult to say; but the appearance of the section impresses me strongly with the conviction that we have here evidence of the passage of a glacier over the surface of the chalk,—the adhesion of the base of this glacier, in places, to the saturated chalk, caused by means of the intense congelation, having, during the glacier's onward motion, dragged up the chalk until the cohesion of the chalk itself balanced the dragging action, and the mass parted. Connecting this section with the masses seen in the contorted portion of the Lower Drift on the coast-section, we seem to see the process under which these masses were dragged from their matrix, and carried onward to the sound into which the glacier disembogued. It is probably in the retirement of this glacier before the increasing warmth which ushered in the Middle-Drift period, that this thin bed of Lower Drift, which spreads over so much of Central and West-central Norfolk, had its origin, the streams of chalky silt which the grinding of the glacier over its bed produced having been spread out as the glacier receded *.

In speaking of a glacier, I do not refer to any such as those occurring in mountain-regions, but to one enveloping the whole surface of the country, as described by Dr. Sutherland, and now covering the land around Baffin's Bay†. The distribution of the three divisions of the Drift seems to show that much of the centre and south-west of Norfolk was, during the Lower-Drift period, the seat of this capping glacier, and that its principal seaward termination was in the direction of Cromer, where the bulk of its moraine was spread out under the sea, the finer silt being carried south-eastwards to form the brickearth continuation of it which stretches as far as the northern border of East Suffolk, and that much of the seat of this glacier, from its more elevated position, remained above water during the whole Middle-Drift period, only passing under the sea when the great submergence of the Upper-Drift (*c* of fig. 1) or true Boulder-clay period set in.

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3. *On the* Existence *of a* Third Boulder-Clay *in* Norfolk. By F. W. Harmer, Esq.

[Communicated by Searles V. Wood, Jun., Esq., F.G.S.]

(Abridged.)

The deposit which is the subject of this paper is shown in a pit near Trowse junction, a mile to the south of Norwich. It consists of a

* In this view the inland bed (*b* of sect. 1) would only represent the very uppermost part of the Contorted Drift of the coast, the rest of that Drift, as well as the subjacent Boulder Till, being represented by the glaciated land-surface.

† Quart. Journ. Geol. Soc. vol. ix. p. 301.

stiff whitish clay, wholly unstratified, containing much chalk débris and occasional quartzose erratics. Its appearance is so like that of the Boulder-clay (No. 7 of figs. 2 & 3) which caps the high land on each side of the valley, that but for its position it could not be distinguished from it. It occurs at a slight elevation from the bottom of the valley, resting on the chalk, and is from 9 to 15 feet in thickness. In one part of the pit it is capped by laminated sands and clays, which since their deposition have been subjected to disturbance and denudation, as represented in the accompanying section.

Fig. 1.—*Section exhibited by the pit at Trowse Junction, being that shown below the Railway Embankment in fig. 2.*

1. Chalk.
a. The clay.
b. Yellow sand, passing up into
c. Laminated blue clay, passing up into
d. Yellow sand.
e. Warp.

In May 1866, Mr. Searles V. Wood, Jun., while examining the country for the purpose of tracing the extension of the Chillesford beds in this district, discovered a still more extensive development of what I believe to be the same deposit, about three miles further down the valley, near the Lunatic Asylum, and within a few hundred yards of the well-known Thorpe crag-pit. In this case there are no laminated beds overlying it, and the clay is of a somewhat darker colour; but in other respects it corresponds with that of the last section, resting as in that case on the chalk, and but slightly elevated above the level of the River Yare. Not only is there here a large pit where the clay is exposed, but the turnpike road is cut through it for some distance.

Figs. 2 and 3 will show the position of the deposit relatively to the other beds of the district.

It will be observed that, in fig. 3, the Boulder-clay No. 7 is not represented as occurring on the north side of the valley, its place being supplied by the coarse plateau gravel No. 8. This gravel extends for some miles over what is known as Mousehold Heath, a plateau to the north-east of Norwich, forming a sheet, in places, from 15 to 20 feet in thickness. It has apparently been formed by the destruction of the Boulder-clay No. 7. That the Boulder-clay No. 7 formerly existed on this side of the valley is shown by the presence of outliers further to the east. One of these outliers (that at Strumpshaw) is overlain by the gravel No. 8.

If these sections be correct, it will appear that the deposit treated

Fig. 2.—*Section across the Yare Valley above Norwich.*

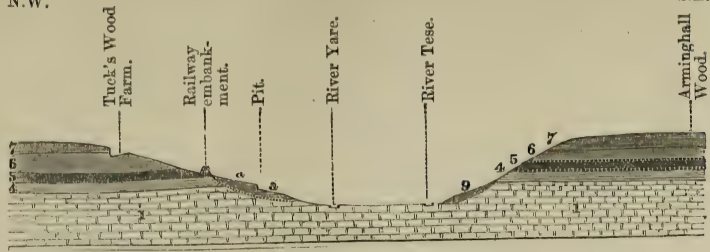
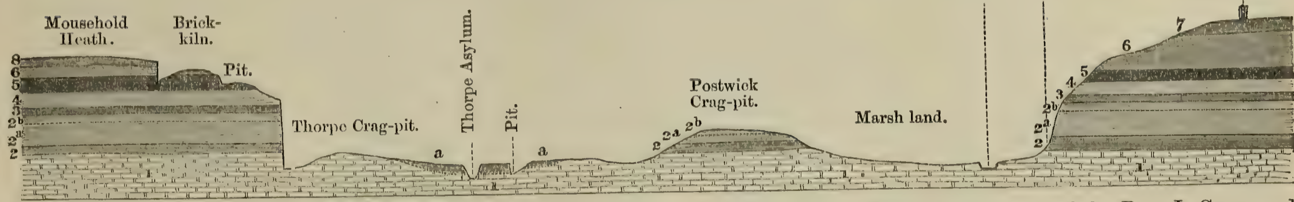


Fig. 3.—*Section across the Yare Valley below Norwich.*



1. Chalk.
2. Fluvio-marine Crag.
2*a*. Sands overlying the Fluvio-marine Crag.
2*b*. Shell-bed, being the Upper Crag of Mr. J. E. Taylor, and identified by Mr. Wood with the Chillesford shell-bed.
3. Laminated clays, identified by Mr. Wood with the Chillesford clays.
4. Sands with pebble-beds, identified by Mr. Wood with the Crag of the Bure valley.
5. Brickearth, the Lower Boulder-clay of the Rev. J. Gunn, and identified by Mr. Wood with the contorted drift of Cromer.
6. Sands, forming the Middle Drift of Mr. Wood.
7. Boulder-clay of Norfolk and Suffolk, being the Upper Drift of Mr. Wood.
8. Coarse flint plateau-gravel.
9. Valley-gravel.
a. Boulder-clay, the subject of this paper.

of in this paper is more recent, not only than the Boulder-clay No. 7, by the period required for the destruction of the latter and the subsequent formation of the great sheet of plateau-gravel No. 8, but than the gravel itself, by the time necessary for the erosion of a deep valley, at this point three quarters of a mile in width, and nearer Yarmouth much wider.

That it is not the Boulder-clay No. 7 thrown down by a fault, and exposed by the erosion of the valley, is, I think, conclusively proved by the fact that, in both the cases I have mentioned, the deposit rests directly on the chalk.

At Bawburgh, on the contrary, five miles to the west of the Trowse pit, and eight miles from that at Thorpe, there are several exposures of Boulder-clay which occur in a precisely similar position in the same valley, but whose relative position to the chalk is not shown in the sections. I believe this clay is identical with that at Trowse and Thorpe; but as its junction with the chalk is not shown, it may be that it is there the Boulder-clay No. 7 faulted to a lower level, and underlain of course by the beds that intervene between it and the chalk along the sides of the valley. At Trowse and Thorpe there are no beds whatever between the chalk and the clay.

A reference to fig. 3 will show that, while to the south of the River Yare, at Bramerton, nearly two miles distant from the pit, and *obliquely* across the valley, the Boulder-clay (No. 7) still remains, there is not a vestige of it left on the side of the river where the deposit in question occurs, the Boulder-clay having there been destroyed not merely before the valley was eroded, but before the great sheet of plateau-gravel of Mousehold Heath was deposited. The mass of the new deposit remaining at Thorpe is a quarter of a mile in length and 10 feet thick; consequently any hypothesis of its being due to a slip of a portion of bed No. 7 into the valley seems inadmissible without adopting the extreme supposition that it travelled across the valley from the Bramerton table-land.

In the case of the Trowse pit (fig. 2) an outlier of the Boulder-clay (No. 7) still remains above the spot where it occurs; but here the finely laminated sands and clays overlying it, the stratification of which indicates an upheaval and denudation, are as strong an argument against its being referable to a slip as the non-occurrence of the Boulder-clay above it is in the other instance.

JANUARY 9, 1867.

George Clark, Esq., of Dowlais; James Eccles, Esq., Springwell House, Blackburn; William Harris, Esq., M.A., Osbourne Villas, Windsor; and J. Charles Pooley, Esq., F.R.C.S., 1 Raglan Circus, Weston-super-Mare, were elected Fellows.

The following communication was read:—

On the Age *of the* Lower Brick-earths *of the* Thames Valley.

By W. Boyd Dawkins, Esq., M.A. (Oxon.), F.G.S.

Contents.

§ 1. *Introduction.*—While engaged in accumulating materials for the definition of the range in space and time of the British Pleistocene Mammalia, I was forcibly struck by the peculiar character of those found in the Brick-earths and gravels of the lower part of the Thames Valley, as compared with those from low-level deposits in other parts of Britain which seem stratigraphically to be of the same date, and which occupy the same horizon above the sea. I propose, therefore, to bring before the Society an analysis of my notes relating to the remains found on the north side of the Thames, at Ilford and Grays Thurrock in Essex, and on the south side at Crayford, Erith, and Wickham in Kent, together with some notices of the strata in which they occur.

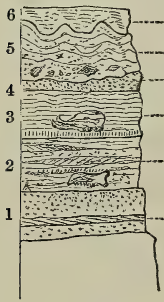
§ 2. *Literature.*—The first to call attention to these deposits was Professor Morris, who published a valuable paper on Grays Thurrock, in 1836*, and extended his investigations in 1838† to the other localities under consideration. After a careful analysis of the evidence afforded by the mollusca, he inferred that "their connexion with the ancient beds of gravel was a subject requiring further elucidation," and abstained from drawing any conclusions about their exact age. Dr. Falconer, in 1857‡, in his masterly treatise on the Mastodon and Elephant, recognized "the true Pliocene assemblage of species" at Grays Thurrock and the lower beds at Brentford, and thence inferred that they were of an earlier age than any part of the Till or Boulder-clay. Mr. Prestwich, on the other hand, in 1864, considered the deposits at Ilford to belong to the Quaternary Low-level Gravels of the Thames Valley, and to be of "late Postpliocene age"§, while Mr. Searles Wood, jun., expressed in 1866|| his conviction that the series at Ilford, Erith, and Wickham, which he terms the Lower Brick-earth, is "in age younger" than the Boulder-clay, and older than, as well as distinct from, those at Grays Thurrock. The discussion of these conflicting views we must defer until we can collect evidence both physical and palæontological on the subject.

* Mag. of Nat. Hist. (Loudon's), 1836.
† Ann. & Mag. of Nat. Hist. 1838.
‡ Quart. Journ. Geol. Soc. vol. xiv. p. 83, 1858.
§ Geological Magazine, vol. i. p. 245, 1864.
|| Geological Magazine, vol. iii. pp. 59-61, 1866.

The most convenient term for the whole series is that used by Mr. Searles Wood, jun., "the Lower Brick-earths," under which name they are described in this essay.

§ 3. *Sections*: *a*. *Ilford*. The mammaliferous deposits at Ilford consist of lenticular masses of stratified Brick-earth and fine river-gravels, and sands that are very variable in section. Those lying on the west side of the road from Ilford to Barking, immediately to the north of a rectangular entrenchment, probably of Roman date, that occupies the angle made by the junction of a small affluent with the river Roding, constitute the Uphall brickfields, elevated about 30 feet above the alluvium of the Thames. The pit in which the remarkable skull of *Rhinoceros leptorhinus*, Owen, was found by Mr. Antonio Brady in 1865, presented the following section (Fig. 1).

Fig. 1.—*Section at Uphall Pit, Ilford, south side.*



The base of the pit (No. 1) consisted of yellow sand and gravel, composed of flint for the most part, but with a few pebbles of quartz, and containing shells of *Anodon* and *Corbicula*. It is the surface water-bearing stratum of the district, and rests on the London Clay. Immediately above this is a series (No. 2) of fine sands and chocolate-coloured Brick-earths containing layers of pebbles, clayey bands, and layers of shells, which are of the usual species and very abundant. From near the bottom of this, Mr. Brady obtained the very remarkable skull above mentioned, and a vast quantity of other remains, which will be enumerated in the tabulated list of mammals from the Lower Brick-earths of the Thames Valley. There are numerous concretions also of carbonate of lime, and specimens of *Helix nemoralis*. On this is superimposed (No. 3) a fine red and grey sandy loam, with its stratified layers rippled, and containing large quantities of shells and bones. At its base is a layer of shells passing into a band of pebbles; and on this rested (the workmen informed me) the large head of the Mammoth that is preserved in the British Museum, having one of its tusks still occupying the alveolus. Next to this comes an irregular layer of gravel (No. 4) composed of flint, both angular and waterworn, of pebbles derived directly from the Eocene beds and from the Chalk, and of quartz. This is covered unconformably by a bed of clay (No. 5), Brick-earth, and gravel, irregularly stratified, with the layers highly contorted, and of such an irregular confused character that no recognized geological term will accurately express its nature. It is termed Loess* by Mr. Prestwich, and is the exact equivalent of the "Trail" described by the Rev. O. Fisher in the summer of 1866†. It contains pebbles of quartz, sandstone of probably Carboniferous as well as of Eocene age, chalk, and Lydian stone, with angular and waterworn flints. Large tabular flints and masses of greywethers (one of which weighed at least 26 pounds) occur in the lower part. There are also irregular layers of peroxide of manganese and of a ferruginous conglomerate. There is one point deserving attention in this bed: the long axes of the pebbles are in the main vertical, instead of occupying the horizontal position of those which have been deposited by water. The surface-soil (No. 6) rests on the contorted surface of No. 5, occupying the hollows and varying from 1 to 3 feet in thickness: it is merely the ordinary rain-wash of the district.

An examination of this section proves the threefold nature of the deposits. The fluviatile shells, as well as the regular stratification and the even sorting of the pebbles, show that the beds from 1 to 3, and perhaps 4, have been the deposits of fresh water undisturbed by the presence of floating ice; No. 5, on the other hand, by the confusion of its bedding, the admixture of clay with sand and gravel, and the presence of pebbles of chalk and of large transported boulders of greywethers and of flint, is proved beyond all doubt to be of glacial origin—to have been carried down by the ice and deposited, on its melting, upon the eroded top of the fluviatile deposits below. According to Mr. Prestwich, "it is formed of reconstructed London Clay and of gravel derived partly from the Boulder-clay." This view may possibly be true (and its truth or falsehood does not affect my argument); but a careful examination compels me to believe that there is no proof of the derivation of this glacial deposit from the wreck of the Boulder-clay, while on the other hand the clayey nature of the bed was probably owing to portions of the London Clay having been caught up by the ice in the higher grounds. The Boulder-clay itself to the north of Brentwood may have been composed precisely in the same manner. Whether or no this deposit be a true Boulder-clay is in my opinion altogether an open question. Its exact relation to the Boulder-clay to the north has not yet been proved, and we can only be certain that, whencesoever it came, it was transported by ice, and that it proves the climate under which it was deposited to have been much more severe than that under which the mammaliferous fluviatile gravels, free from ice-action, were formed. At the top of all is the result of the atmospheric wear and tear of the ground under temperate conditions of climate.

The mammalian remains are found scattered throughout the beds 2 and 3, more abundantly however in the layers in which the heads of Rhinoceros and Elephant occur. None of them presents any

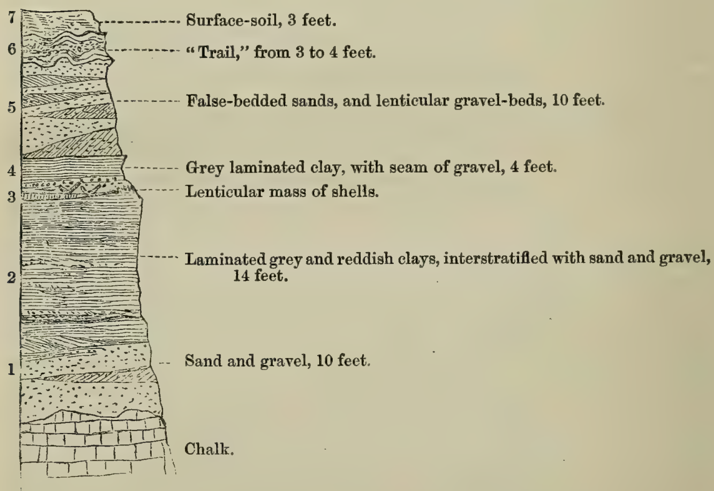
* Geological Magazine, vol. i. p. 245, 1864.

† Quart. Journ. Geol. Soc. vol. xxii. p. 553 *et seq.*, 1866.

traces of rolling, the most minute processes and the most delicate ridges being as perfect as in the day when they dropped from the decaying carcases swept down by the current. They are therefore in exactly the same position as when they originally dropped from the stranded or floating animal, and are not derived from any preexistent mammalian deposit—a very important fact in determining the palæontological age of the beds.

Other pits have been opened in the same layer of Brick-earth in the neighbourhood of Ilford, and have afforded vast quantities of remains to the cabinets of collectors for the last fifty years. Most of them are now closed. The Mammalia which are in Dr. Cotton's collection were obtained from one of these pits at a depth of 15 feet below the surface, or from the same horizon as the head of the Mammoth indicated in my section (fig. 1).

Fig. 2.—*Section at Mr. Pearson's Pit, Grays Thurrock.*



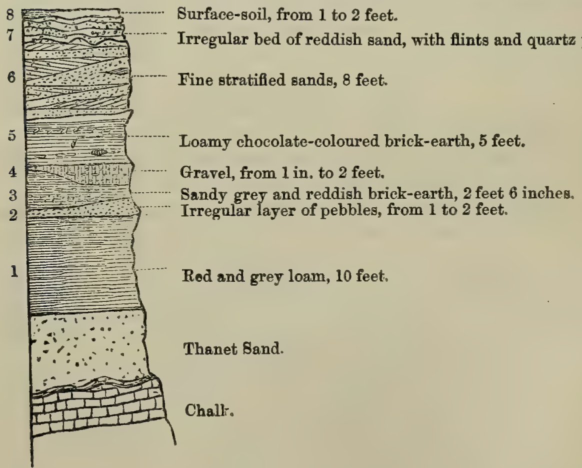
β. Grays Thurrock.—The Brick-earths at Grays Thurrock are situated on the north bank of the Thames, about 12 miles to the east of those at Ilford. The summit of the ground at Mr. Pearson's portion of the large brickfield is about 40 feet above the level of the alluvium, from which it is separated by a low bank of gravel; on the north side it abuts against the Thanet Sand; and at the point where the section (fig. 2) is taken it rests directly on the chalk, occupying an area about one mile long and a quarter of a mile broad, between Grays and Little Thurrock. On the north side of Mr. Pearson's pit the following section is presented:—Immediately on the top of the chalk is a deposit of sharp sand and gravel (No. 1), consisting of subangular and rounded flints, with a few pebbles of quartz, and containing shells of *Anodon, Corbicula, Unio,* and other characteristic fossils, among which *Helix nemoralis* is to be found. Resting conformably on this is a series of laminated grey and reddish clays (No. 2), interstratified with sand and fine seams of gravel, and containing vegetable impressions, with the usual shells and mammalian bones. The latter are comparatively rare. The colour-bands of *Helix nemoralis* are almost as brilliant as in the snails now living in our hedgerows. At the top of this is a lenticular mass of shells (No. 3) of *Unio pictorum*, *Cyclas*, *Pisidium*, *Ancylus*, &c., decreasing from a foot to a thin layer an inch in thickness, which passes in other parts of the pit into a thin band of pebbles. In its upper part is a thin layer of ferruginous gravel, composed of flint with a few pebbles of quartz. From this point Mr. Etheridge obtained a nearly perfect lower jaw of *Elephas antiquus* in 1864, which in company with him I saw *in situ* along with the antler of a Red deer and the skull of *Bos primigenius*. It is the principal mammaliferous bed in the pit. As both valves of the fresh-water shells are preserved in apposition, it is evident that they lived on the spot where they are now found. A grey laminated clay (No. 4) rests conformably upon No. 3, containing a seam of gravel, composed of flint, with a few quartz pebbles, and covered also conformably by No. 5, a series of false-bedded sands, and lenticular gravel-beds without organic remains. Lying unconformably on these is (No. 6) a *sandy* irregularly contorted layer, "the trail" of Mr. Fisher, containing angular and waterworn flints, large tabular masses of flint, and pebbles of quartz. Above this, again, is the rain-wash, composing a surface-soil of from 2 to 3 feet in thickness (No. 7).

The threefold nature of the strata already noticed at Ilford is visible also here. The beds from one to five inclusive are undoubtedly the result of currents of fresh water free from gravel-laden ice, while No. 6, as shown by the irregular size of its pebbles, its tabular flints, its contortions, and its irregular deposition, owes its presence to ice in some form or other, and was not formed under the same conditions as the fluviatile beds below. Its sandy nature may be owing to the Thanet Sand (which forms the northern boundary of the brick-pit) having been caught up by the ice and deposited on its melting, just as the clayey nature of the trail at Ilford was probably owing to portions of the London Clay being in like manner transported. The rain-wash is the product of the disintegration of the deposits at a higher level under a temperate climate. To the south of this pit is another, near Little Thurrock, which is devoid of organic remains.

None of the bones are rolled, or mutilated in any way; and all present the appearance of having been dropped directly from carcases swept down by some ancient river, in the exact positions in which they are now found. Among other curious remains of mammals are the coprolites of *Hyæna spelæa*, which, so far as I know, have not been discovered in any other river-deposit.

γ. *Crayford.* The next series of Brick-earths that comes before our notice is that situated on the south side of the Thames, fully 6 miles in a straight line from Grays Thurrock; it occupies the lower ground between Erith and Crayford, and constitutes an unbroken mass, which has been worked in many places. The two sections I have chosen for this paper are from its southern end near Crayford and its northern at Erith, and afford a fair example of the rest. The first (fig. 3) is that of the northern side of Stoneham's pit, half a mile to the north of Crayford, and marked Brickfields on the map. From it were obtained the wonderful collections of fossil mammals in the possession of Dr. Spurrell and Mr. Grantham. On the west side the Brick-earths abut directly on the Thanet Sand, which must have constituted the banks of the river in which the deposits were found. At the bottom of the pit is a thick bed (No. 1) of red and grey loam with concretions of carbonate of lime, on which rests an irregular layer of pebbles (No. 2) for the most part black and of Eocene age, with greywether pebbles and subangular flints derived directly from the chalk. No. 3 consists of a sandy-grey and reddish Brick-earth, the thinning away of which causes the layer of gravel above (No. 4), containing shells and mammalian remains, to coalesce with No. 2. No. 4 is composed of subangular and Eocene flints; it contains calcareous concretions, and is in places ferruginous. On its top is the principal mammalian bed in the pit (No. 5), consisting of loamy chocolate-coloured Brick-earth, full of calcareous concretions and shells. Above this is 8 feet of fine stratified sands (No. 6), with an abundance of the usual freshwater shells. Resting unconformably on this is an irregular reddish-sandy contorted stratum (No. 7), full of large flints, both angular and waterworn, and of quartz pebbles. The confusion of its bedding is a remarkable surface-contrast to the horizontality of the beds below. Above this is the soil (No. 8).

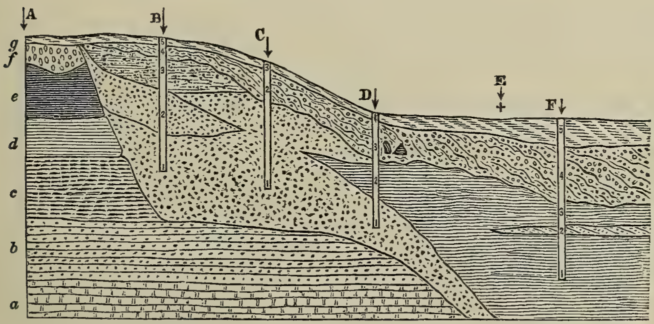
Fig. 3.—*Section at Stoneham's Pit, Crayford.*



In this section also the threefold condition of the beds, indicative of different circumstances of deposit, is observable. Its discrepancy with the admirable section given in 1838 by Professor Morris may be explained by the variability of the beds in the enormous pit. The top of the Brick-earth is about 50 feet above the alluvium of the Thames.

δ. *Erith.* The second brick-pit is situated on the right-hand side of the road from Erith to Crayford, immediately after it has crossed the North Kent Railway, and about one mile from that at Crayford. It is peculiarly interesting as affording a section from the top of the Woolwich beds down to the Chalk, as well as proving that the Brick-earth rests on the edges of the Eocene strata, and in a hollow excavated in the Chalk. In the diagram (fig. 4) I have not attempted to give the horizontal distribution of the strata, but merely the vertical thickness.

Fig. 4.—*Section at White's Pit, Erith.*



Vertical scale $\frac{1}{20}$ in. to a foot. Horizontal extent not represented.

a. Chalk with flints. *b.* Thanet Sand, with a layer of tabular flints at the base. *c.* Woolwich sand. *d.* Stiff black clay. *e.* Lenticular mass of shells. *f.* Bed of black Eocene flints, with quartz pebbles. *g.* Surface-soil.

At the base both of the Eocene beds and of the Brick-earths lies the Chalk with flints, nearly horizontal, and quarried to a depth of more than 100 feet (*a* of section A). Above this is the Thanet Sand with the usual layer of tabular flints at its base (*b* of the same section), and with a dip of 10° to the N.N.W. It is overlain by the Woolwich sand, reddish-brown in colour (*c*), containing a bed of stone, and in its upper part consisting of sandy and loamy layers with *Septaria* and many shells, on which rests conformably a stiff black clay with few shells (*d*). Above this is a lenticular mass of Eocene shells, very irregular (*e*), capped by a bed of black Eocene flints with a few quartz pebbles (*f*), at the top of which is the surface-soil (*g*). *a* and *e* are peculiarly interesting as presenting the beds, *in situ*, whence some of the materials of the "Trail" covering the Brick-earth were derived.

At 50 paces to the south the gravel-series comes suddenly in, at section B, where 14 feet of regularly stratified sandy gravel, composed of Eocene flints, angular and waterworn flints, and quartz pebbles, ferruginous in places and charged with peroxide of manganese (No. 1), is overlain by a sharp sand containing Eocene pebbles (No. 2), and this again by a sandy loam (No. 3), in a trough of which is a layer (No. 4) of rearranged black clay from *d* of section A; above is the surface-soil No. 5. These beds abut sharply on the Woolwich series, and rest on the Thanet sand. Section C, taken 71 paces further to the south, reproduces the beds 1 & 2 of the previous section covered unconformably by a mass of black clay (2) highly contorted and full of black Eocene pebbles. Still further to the south and close to the bridge crossing the tramway is section D, showing 5 feet of gravel of the same character as in B & C, covered conformably by regularly stratified sandy Brick-earth (No. 2), upon the eroded surface of which is a mass of clayey and gravelly "trail," mixed up in a remarkable manner, and containing in its mass large numbers of comminuted Eocene shells derived from *e*, of section A. A large block of black clay with its angular shape preserved (shown by the thick horizontal lines in the section) was resting in the middle of this bed. Around it passed the highly contorted layers of "trail," and close to it was a mass of comminuted shells. It corresponds exactly with the black clay (*d*) of A. Section E, taken at the deepest point in the brick pit, shows a thickness of 65 feet of chocolate-coloured and grey loams, with sandy partings and horizontally bedded lenticular patches of gravel containing freshwater shells and mammalian bones, and covered by 4 feet of "trail" and one foot of surface soil. The section F, close to the highroad, shows a marked decrease in the thickness of the beds, the Brick-earths at its base being not much more than 12 feet thick (No. 1), covered by a foot of false-bedded sand with shells (No. 2), above which is a layer of Brick-earth with calcareous nodules (No. 3). Upon this rests unconformably the "trail" (No. 4), full of Eocene shells, of its usual irregular structure, from 6 to 8 feet thick, and capped by the surface-soil (No. 5).

The summit of the Brick-earth is about 45 feet above the level of the Thames alluvium. In this pit also we have the threefold nature of the deposit repeated as in the rest. We can not only see the stones and masses of Eocene shells and clay imbedded in the "trail," but we can also trace them to the beds from which they were torn. It is altogether impossible that an angular mass of clay could be transported more than 150 yards, preserving its angularity, and deposited in such a matrix by any other agency than that of ice. It would in a short time have been destroyed by the wash of water under ordinary temperatures. The horizontality of the beds below proves, as in the other cases, that the river which deposited them was not burdened with melting ice.

ε. *Wickham.* The last of the series of Brick-earths which form the subject of this essay is that about half a mile north of East Wickham Church, on the left side of the road leading from thence to Plumstead. It is extensively used in brickmaking. The section now exposed presents 50 feet of chocolate-coloured loams, devoid of shells and bones, but highly charged with snow-white crystals of carbonate of lime, which form ramifications in every direction. The layer of sand and gravel, whence the remains in Dr. Spurrell's collection, and in the museum of the Royal Artillery at Woolwich, were obtained, is now worked out. Mr. Flaxman Spurrell, however, who carefully worked at it some years ago, has informed me that it occurred near the bottom of the pit. In the upper part the Brick-earth passes into the tilth without any well-marked surface-soil, excepting that arising from its own atmospheric disintegration, and is at the present time being swept down into the valley below by the rain and frost. It is, indeed, undergoing a process of denudation such as none of the other sections present. Whether or no the absence of "trail" can be ascribed to this cause may perhaps be an open question; but on the whole I am inclined to believe that this pit afforded no exception to the rest, and that the "trail" has been removed by the same process that is going on now.

The excess of carbonate of lime in the strata will probably account for the absence of the usual freshwater shells. The mammalia present no direct evidence as to the relation in point of time of this to the other Brick-earths, as they consist merely of the Urus, Bison, Horse, Mammoth, and the tichorhine and leptorhine Rhinoceroses. As, however, it stands at about the same height above the level of the Thames alluvium (from 30 to 40 feet) as the rest, and as no remains of Reindeer have been found in it, I am inclined to agree with Professor Morris in classifying it with the rest.

In Dr. Spurrell's collection are two metacarpals of Bison from this pit, with the first phalanges in their natural position, which of course proves that the bones must have been held together by ligaments at the time of deposit.

On the opposite side of the valley is an admirable section of the silted-up bed of an affluent into the stream that once flowed through the valley. The Thanet Sand is cut down to the Chalk, and the hollow thus formed is filled with Brick-earth of the same nature as that just described.

4. *Inferences from Sections.*—An examination of the above sections (Wickham excepted) proves that the beds which they each represent are of precisely the same geological date, whatever that may be. All of them exhibit the three conditions of deposit in the same order, namely:—First of all a comparatively temperate period, during which the water brought down sand and gravel, and was not burdened with ice-rafts. This is proved by the even bedding and the horizontality of the fluviatile beds, as well as by the regular sorting of the sands and gravels. Then, after an interval of uncertain duration, represented in all the sections by the erosion of the upper fluviatile beds, came a period of intense cold, in which stones, sand, clay, and, indeed, whatever came within the reach of the ice in the neighbourhood, was caught up and deposited in a most confused jumble on its melting; and, lastly, after this the rain-wash on the top of all indicates the obtaining of temperate conditions in the Thames Valley. The "trail," totally devoid, so far as I know it, of organic remains, may be the ice-wash (if I may coin a term) of the neighbour-

hood, and the result of the melting of masses of ice formed in the winter in the higher grounds, and sliding down into the lower at the break-up of the frosts in the spring. This hypothesis would explain its unconformity to the beds on which it rests. The identity of physical conditions, then, as well as the evidence afforded by the Tables of the fauna given below, proves that Mr. Searles Wood's view, that the Grays Thurrock deposit is of later date than the rest, is altogether untenable, and that Professor Morris was right when, in 1838, he united them into one group.

5. *Testacea.*—Let us now pass to the evidence afforded by the Testacea. The following list of shells, partly fluviatile and in part terrestrial, is made principally from my own notes taken in

List of Testacea from the Lower Brick-earths.

Freshwater Species.	Ilford.	Grays Thurrock.	Crayford.	Erith.	Wickham.
Corbicula fluminalis	*	*	*	*	*
Cyclas cornea, *Linn.*	*	*	*	*	
Pisidium amnicum, *Müll.*	*	*	*	*	
Unio pictorum, *Linn.*	*	*			
U. litoralis, *Drap.*	*	*	*	*	
Anodon cygneus, *Linn.*	*	*	*	*	
Limnæa peregra, *Müll.*	*	*	*		
L. auricularia, *Linn.*	*				
L. stagnalis, *Linn.*	*	*	*	*	
Planorbis carinatus, *Müll.*	*	*	*	*	
P. corneus, *Linn.*	*	*	*	*	
Hydrobia marginata, *Michaud*	...	*			
Paludina vivipara, *Linn.*	*	*	*	*	
Bythinia tentaculata, *Linn.*	*	*	*	*	
Ancylus fluviatilis, *Müll.*	*	*	*	*	
Valvata piscinalis, *Müll.*	*	*	*	*	
Terrestrial Species.					
Helix hispida, *Linn.*	*	*	...	*	
H. nemoralis, *Linn.*	*	*	*	*	
H. caperata, *Mont.*	*	*	*	*	
Pupa marginata, *Drap.*	...	*	*	*	
Carychium minimum, *Müll.*	*	*	*	*	

each of the pits, partly from the valuable collections of Dr. Spurrell, Mr. Grantham, Mr. Brady, and Dr. Cotton. The fluviatile shells were found in groups occupying, for the most part, in death the spots on which they had lived on the then bottom of the river. The land-shells were comparatively rare and scattered about, and probably were swept down by the floods in the same manner as the mammalian bones. All the species are now alive in Britain except *Unio litoralis* and *Corbicula fluminalis*, the former being now found in the rivers of Auvergne, and the latter ranging from the river Nile throughout the streams of the central plateau of Asia and the Himalayas (having abounded at the bottom of the ancient lake which is now the fertile vale of Cashmere), as well as throughout the great plain of China, drained by the Hoangho and Yangtse Keang rivers *. Sir Charles Lyell states in 'The Antiquity of Man' (p. 225), that *Hydrobia marginata* is also extinct in Britain.

The range of the species through the different sections proves that the strata they represent were deposited under precisely the same conditions, and therefore probably at the same time.

6. *Mammalia. α. List of Species.* We have already seen that the identity of physical conditions and the distribution of the Testacea prove that the strata which form the subject of this paper are of the same geological date. The following Table of the mammalia found

Fossil Mammalia of the Lower Brick-earths of the Thames Valley.

	Ilford.	Grays Thurrock.	Crayford.	Erith.	Wickham.
1. Felis spelæa, *Gold.*	*	*	*	*	
2. F. catus, *Linn.*	...	*			
3. Hyæna spelæa, *Gold.*	...	*	*		
4. Ursus spelæus, *Gold.*	*	*	?		
5. U. arctos, *Linn.*	*	*	*		
6. Canis lupus, *Linn.*	*	*	*	*	
7. C. vulpes, *Linn.*	...	*			
8. Lutra vulgaris, *Erxl.*	...	*			
9. Bos primigenius. *Boj.*	*	*	*	*	*
10. Bison priscus, *Ow.*	*	*	*		*
11. Megaceros Hibernicus, *Ow.*	*	*	*		
12. Cervus elaphus, *Linn.*	*	*	*		
13. C. capreolus, *Linn.*	?	?			
14. Elephas antiquus, *Falc.*	*	*	*	*	
15. E. primigenius, *Blum.*	*	...	*	*	
16. E. priscus, *Gold.*	...	*			
17. Equus fossilis, *Ow.*	*	*	*	*	*
18. Rhinoceros tichorhinus, *Cuv.*	*	...	*		*
19. R. leptorhinus, *Ow.*	*	*	*		*
20. R. megarhinus, *Christ.*	*	*	*		
21. Sus scrofa, *Linn.*	...	*			
22. Hippopotamus major, *Desm.*	...	*			
23. Castor fiber, *Linn.*	*	*			
24. Arvicola amphibia, *Desm.*	*	*	*		

in each locality adds cumulative proof. None of the species have been accepted on hearsay, but are the result of the study of the collections in the possession of Drs. Cotton and Spurrell, Messrs. Grantham, Brady, and Wickham Flower (to whom I take this opportunity of returning my best thanks), and of those in the College of Surgeons and British Museums, and in the Museum of Practical Geology. The list of animals given under the heading of Erith was

* On the authority of Dr. Lamprey, Journ. of North China branch of the Royal Asiatic Society, No. 2, 1866.

derived partly from White's Pit (fig. 4), and partly from Slade's Green, between the former and Crayford.

The comparative abundance of the species from each of these localities is also worthy of note. *Bos primigenius* is abundant in all; *Elephas primigenius* is most abundant at Ilford, Erith, and Crayford; while *E. antiquus* is comparatively rare. The latter species on the other hand is most frequently met with in the brick-pits of Grays Thurrock.

Before, however, I pass on to the range of the mammalia found in these deposits, there remains a most important point to be discussed. Were these animals found in different portions of the same section, the older forms in the lower, the newer in the upper parts? Such, indeed, was the hypothesis upon which Dr. Falconer strove to reconcile the association, at Brentford, of Pliocene species with animals clearly proved to have been of Postglacial age, in the journal of this Society*; and such was the view he took of the mammalia found at Crayford. Knowing the value of the smallest of his hints, I have over and over again gone over the pit in company with Dr. Spurrell, and with Mr. Flaxman Spurrell, to find evidence for this view, and have come back each time more and more convinced that the mammalian beds, 4 & 5 of fig. 3, are of the same age, and that the animals found in those beds were living in the Thames Valley at the time of their deposit. The evidence, indeed, of the association of species at Crayford is corroborated by that of the sections at Ilford and Grays Thurrock. The proof of the tichorhine Rhinoceros being associated with the leptorhine and megarhine species, is to be found in the cabinets of Drs. Cotton and Spurrell, and of Mr. Grantham. For the proof that these three species have been rightly determined, I must refer to the monographs on their dentition in the Natural History Review†, and to that now in the hands of the Geological Society.

β. Range of the species. The above list of mammalia enables us to draw some important inferences about the deposits whence they were derived. The interest centres more particularly on the genera which composed Baron Cuvier's group of the Pachydermata, namely, *Elephas* and *Rhinoceros*. The Carnivora are such as might have been derived from any Pleistocene cave- or river-deposit in Britain; and, with one exception (the Cave-Bear), they still survive in some quarter of the world. Of the Ruminants, the great Urus‡ probably survives in our larger breeds of domestic cattle, and the Aurochs or Bison still ranges through the temperate zones of North America, and lingers on in Europe in the Lithuanian forests, under the protection of the Russian government. Extinct in the high northern latitudes of Asia and America, it has left its bones, along with those of the Elk, Reindeer, Musk-sheep, and Mammoth, in the frozen loam that caps an ice cliff in Eschscholtz Bay§, to prove that it

* Quart. Journ. Geol. Soc. vol. xiv. p. 83, 1857. † Vol. v. p. 399, 1865.

‡ See paper by the author in Quart. Journ. Geol. Soc. vol. xxii. p. 391, 1866.

§ Zool. H.M.S. 'Herald;' and Beechey's 'Voyage to the Pacific,' Appendix by Dr. Buckland.

shared with those animals the northern shores of the American continent. Of the Cervidæ, the Irish Elk is alone extinct, and, having begun to live in Præglacial times in the Norfolk forest-bed, and having sufficient elasticity of constitution to survive the cold of the Glacial period, ranged through the Postglacial division of the Pleistocene, and at last died out in the Prehistoric period, not without giving room for the suspicion that the hand of man was one of the causes of its extinction. The Red Deer and the Roe Deer, its contemporaries with a parallel range, have lived on to the present time in Britain, protected by the law, but dwarfed in stature from their banishment to the wilder and more inhospitable regions by the inroads of civilization on their ancient haunts. The three species of Elephant, all of them utterly extinct, have a very unequal range in both space and time. The Mammoth, *Elephas primigenius*, occurs in the Præglacial forest-bed of Norfolk, and, having been defended from the intense cold of the Glacial period by his clothing of hair and fur, is most abundant in the Postglacial deposits of France, Germany, and Britain, and in the frozen gravels of Russia in Europe and Asia, and of Eschscholtz Bay on the shores of North America. Its remains are found in the Europeo-Asiatic continent north of a line passing through the Pyrenees, the Alps, the northern shores of the Caspian, Lake Baikal, Kamtschatka, and the Stanovoi Mountains. The discovery of the frozen carcase by a Tungusian hunter in Siberia in 1790, and the representation of it, graven by the Reindeer-folk in the caves of the Dordogne*, on a fragment of fossil ivory, prove that it was well defended against the cold; and its association with the Lemmings at Salisbury, with the Musk-sheep at Freshford† near Bath, and with the Reindeer universally in the Postglacial deposits, proves that it was fitted for enduring a very low temperature. The *Elephas antiquus*‡, found abundantly in the forest-bed of the Norfolk shore, and in some few deposits of unequivocally Postglacial age (as those of Lexden, Oxford, and Bedford), occurs in the Pliocene strata of France and Italy, and in the caverns on the shores of the Mediterranean, at Malaga, Gibraltar, Sicily, and Malta. It is, indeed, as remarkable for its southern as the former species is for its northern range. It appears to me to be a Pliocene species that lived in great numbers in Britain while the Præglacial deposit on the Norfolk shore was being formed, that was gradually supplanted by the Mammoth and driven southward by the lowering of the temperature. It occupied in Pleistocene times precisely the same climatal relation to the Mammoth as the Waipiti does now to the Reindeer in North America, the former being adapted for a mild or even hot climate, the latter being fitted to endure all the severity of an Arctic winter. As the climate gradually became colder, the former species would replace the latter in any given district; as the climate became warmer it would yield to the latter. To some such oscillation of temperature I would

* Revue Archéologique, 1866.

† All the Mammalia cited from British localities have been examined by the author, and, for the most part, have not yet been put on record.

‡ See Dr. Falconer's papers, Quart. Journ. Geol. Soc. vol. xiii. p. 307, 1857; vol. xxi. p. 253, 1865.

attribute the occurrence of the remains of these two species in the same deposits. The headquarters of the *Elephas antiquus*, into which the Mammoth never penetrated, was in Pleistocene times Southern Europe, bounded to the north by the Alps and the Pyrenees—just as that of the Mammoth, in which *Elephas antiquus* has never been discovered, is North Germany and the large wooded plains of Northern Russia. The debateable district, over which each of these species ranged according to the season, would, on this hypothesis, be the districts between these two areas, England and Central Europe, where their remains have been found commingled: the fact that the varying temperature in northern regions now regulates the migration of the herbivores, and causes a continual oscillation of animals* to and fro over a given area, lends great weight to these views. The third species of Elephant, *E. priscus*, has only been determined by the late Dr. Falconer in three British localities—Grays Thurrock in Essex, an uncertain locality in the Thames valley, and in the forest-bed of the coast between Cromer and Lowestoft. It occurs also in Italy (in the Pliocene strata of the Romagna) and possibly in Central France. The Horse varies considerably in size; and to those who think themselves justified in ascribing the larger remains to the true Horse, and the smaller to the Zebra, Quagga, or Ass, there may seem reason for believing that two species or varieties of *Equus* were living at the time the Lower Brick-earths of the Thames valley were being deposited†. The examination, however, of a very large series of Equine remains from all parts of England, and from Pleistocene deposits in France and Germany, leads me to the conclusion that, in the days before Man's influence in modifying the animals in contact with him was felt, there was considerable variation in the size of the Horse, dependent probably upon various conditions of life, food, habitat, and climate; and as these varieties constitute an unbroken series from animals of the largest to those of the smallest size, there being no difference of form, I see no reason for M. Puel's‡ and Professor Owen's insertion of the Ass into the list of the Pleistocene mammalia. The range of the *Equus fossilis* was coextensive with that of the Mammoth in the Pleistocene period; it is unknown in the Pliocene strata of France, Germany, and Italy; and its first appearance is in the Præglacial forest-bed of Norfolk. It cannot be differentiated specifically from the common Horse.

We have already seen the unequal ranges of the three species of fossil Elephant; the species of Rhinoceros found in the deposits under consideration afford an exact parallel. The stout-limbed massive tichorhine Rhinoceros, possessed of two horns, and with foldless skin, ranged throughout Pleistocene Europe and Asia, north of a line passing through the Alps, Pyrenees, the head of the Caspian, and Lake Baikal. This species did not cross, along with the

* See "Introduction to British Pleistocene Mammalia," Palæont. Soc. vol. for 1864, p. 46 *et seq.*

† See Owen, article "Equus," Foss. Mamm. 8vo, 1846.

‡ Bull. Soc. Géol. Fr. 2me série, tom. ix. p. 244, 1854.

Mammoth, Behring's Straits into America; nor in time did it range so far back as the latter animal, being absent from the forest-bed, and having the Brick-earths at Ilford, Crayford, and Wickham as its earliest resting-places. It was a northern form, ranging up to the highest latitudes, and, unlike any of the living species, had its body defended from the cold by a thick clothing of wool. The second, or the leptorhine, species is that determined first of all by Professor Owen* from Clacton, and is named from its supposed identity with the leptorhine species of Baron Cuvier from the Val d'Arno. As, however, the former is defined by Professor Owen as the "Rhinoceros à narines demi-cloisonnées," and the latter by Baron Cuvier as "R. à narines non cloisonnées"†, it is clear that these two species are not identical. In consequence of the conflict of evidence as to the existence of a bony nasal partition in the Italian skulls upon the drawings of which Baron Cuvier's species was based, and because he has confounded together all the non-tichorhine species of Pleistocene Rhinoceros under the common name of leptorhine, I have preferred to retain the name of *R. leptorhinus* of Professor Owen, as having been used in Britain for a group of remains truly and accurately defined under that name in 1846, rather than adopt the name which the late Dr. Falconer applied to the same species, *R. hemitœchus*, by turning Professor Owen's definition of Rhinoceros à narines demi-cloisonnées into a Greek specific name‡. The leptorhine species of Owen ranges, in space, throughout England and Auvergne, and in time from the Thames-valley deposits to the epoch of the caverns of Gower, Wookey Hole, Kirkdale, and of the deposit of Bielbecks in Yorkshire. Unless that of Clacton turns out to be Præglacial, which is not yet proved to be the case, it has not been found in any strata formed anterior to the great Glacial era. It was a slender-limbed animal, and, from its limited northern range, was probably not able to endure the same severity of climate as its tichorhine congener. The third species, or *Rhinoceros megarhinus* of De Christol§, which I was able to determine satisfactorily as occurring in Britain in 1865‖, stands in the same relation to the tichorhine species as the *Elephas priscus* does to the Mammoth. Its headquarters are to be found in the Pliocene deposits of Italy, whence it ranges northwards across the Alps into the French Pliocene beds. I am indebted to the courtesy of the Rev. John Gunn for being able to determine its remains in the forest-bed of Cromer. In the Thames-valley deposits under consideration, it is comparatively abundant, especially so at Grays Thurrock. With the exception of the above localities, it is found nowhere else in Britain. I am inclined to view it as one of the links binding the Pleistocene period to the Pliocene. Like the leptorhine it was possessed of two horns and was of slender build. It is differentiated

* *Op. cit.* pp. 356–382.

† Oss. Foss. tom. ii. p. 110. 4to. 1825. See Nat. Hist. Rev. vol. v. (1865), pp. 400–1.

‡ The *R. leptorhinus* of Dr. Falconer = the *R. megarhinus* of De Christol, and it is so used throughout his paper.

§ Ann. Sc. Nat. 2d series, Zool., tom. iv. p. 42–112, 1865.

‖ Nat. Hist. Rev. vol. v. p. 403, 1865.

from the latter by the enormous development of the nasal bones and the absence of the cloison or long partition between the nostrils.

Of the Wild Boar there is nothing to be said, except that it ranges from the forest-bed of Norfolk up to the present day, and is probably the lineal ancestor of that still alive in the wilder parts of Europe. It was, however, comparatively rare in the Pleistocene period, occurring only in 4 out of 26 ossiferous caverns, and in 4 out of 35 stratified deposits, which constitute my Tables of distribution of British mammalia, which I hope shortly to publish in the works of the Palæontographical Society.

The *Hippopotamus major* is to be placed in precisely the same category as the *Elephas antiquus*—as a Pliocene species that passed northwards over the Alps into France, England, and Germany, into what must have been the area in which the Northern and Southern faunæ met. Its occurrence in association with the remains of northern animals may be explained in the same way as that of *Elephas antiquus*, and is probably due to oscillation of climate—a view that Sir Charles Lyell has adopted in his 6th edition of 'The Elements,' in 1865.

The last two species, the Beaver and the Water-Rat, present no points that are useful for my present purpose relative to the Brick-earths in question.

γ. *Relation to Præglacial and Postglacial Faunas.* Such is the brief epitome of the fossil species, and their range in space and time; let us now pass to the consideration of the value of their evidence in stamping the relative age of the deposits in which they occur, as compared with the Præglacial forest-bed, the Postglacial river-beds, and the ossiferous caverns which are probably of Postglacial age. The following Table is an abstract of the larger one bearing on this question, which was constructed after an examination during more than five years of British and Irish collections of mammalia.

A study of this Table enables us to draw important inferences as to the geological age of the Lower Brick-earths. Passing over all the species which are common to the 4 columns, and, therefore, of no classificatory value, the presence of *Elephas priscus* and *Rhinoceros megarhinus* indicates the affinity of the group to the Præglacial deposits of Norfolk and to the foreign Pliocene strata. The tichorhine and leptorhine Rhinoceroses, on the other hand, point towards deposits of clearly defined Postglacial age. It was probably this peculiar clash of evidence that led Dr. Falconer* to believe that the organic remains *must* represent two geological epochs, and especially because these animals had never before been found in association. For any other fact in corroboration of his hypothesis I have sought in vain. The beds under consideration are also as remarkable for the absence of some as for the presence of others of the Pleistocene mammals. The Præglacial Trogonthere, *Rhinoceros Etruscus*, *Elephas meridionalis*, *Sorex moschatus* and *Cervus dicranios* are absent on the one hand, the entire group of Postglacial Arctic mammalia, the Glutton,

* *Op. cit.*

Table showing the relation of the Mammals of the Lower Brick-earths to the Præglacial and Postglacial Fauna.

	Forest-bed, Præglacial.	Brick-earth, Thames Valley.	River-bed, Postglacial.	Caverns.
Homo, *L.*	...	...	*	*
Rhinolophus ferrum-equinum, *Leach*	...	...	...	*
Vespertilio noctula, *Schreb.*	...	...	...	*
Sorex moschatus, *Pall.*	*			
S. vulgaris. *L.*	*			
Talpa Europæa, *L.*	*			
Ursus arctos, *L.*	...	*	*	*
U. spelæus, *Gold.*	*	*	*	*
Gulo luscus, *Fab.*	...	...	...	*
Meles taxus, *L.*	...	...	...	*
Mustela erminea, *L.*	...	...	*	*
M. putorius, *L.*	...	...	*	*
M. martes, *L.*	...	...	...	*
Lutra vulgaris, *Erxl.*	...	*	...	*
Canis vulpes, *L.*	*	*	*	*
C. lupus, *L.*	*	*	*	*
Hyæna spelæa, *Gold.*	...	*	*	*
Felis catus, *L.*	...	*	...	*
F. antiqua, *Cuv.*	...	...	...	*
F. spelæa, *Gold.*	...	*	*	*
Machairodus latidens, *Owen*	...	..	...	*
Megaceros Hibernicus, *Owen*	*	*	*	*
Alces malchis, *Gray*	...	...	...	*
Cervus tarandus, *L.*	...	...	*	*
C. capreolus, *L.*	*	*	...	*
C. dicranios, *Nesti*	*			
C. elaphus, *L.*	*	*	*	*
Ovibos moschatus, *Desm.*	...	...	*	
Bos primigenius, *Boj.*	...	*	*	*
Bison priscus, *Owen*	...	*	*	*
Hippopotamus major, *Desm.*	*	*	*	*
Sus scrofa, *L.*	...	*	*	*
Equus fossilis, *Owen*	*	*	*	*
Rhinoceros Etruscus, *Falc.*	*			
R. megarhinus, *Christ.*	*	*		
R. leptorhinus, *Owen*	...	*	*	*
R. tichorhinus, *Cuv.*	...	*	*	*
Elephas meridionalis, *Nesti*	*			
E. priscus, *Gold.*	*	*		
E. antiquus, *Falc.*	*	*	*	*
E. primigenius, *Blum.*	*	*	*	*
Lemmus sp., *Link*	...	...	*	
Lepus cuniculus, *Pall.*	...	...	...	*
L. timidus, *Erxl.*	...	...	...	*
Lagomys spelæus, *Owen*	...	...	*	*
Spermophilus erythrogenoides, *Falc.*	...	...	...	*
S. citillus, *Pall.*	...	...	*	
Arvicola pratensis, *Bell*	...	...	...	*
A. agrestis, *Flem.*	...	...	...	*
A. amphibia, *Desm.*	...	*	...	*
Mus musculus, *L.*	...	...	...	*
Castor trogontherium, *Fisch.*	*			
C. Fiber, *L.*	*	*		

Lemming, Marmot, Musk-sheep, Elk, and Reindeer, on the other. It may be objected that negative evidence has no place here, and that the absence of these animals from the river-deposits does not prove their non-existence in the district. When, however, we consider the vast stores of remains belonging to all the great classes of mammalia living at the time in Europe, and indicating the presence of twenty-four out of the fifty-three British Pleistocene species, the absence of the whole northern Postglacial group, and of the four characteristicspecies of the forest-bed, is fairly entitled to weight in the determination of their relative age. The absence of the Reindeer is peculiarly valuable, from its great abundance in nearly all the Postglacial deposits. From these premisses one conclusion inevitably follows:—that the Lower Brick-earths of Crayford, Erith, Ilford, and Grays Thurrock, as affording remains of mammals in part peculiar to the forest-bed of Norfolk and the Pliocene deposits of France and Italy, in part to the Postglacial deposits of England, France, and Germany, occupy a middle point in time between the two, being more modern than the former and more ancient than the latter.

7. *The Lower Brick-earths not of late Postpliocene age.* At this point in the argument we must pause to consider the view of the great authority on river-deposits, Mr. Prestwich. He stated, in 1864*, that the Lower Brick-earths at Ilford, because they occupy a low level, are of late Postpliocene age,—an inference that is diametrically opposed by the mammalian evidence, and which if proved to be true would overthrow the Palæontological value of the labours of all the Tertiary mammalogists. These seem to me insuperable obstacles to its adoption. If all the superficial deposits in the valley of the Thames have been left by its waters at different levels above the present stream, those levels will give the relative antiquity of the beds of loam, sand, or gravel, *provided that the land has remained stationary*. But if the land was elevated in one place and depressed in another, as we are bound to admit was the case throughout the Pleistocene period, then the evidence of level is of no importance, and the low-level deposits may in some cases be of the same antiquity as those at higher levels; or, if we suppose a valley with a river flowing through it to be depressed beneath the surface of the sea, the higher marine deposit may even be *younger* than the lower fluviatile one. A notable instance of this is to be found in the Boulder-clay overlying the mammaliferous bed on the Norfolk shore. Unless, therefore, in any particular case, there be no oscillations of level, and unless there be no interference by the sea with the cutting-down action of the river, relative height is no standard of age. No proof of either of these conditions necessary to the truth of Mr. Prestwich's theory is to be found in the lower part of the Thames Valley. On the contrary, Præglacial Britain was depressed to a depth of 2000 feet in Scotland, according to Sir. Charles Lyell†. Thence the Glacial sea gradually shallowed until the line of the Thames Valley roughly marked its southern boundary. That this valley should not have shared in some degree in this depression is to

* *Op. cit.* † Antiquity of Man.

me perfectly incredible. Whether or not the true Boulder-clay was ever deposited in the Thames Valley proper, is an open question; but the fact that it lies in the basin of its affluent the Roding, as well as in those of the next two rivers to the north, the Blackwater and the Colne, would prove that the main features of the country were sketched out before the Boulder-clay period, and that it also was excavated in Præglacial times.

Again (to test the truth of relative levels being any guide to antiquity in some instances), the mammal-bearing stratum of the Norfolk shore is proved by its fluviatile shells to have owed its origin to a river; it lies below high-water mark, at a slightly lower level than the Lower Brick-earths; and yet no one would venture to call it of late Postpliocene age for that reason, because the Boulder-clay happens to lie on its top. Were it not for this accident, or had the Boulder-clay been lost by denudation, it would be precisely in the same category as those deposits. Under these circumstances I cannot agree with Mr. Prestwich in considering them of late Postpliocene age, but believe that the evidence adduced in this paper is sufficient to relegate them to a higher antiquity than any river-deposits in Britain, the Forest-bed only being excepted.

8. *Summary of Evidence as to Age.*—In conclusion I will briefly recapitulate the inferences which the foregoing premisses seem to me to warrant. The direct relation of the Lower Brick-earths to the Boulder-clay being not absolutely proved, it is very probable that the "trail" may be its equivalent in point of time. The superposition of the "trail" over the Lower Brick-earths indicates a far lower temperature at the time of the accumulation of the former deposit than at that of the latter. The mammals form a connecting link between the fauna of the Forest-bed and that of Postglacial times. The absence of the Arctic group of mammals implies also an absence of cold such as prevailed in the Glacial and Postglacial epochs, and adds to the probability of the beds in question being of an age anterior to the great refrigeration of our climate. For these reasons I would suggest the insertion of the Lower Brick-earths in the classified list of Pleistocene deposits as follows:—

1. Forest-bed of Norfolk—climate temperate.
2. Lower Brick-earths of Thames Valley—climate comparatively temperate.
3. Glacial deposits—climate severe.
4. Postglacial deposits—climate severe, but gradually becoming temperate.

January 23, 1867.

The Rev. George Deane, B.A., B.Sc. (Lond.), Harrold, Bedfordshire; Joseph Gledhill, Esq., F.M.S., King's Cross, Halifax, Yorkshire; and James Parker, Esq., of Oxford, were elected Fellows.

The following communications were read:—

1. *On the* Occurrence *of* Consolidated Blocks *in the* Drift *of* Suffolk. By George Maw, Esq., F.L.S., F.G.S., &c.

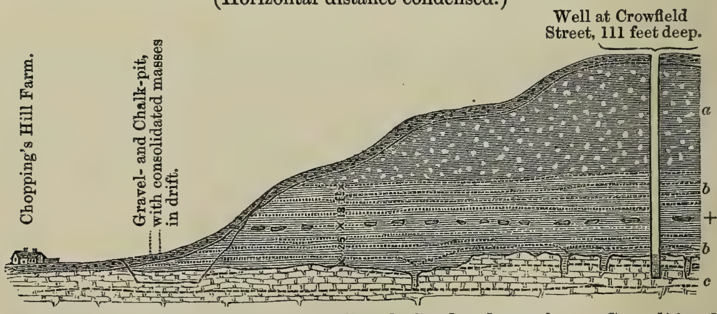
As a contribution to the evidence on the geological position of the blocks of saccharoid sandstone scattered on the surface of many parts of the chalk-districts, I beg to lay before the Society a brief account of the occurrence of similar blocks of large size in the Drift of Suffolk, both *in situ* and on the surface. In the chapter on "Druid Sandstones" or "Sarsen Stones," in Mr. Prestwich's paper on the Woolwich and Reading Series (Quart. Journ. Geol. Soc. vol. x. p. 123), the original source of these remarkable blocks is assigned to the sand-beds of the Woolwich and Reading Series, but less from the direct evidence of their actual occurrence *in situ* than from the mineralogical resemblance of the consolidated blocks to the Woolwich and Reading Sands, and from their geographical distribution pointing to a derivation from the Lower Tertiaries. A case is also mentioned of the occurrence of such blocks in Drift, in which that author considers that they were derived from the Woolwich and Reading Sands.

Blocks of saccharoid sandstone also occasionally occur in the Bagshot Sands, from which they appear to have been consolidated. The blocks, of similar mineral character and structure, about to be described from the Quaternary Drift of Suffolk, are so placed as to render it certain that they were composed from the sands and gravels of the drift where they now lie; it would appear, therefore, that such masses are not limited to any particular deposit, but have been consolidated from most of the sandy formations resting on the Chalk.

The accompanying diagram represents the section of a well sunk by Lady Middleton, at Crowfield-Street, near Coddenham, together

Section from Chopping's Hill Farm to Crowfield-Street, near Coddenham, Suffolk.

(Horizontal distance condensed.)



a. Boulder-clay, with fragments of chalk. *b.* Sand and gravel. × Consolidated blocks. *c.* Chalk.

with the outcrop of the strata between Crowfield and Coddenham.

The well-section, 111 feet deep, included:—

		feet.
1.	Loamy gravel on surface	4
2.	Boulder-clay, containing fragments of chalk, flints, chalk-fossils, and fragments of septaria	53
3.	Drift sands and gravels containing much chalk-detritus, and varying in character	43
4.	Chalk	11
		111

The mouth of the well is, as nearly as I could ascertain, 200 feet above the sea-level, and the surface of chalk, near its bottom, just 100 feet above the sea. This corresponds, within a very few feet, with the level of the chalk at its out-crop at various points in the neighbourhood, as at Chopping's Hill Farm, the field adjoining Hemingstone Church, the Clayton Chalk-pit, &c. The thickness of the sand- and gravel-drift also appears to be tolerably uniform; and as the general flat-topped level of the country at Crowfield-Street is maintained for many miles, with but very trifling variations, the section may be taken as typical of a large district in the south-east of Suffolk.

In descending from this flat plateau into one of the tributary valleys of the river Gipping, the out-crop of all the beds is exposed; and at the gravel-pit adjacent to the Chopping's Hill farm-house, nearly the whole thickness of the Drift is exhibited resting on the chalk.

The consolidated masses occur at a tolerably uniform level, at about 18 feet below the Boulder-clay, and 25 feet above the Chalk. A few are to be seen exposed *in situ* in the gravel-pit, also in the garden at the back of Chopping's Hill farm-house, in the lane leading up thence to Crowfield-Street, and in another small gravel-pit in a field to the south-east of the farm-house. A few may be seen lying about on the surface, also in the bed of a small streamlet between the Crowfield-Street Lane and the farm-yard. A considerable quantity of the stone has been employed in building at Chopping's Hill Farm: indeed, from the absence of any other stone in the district, these consolidated blocks are eagerly sought after for building-purposes, and broken up as soon as exposed; this will account for the small number to be seen on the surface compared with their frequency of occurrence in the Drift. This band of consolidated masses appears to be rather general throughout the Drift of the district, as in an exposure of the sand- and gravel-beds in the railway-cuttings between Westerfield and Bealings station, seven or eight miles to the south-east, similar masses of large size occur, though at a somewhat lower level than those near Coddenham. I should also mention the occurrence, on the surface of the Red Crag at Sutton, near Woodbridge, of a mass of very hard saccharoid sandstone exactly resembling in texture and appearance the "greywethers" of Wiltshire. It does not appear to be an erratic boulder, as there are no other transported materials in the neighbourhood; and as it overlies the Crag, it seems probable that it is not older than the Coddenham drift.

The blocks at Chopping's Hill Farm vary in size, and are generally longer and broader than they are thick: one or two that I measured were six feet in length, containing from 80 to 90 cubic feet of stone, and must have weighed from four to five tons; others (which had been broken up) appeared to have been of much larger dimensions. The whole of the blocks showed a distinct bedding, which when *in situ* invariably ranged with the stratification of the drift; and I was therefore convinced that the consolidation had taken place where they occurred. One remarkable point was the isolation of each individual block; for although the masses were placed at a general level, they did not appear to occur as a connected band. There was not even any gradation between the extreme compactness and hardness of the blocks and the loose drift forming a horizontal continuation of their strata, and out of which they were evidently composed.

The power of consolidation did not seem to be related to any particular variety of the drift, as some of the blocks were composed wholly of sand, some entirely of pebble-beds and gravel, and a few of the thicker individuals included alternations of fine sands and pebble-beds in the same block, all alike remarkable for their extreme hardness.

The general aspect of the blocks, although varying much in character and composition, strongly resembled the "Greywethers" or "Druid Sandstones" of Wilts and Berks. Some were quite saccharoid in structure; and others could not be distinguished from compact millstone-grit, except by the presence of fragments of flint; indeed, hand-specimens might be selected to match almost any of the sandstones and conglomerates of the Palæozoic rocks, which they more closely resemble than later formations. A few of the blocks contained comminuted chalk; and as these were invariably softer than the others, it occurred to me that they might be in a more incipient stage of concretion than the saccharoid blocks, which exhibit no trace of separate chalk particles. It is possible that the finely divided chalk first formed the cementing medium, and that on its gradual dissolution the crystalline structure of the blocks has been slowly perfected through the agency of a small quantity of lime in solution. Some of the blocks are so extremely compact that the original sandy agglomeration seems to have given way to an inherent crystalline structure. The water of the well sunk through the drift is strongly chalybeate, and throws down, on standing, a thick sediment of lime and iron; the drift-bed itself, therefore, supplies all the conditions necessary for its consolidation.

On reaching the sand through the Boulder-clay in sinking the well, much "foul air" or carbonic-acid gas was given off; and from this cause the life of one of the well-sinkers was sacrificed. The discharge of gas, apparently from the chalk, still continues; and it may be distinctly heard bubbling up through the water, which stands at a level with the top of the chalk. The solvent power on lime and iron, of carbonic acid in solution, will readily account for the chalybeate character of the water, and suggests an explanation of the means by which the drift was first cemented together: the comminuted chalk, which is largely intermixed with the sand and gravel, would be gradually dissolved out by the carbonic acid, and the soluble carbonate of lime would form the cementing medium for the residue.

When it is borne in mind that the soluble and insoluble conditions of carbonate of lime are easily interchangeable through different proportions of the acid, the cementing together of Drift containing calcareous matter, by springs charged with carbonic acid, is readily explained; the only difficulty with respect to the blocks in the Coddenham drift is the isolated and unequal way in which the process has acted. In such open porous gravels, water charged with carbonic acid would freely percolate through the entire mass; and it seems difficult to explain the consolidation taking place in well-defined unconnected patches, unless it results from the local discharge of carbonic-acid gas at particular points.

The whole of the concrete masses at Chopping's Hill Farm were readily resolvable into sand and gravel by the action of hydrochloric acid, proving that they were held together by a calcareous cement.

The block before referred to, resting on the Red Crag near Woodbridge, contained no carbonate of lime, but a small quantity of lime in the form of silicate. The following is an analysis by Dr. Voelcker:—

Analysis of Saccharoid Block resting on the Red Crag near Woodbridge.

Lime in a state of silicate	0·41
Oxides of iron and alumina	3·04
Silica and loss	96·55
	100·00

A Sarsen Stone from Avebury, Wilts, contained a little free carbonate of lime, but otherwise showed a composition somewhat similar to that of the block from Woodbridge:—

Analysis of Sarsen Stone from Avebury, Wiltshire.

Oxides of iron and alumina	0·29	soluble in dilute hydrochloric acid.
Carbonate of Lime	0·46	
Alumina } in a state of silicate	0·58	
Lime } in a state of silicate	0·56	
Silica	98·11	
	100·00	

The composition of both of these stones indicates the presence of from two to three per cent. of silicate of lime and alumina, which appears to hold the siliceous particles together.

It is probable, as in the case of the concrete masses at Chopping's Hill Farm, that carbonate of lime was the original cementing material, and that lime in solution in contact with the silica, and a small quantity of alumina, would form a thin coat of silicate of lime and alumina round each particle of sand, and agglomerate them together into a saccharoid mass insoluble in hydrochloric acid.

The beds of gravel including the blocks contain fragments of marine shells, as *Turritella*, *Cardium*, *Cyprina*, &c., examples of which I obtained from a gravel-pit near Hemingstone Church.

Unless it can be proved that the coast Boulder-clay of Norfolk is really older than that occupying the high ground of the eastern counties, the gravel containing the consolidated blocks would appear to be the lowest member of the Boulder-clay series in the east of England.

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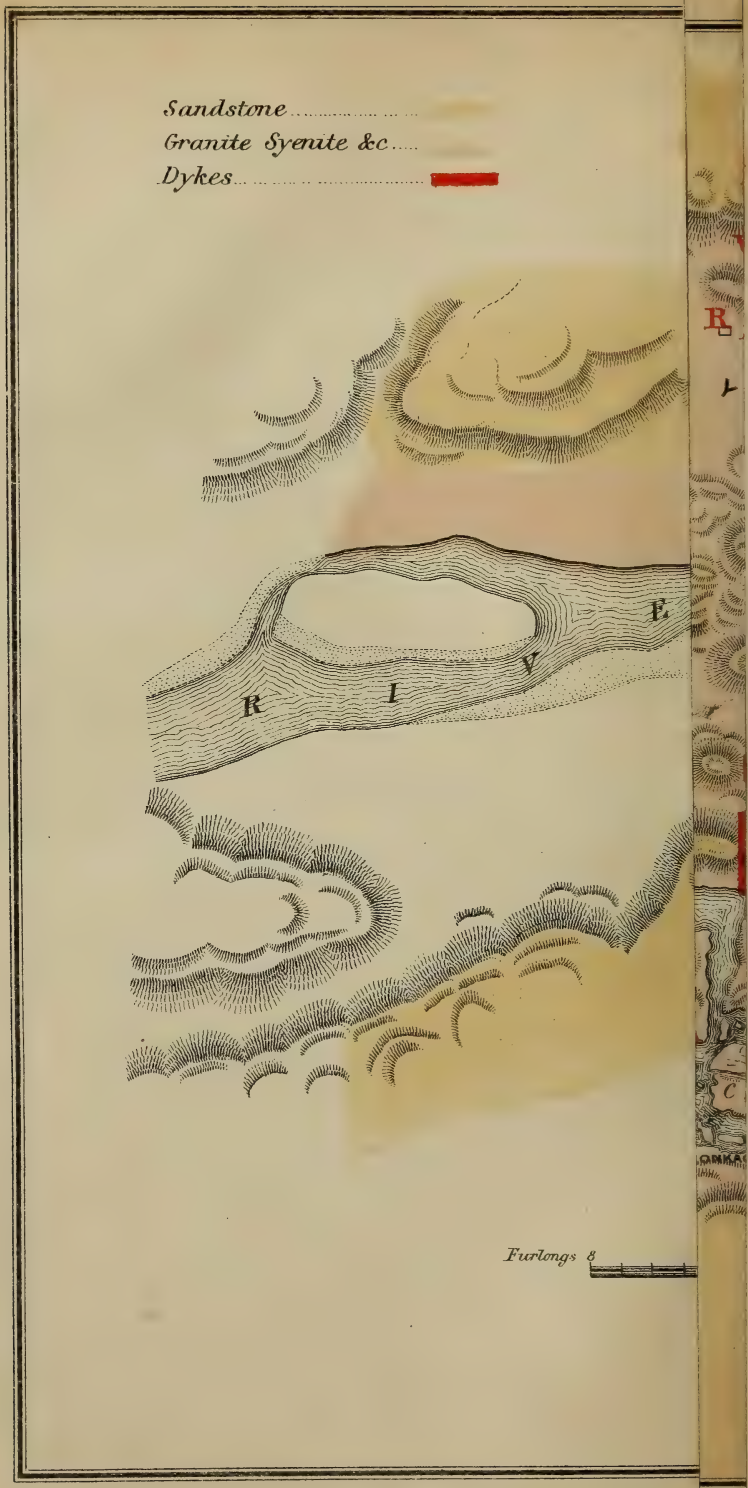
2. Notes *on some* Chemical Analyses *of* Variegated Strata. By George Maw, Esq., F.G.S., F.L.S., &c.

[The publication of this paper is deferred.]

(Abstract.)

The author gave the results of some analyses for the determination of iron in the light and dark parts of variegated slates, sandstones, and marls, the colour of which is due to oxide of iron, and in which the variegation appears to be disposed independently of mechanical arrangement. The analysis in each case exhibited the fact that the lighter blotches, spots, and stripes contained a smaller proportion of the colouring oxide than the average mass, a proportion which implies an actual difference in the percentage of the metallic iron, and which could not be accounted for by any mere difference in the state of its combination. This shows an actual departure of a part of the colouring oxide out of the colourless patches, and a dispersive process which seemed to be the very reverse of the segregation of nodules of carbonate of lime and carbonate of iron out of a clayey matrix. Among the forms of variegation referred to were:—(1st) that resulting from the segregation of dark blotches out of a lighter matrix, the evenness of colour of which does not appear to have been materially affected by the withdrawal of a part of its colouring-matter; (2nd) that resulting from the segregation of dark blotches out of a lighter ground, each of which is concentrically surrounded by a distinct and well-defined zone lighter than the general ground; (3rd) strata variegated with light blotches containing a smaller proportion of colouring-matter than the general ground, but not arranged concentrically round a darker nucleus; (4th) the variegation of coloured strata with both light and dark blotches, containing respectively a smaller and larger proportion of the colouring oxide than the general ground, but which are not arranged, as in the second case, concentrically with each other.


Sandstone
Granite Syenite &c
Dykes
RIVER
Furlongs 8

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

GEOLOGICAL DESCRIPTION *of the* FIRST CATARACT, UPPER EGYPT.

By JOHN CLARKE HAWKSHAW, Esq., B.A., F.G.S.

(Read December 5, 1866 *.)

[PLATE IV.]

THE following remarks are written with a view to describe the geological features of the First Cataract, and to illustrate the localities of the accompanying specimens †, which, with the exception of a few from the neighbourhood of Cairo and a few from other places, were collected by the author during a month's stay on the Island of Sehayl, at the First Cataract of the Nile, near Assouan, Upper Egypt, in the spring of 1865. The accompanying map (Pl. IV.) is for the most part taken from a survey of the district made during the author's stay there, the river Nile being represented at a time when it was nearly at its lowest level.

The First Cataract commences at the southern extremity of the Island of Hesseh, and includes the portion of the river extending thence to the Island of Elephantine opposite Assouan, a distance of about six miles: throughout this district the river is generally divided into two principal branches by the Islands of Hesseh, Sehayl, Soulujie, and Elephantine. One branch, that to the eastward, flows at a higher level than the other or western branch; and the two communicate by some considerable streams and by innumerable small ones until they unite for a time at the southern end of the Island of Sehayl, where the actual rapids cease. The difference of level between the two branches at the north of the Island of Hesseh is 10 feet; and at this point an artificial cut was made by Mohammed Ali, the fall being distributed over a length of about 200 yards. The whole fall of the river from the south of the Island of Hesseh to the south of Sehayl, a distance of upwards of four miles, is 15 feet at low Nile and 12½ feet at high Nile. In no one of the rapids which form the so-called "Cataracts" of the Nile does the fall exceed 3½ feet, which is spread over a length of 20 yards or more, with the exception of Mohammed Ali's cut mentioned above. Many

* For the other communications read at this Evening-meeting, see p. 38.

† Deposited in the Society's Museum.

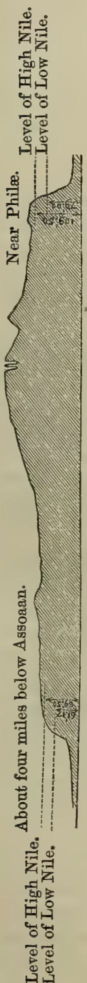
J. Dangerfield Lith 22, Bedford St. Covent Garden.

of the channels are of great depth, that to the west of Hesseh being more than 50 feet deep in some places, even close to the detached rocks which occur throughont the channel.

At the First Cataract the Nile flows without exception over crystalline rocks, consisting principally of quartz, felspar, hornblende, and mica combined in various proportions and then appearing under the forms of syenite, greenstone, hornblende- and mica-schists, or else occurring in separate masses. The whole district is traversed by dykes and smaller veins of quartz, felspar, and pitchstone. The more compact masses of these rocks, of which the surface is often beautifully polished (specimens 1 and 5), divide the river into numerous channels, the direction of many of them being determined by the line of the dykes, which, as a rule, have caused the rocks in immediate contact with them to be more destructible than the same in their unaltered condition; or else the material of the dykes themselves has yielded readily to the action of the water, spliting into small angular fragments along joints coated with brown oxide of iron (specimens 31 to 38). As the direction of the dykes is generally east and west, those channels already mentioned as connecting the two main divisions of the river, and which are at right angles to the usual north and south course of the Nile, will generally be found to be in the line of dykes. For instance, the channel to the south of the Island of Sehayl is along the line of a dyke 30 feet wide running east and west, and which may be traced for some distance into the Arabian desert. Again, the Island of Sehayl is nearly divided into two parts by a dyke parallel to the one above mentioned.

The crystalline rocks forming the bed of the river are overlain, both on the eastern and western banks, by a sandstone of very variable consistency (specimen 106), some beds being coarse and gritty, others fine-grained and compact, containing but little lime, occasional crystals of sulphate of barium (specimen 92), the whole being generally strongly impregnated with iron, which gives it a red or dark-purple, and sometimes almost black colour (specimens 93 to 106, 115). It seems to contain no vestige of organic remains, unless some of the nodules and concretions of ironstone (specimen 112) can be regarded as indicative of such, as many of these appear at first sight to be the actual casts of shells. This sandstone rests on the uneven surface of the syenite in slightly inclined strata dipping to the N.N.E. It is nowhere penetrated by dykes or altered by contact with the syenite, which is, however, often much decomposed at its junction with the sandstone, so that at places it is difficult to distinguish the one from the other. In the lower beds of sandstone rolled pebbles of quartz and chalcedony abound, sometimes 6 or 8 inches in diameter. Opposite Assouan, on the western bank of the river, the syenite is seen underlying the sandstone; and as we ascend this bank it attains a gradually higher elevation until, opposite the southern extremity of the Island of Hesseh, it forms a plateau about 200 feet above the Nile, extending about a mile to the west of the river, when we again meet with the overlying sandstone (specimen 112). The desert to the westward seems to consist entirely of low hills of sandstone, the intervening valleys being filled with sand of a rich yellow colour composed of rounded grains of quartz.

The sandstone on the exposed sides of these hills yields easily to the action of the weather, presenting a branched and almost coralline appearance in situations exposed to the wind. Hesseh is the only island of the Cataract on which sandstone occurs; it is there seen capping a rocky eminence at the northern extremity of the island (see Pl. IV.).



Section of the Valley eastward of the First Cataract.

Horizontal scale 1 mile to $\frac{3}{8}$ inch. Vertical scale 480 feet to 1 inch.

On the eastern side of the Cataract the crystalline rocks appear in the form of hornblende- and mica-schists, and at about four miles below Assouan are overlain by sandstone, which caps all the hills for many miles to the eastward, forming a layer often not more than a few feet thick on the top of the syenite. The latter appears in most of the hollows and valleys in bare coarse-grained bosses, rapidly decomposing and scaling off in layers, or else is covered with sand strewed with pebbles of quartz and chalcedony, these being derived from the sandstone, which wastes quite as fast.

To the eastward of the First Cataract there is a wide valley, which may be seen on the map, commencing at Philæ and joining the Nile valley again about four miles below Assouan. As it has more than once been suggested that the course of the Nile was formerly along this valley, it may be of interest to state that the level of the highest point of this valley (R on map) is 100 feet above the level of high Nile at Philæ; the total length of the valley is $7\frac{1}{2}$ miles. At this point, R, a pit 16 feet deep has been dug through a sandy deposit, containing branched concretions of lime. As rock in the form of hornblende-schist and greenstone occurs on both sides of this valley, and at no great distance from the pit, this deposit of sand probably extends to no great depth, though we have seen that to the west of Hesseh the Nile flows through a narrow channel of very great depth; the river is not, however, entirely confined to that channel. The section along this valley (of which an accurate one was taken) seems to favour the idea that the Nile did formerly flow through it; for to the north of its summit the valley (see the section) is, for the last three miles and a half, below the level of high Nile at Philæ, whilst the portion to the south is considerably above that level, and is covered with a considerable thickness of deposit from the Nile. It is in this part of the valley that the section of Nile deposit 30 feet thick, described by Dr. Leith Adams, in a paper printed in the

Society's Quarterly Journal*, is exposed in the side of a dry watercourse. And this is what we might expect to find; for a considerable deposit would take place over this portion of the valley on the river finding an outlet more to westward.

The watercourse above mentioned must at times form the bed of a considerable torrent issuing from a narrow gorge running nearly N.E. and S.W., the bottom of which is strewed with large rounded boulders of greenstone and syenite. The gorge is bounded on both sides by perpendicular cliffs traversed by dykes; and at the upper end, after the deluges of rain which occasionally, though rarely, occur, there would be a considerable fall of water, as a hollow of some depth shows the successive heights at which the water has stood until dried up by evaporation.

The author walked about fourteen miles to the eastward of this gorge, and ascended what appeared to be the highest hill in the neighbourhood. The base of this hill consists of crystalline rocks, the upper 200 feet being coarse sandstone of a dark-purple colour (specimen 115), the height of the summit above the Nile at Assouan being about 1000 feet.

Of the crystalline rocks at the First Cataract, the coarse-grained pink syenite, described by Professor Delesse in vol. vii., of the Society's Journal, is perhaps the most abundant variety. The rocks forming the eastern bank of the Cataract consist of this, as also do the higher portions of the Islands of Sehayl and Hesseh: in the latter place they are associated with hornblende-schists (specimen 75) much contorted. In places they are vertical and horizontal within a few yards.

In a quarry to the east of Assouan (D on map) this pink syenite may be seen and obtained in homogeneous masses of almost any size. A block said to be (for it is partially covered with rubbish) 95 feet × 12 feet × 12 feet, squared on three sides, and still attached to the rock on the fourth, may still be seen in this ancient quarry. The material of this block is the same as specimen 19 throughout the exposed part, with the exception of a few angular patches similar to specimens 20 and 25. Near this spot (D on map) a mass of greenstone is quarried; it occurs with veins of quartz and felspar containing garnets (specimens 27 and 29). This coarse pink syenite varies much in durability. Among the ancient monuments of Egypt masses of it weighing many tons (as much as 800 tons in one case) may be seen unaffected by the action of the weather after an exposure of from 2000 to 3000 years. On the other hand, at the First Cataract we see on all sides signs of its perishable nature, in the rugged hills formed of rectangular blocks piled one on another not unlike rude masonry, or more often covered with huge boulders heaped one on another in the greatest confusion. These spherical masses weather by scaling off in thin concentric shells, as may be seen in a curious block on the Island of Hesseh.

Associated with the coarse-grained syenite occur finer-grained varieties, sometimes in narrow veins, sometimes in large compact

* Vol. xx. p. 15.

masses. Often the hornblende is nearly wanting. In a variety of the coarse-grained syenite, which occurs in large quantities, the hornblende is in such preponderance as to give a dark-green colour to the rock, relieved here and there by large flesh-coloured crystals of felspar. Near the northern end of the Island of Hesseh a great variety of specimens may be obtained from the débris remaining from the artificial cut before alluded to (specimens 41 to 53). The prevailing colour of the felspar in the neighbourhood of this cut is deep red; sometimes, however, it is much decomposed and chalky white (specimen 50). The dykes that intersect the cataracts are mostly of dark-green compact greenstone or felstone speckled with crystals of pink felspar—or sometimes rotten and decomposed, and traversed by detached veins of quartz and felspar, being then of a brown colour in places (specimens 31 to 38). In the neighbourhood of the dykes the syenite is often separated into its component parts (specimens 1 and 5).

Hornblende-schist occurs at the western side of the river, opposite the Island of Hesseh (point K on map), overlain by, and reposing on, pink syenite.

Hornblende-schist forms a large portion of the Island of Hesseh; a little occurs in the Island of Sehayl, and it is again met with in the large eastern valley before described. At the northern extremity of this valley the hornblende-schist or mica-schist is in places nearly vertical, and is overlain by sandstone. At the junction of the two, the sandstone contains pieces of schist and large angular fragments of quartz (specimen 111).

There is near this point a very conspicuous mass of white quartz, about 150 yards long by 50 yards wide, rising 30 feet above the schist, which is nearly vertical in its neighbourhood.

In conclusion, I would call attention to the advantages offered by the locality I have endeavoured to describe for observing the different combinations of granitic and syenitic rocks and of their elements, and more especially the gradual transition from one variety of combination to another. Every variety of combination of these minerals, sometimes weatherworn and in all stages of decay, at other times having the surface polished as if by the hand of a lapidary, may be seen at low Nile over a few square miles of country, on the banks of the river and on the islands of the First Cataract.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

FEBRUARY 6, 1867.

R. G. M. Browne, Esq., Admiralty Registrar, Doctors' Commons, and 9 College Crescent, Hampstead, N.W.; the Rev. Michael Alfred Moon, Cleator, near Whitehaven; and Benjamin B. Orridge, Esq., 33 St. John's Wood Park, N.W., were elected Fellows.

The following communications were read:—

1. *On some* SECONDARY FOSSILS *from* SOUTH AFRICA. By RALPH TATE, Esq., A.L.S., F.G.S.

[PLATES V.–IX.]

CONTENTS.

I. INTRODUCTION.

As a large number of fossils from the Secondary rocks of South Africa remain undescribed in the Society's Museum, it seems desirable that an account of them should be submitted to the Society, as a sequel to the Monographs on Secondary Fossils from South Africa which have appeared in the Society's Transactions and Quarterly Journal.

This paper contains descriptions of the Plants of the Karoo beds, the Reptilian and Molluscan life of which has been made known by the labours of Professors Owen and Huxley, and the late Mr. Daniel Sharpe—of the vegetable remains from the phytiferous beds of Geelhoutboom, and of the fossils from the Jurassic strata of the Zwartkop and Sunday's River (the last part being a Supplement to Mr. Daniel Sharpe's "Descriptions of Fossils from the Secondary Rocks of South Africa"). The study of the organic remains of the beds enumerated has enabled me to offer, in addition, some generalizations on the affinities of each of the above-mentioned groups of Secondary strata developed in this region.

II. Karoo Beds.

a. *Fossil Flora of the Karoo Beds.*

1. Glossopteris Browniana, Pl. VI. figs. 5*a*, 5*b*, 7*a*, 7*b*.

The Society is in possession of several impressions of a *Glossopteris*, in a friable sandstone, obtained by Dr. W. G. Atherstone, F.G.S., from Heald Town, near Fort Beaufort, Eastern Province, South Africa,—and many others of the same form, in a dark shale, from Bloemkop *, collected by Mr. C. J. Powell, of Graaf Reinet, and presented by Dr. R. N. Rubidge, F.G.S. There are also in the Collection some well-preserved specimens from Natal, that were collected and sent to England by Dr. P. C. Sutherland. These all agree, in the main, with *Glossopteris Browniana*.

The following words employed by Sir C. Bunbury †, on comparing the Indian *Glossopteris* with the common Australian *G. Browniana*, are applicable when the *Glossopteris* from Natal is compared with the *G. Browniana*:—"I can find no satisfactory specific distinction; the venation is essentially the same. We may, indeed, find African specimens in which the meshes of the reticulation near the midrib are larger and broader than in the ordinary Australian plant, and others in which the veins are more strongly recurved; but in both the Indian and Australian plants I find so many shades of variation in these particulars that I cannot attach much importance to them."

The apex of the African plant is obtuse, like that of the Australian plant, and never acute as in the Indian. The frond is more attenuated below in the African fern; but there seems to be some degree of variation in this particular. It has a more firm and rigid appearance than the Indian and Australian forms.

2. Glossopteris Sutherlandi, spec. nov. Pl. VI. figs. 2*a*, 2*b*.

This species, dedicated to Dr. P. C. Sutherland, Surveyor-General of Natal, its discoverer, is associated with *G. Browniana* in the coal-

* Quart. Journ. Geol. Soc. vol. xv. p. 198; and vol. xvii. p. 329.
† *Ibid.* vol. xvii. p. 328.

deposits of Natal; the materials at my command consist of fragments of fronds, the distinctive characters of which may be thus stated:—Frond narrow, strap-shaped, with nearly parallel edges; apex obtuse (?). Midrib narrow, continued to the apex. Lateral veins strong, slightly oblique, dichotomous, anastomosing and forming a lax network from the midrib to the margin.

Locality. Natal (Dr. P. C. Sutherland).

3. With the above-mentioned specimens from Bloemkop are some of an apparently, at first sight, second species of *Glossopteris*; these do not exhibit fructification. Dr. Rubidge, however, has communicated a drawing (by Mr. M'Kay) of a specimen of this species obtained by Mr. M'Kay near East London: and I find that it presents characters generically distinct from those of *Glossopteris*; for the position of the fructification is indicated by a few large elevated rings, arising from many veins, and somewhat regularly arranged in a row coincident with the margin, and not by numerous spots, small in size, supported by one vein, distributed over much of the surface of the frond. This new genus thus bears the same relation to *Glossopteris*, among fossil ferns, that *Acrostichum* does to *Polypodium* among living forms.

I propose for this genus the name *Rubidgea*, in compliment to Dr. R. N. Rubidge, F.G.S. One species only is known, the characters of which are as follows:—

RUBIDGEA MACKAYI, gen. et spec. nov. Pl. V. fig. 8.

Frond oblong, obovate, rounded and obtuse at the apex; secondary veins very slender, very much crowded, dichotomous, oblique. There is no indication of anastomosis of the veins.

Localities. Bloemkop, near the Sunday's River, Graaf Reinet (Dr. Rubidge); East London, at the mouth of the Buffalo River (Mr. M'Kay).

4. DICTYOPTERIS? SIMPLEX, spec. nov. Pl. VI. fig. 6.

The material at my command consists of a fragmentary specimen of a single frond, showing neither base nor apex.

Frond simple, large, oblong, broad (?); venation arising from a prominent midrib, and forming a lax and regular network, composed of elongated subquadrangular areolæ.

This species, in the form of its frond, approaches *Glossopteris*: but its venation is more like that of *Dictyopteris* than of *Glossopteris*. The specimen is on a brownish-grey shale from Bloemkop (Graaf Reinet), and was presented by Dr. Rubidge; it was alluded to by Sir C. Bunbury in 1861 as "consisting of mere fragments, with veins forming a lax and regular network, perhaps more like the venation of *Dictyopteris* than of *Glossopteris*." (Quart. Journ. Geol. Soc. vol. xvii. p. 329.)

5. Specimens of flattened stems are not rare in the shales of Bloemkop; they appear to belong to *Phyllotheca* (Pl. V. fig. 6); but as the materials are very imperfect, I refrain from attaching any

specific title. The shales with *Phyllotheca* are dark-grey, somewhat calcareous, and associated with a band of obscure Bivalves (*Iridinæ*?).

b. *General Remarks on the Fossil Plants of the Karoo Beds.*

1. A marked feature in the ancient flora of the Karoo district is the paucity of specific forms (five in number), in proportion to the abundance of specimens (forty in the Collection).

2. This flora presents close analogy with that of the Coal-formation of Eastern Australia and the plant-bearing beds of Burdwan and Nagpur in India. The characteristic plant in each of these deposits and in the Karoo beds is a *Glossopteris*; and it seems that the Indian, Australian, and South-African plants are specifically identical.

The association of the genera *Glossopteris*, *Phyllotheca*, and *Dictyopteris* (?) affords some evidence of Mesozoic affinities in this fossil flora.

3. From the very characteristic Jurassic flora presented by the Geelhoutboom shales and limestones (which, from the structure of the country, may be confidently regarded as being higher in the geological scale), the flora of the Karoo beds (which has no affinity with the former) cannot be regarded as contemporaneous with the Jurassic flora of Europe; but, as it possesses a Mesozoic facies, it may be considered to be of Triassic age.

4. The nature of the flora conspires with the fauna to establish the lacustrine origin of the Karoo series. The following synopsis (by Prof. Rupert Jones) of these beds and their vertebrate and other fossils (as far as hitherto described) embraces the characteristics of this remarkable formation.

c. *Synopsis of the Karoo Beds.*

The Karoo Beds*, as far as described by the late Mr. Bain, appear to comprise (beginning with the lowest):—

1. The *Ecca Beds.* Hard blue shales (with Plant-remains resembling those of the still higher Beaufort Beds) alternating with variegated and rippled sandstones, and containing some thin layers of hard, blue, impure, nodular limestone. They are divisible into an Upper and a Lower series †, separated by, and lying conformable with, the remarkable band of igneous rock ‡ which extends across South Africa. In the lower portion of the Ecca Beds Mr. Bain noticed a band of vegetable remains 9 inches thick (at Ecca Heights). The fossil wood on the Pattates River, in the Great Karoo, belongs to the Ecca Zone.

2. The *Koonap Beds.* Sandstones and hard shales, with fossil trees at the Kleine Roggeveld.

* Mr. Bain referred to these as the "Karoo Formations" in the East. Prov. Magaz. 1856, p. 19.

† Dr. Rubidge seems to regard this lower band, underlying the great trap-breccia, as being probably a part of the Devonian series of strata.

‡ On the flanks of the Zuurberg it is decidedly a *dolerite*, containing angular and rounded fragments of quartzite and granite. This trap-breccia and the Ecca beds have participated in the foldings by which the quartzites and schists (Devonian) of the Zuurberg have been raised into a ridge.

3. The *Beaufort Beds* (Beaufort West and Fort Beaufort are both on this band). Greenish laminated sandstone, with shale, calcareous bands*, and numerous hard nodular masses often containing Dicynodont remains†. Fossil wood is common; and Dr. Gray found fossil Ferns near Cradock. The "Fort-Beaufort Grit," containing *Glossopteris, Palæoniscus* (?), *Oudenodon Bainii*, Owen, and *Oud. prognathus*, Owen, is a band of coarse sandstone towards the base of this zone. Small bivalves also have been found in zone No. 3, at Manzalan (on the Kat River), and near Graaf Reinet‡; and *Glossopteris* and *Dictyopteris* come from Bloemkop, near the same place. A peculiar Fern (*Rubidgea Mackayi*, see above, p. 141) has been found in this zone by Mr. M'Kay near the sea-level at East London (Buffalo River Mouth). Dicynodont remains are numerous in "No. 3," near Fort Beaufort and the Mankazan Post; and from Blinkwater, in the same district, Mr. Bain got the remains of a large Reptile with 60 *fluted and serrated teeth* (his "Blinkwater Monster"§). His "Gamkasaurus" (an immense reptile, as yet undescribed) also belongs to this zone in Beaufort West; also his "Asterophyllites?" and "Lycopodium?" of the Roggeveld‖. *Dicynodon lacerticeps*, O., *D. strigiceps*, O., *D. Bainii*, O., and *D. tigriceps*, O., came from the same set of beds, at various localities, east and west; and from the higher and more northern portion of the zone have been obtained:—*Palæoniscus* (Spitzkop and Styl Krantz) and other Fish-remains (Brak River); a Reptile having the characters of the "Blinkwater Monster"¶, but smaller (Sneeubergen); *Micropholis Stowii*, Huxley, *Dicynodon declivis*, O., *D. latirostris*, O., *D. verticalis*, O., *Oudenodon Grayii*, O., *Galesaurus planiceps*, O., *Cynochampsa laniarius*, O., and a portion of an Encrinital Stem** from the Rhenosterberg; and *Dicynodon Murrayii*, Huxley, still further north, near Colesberg. The buff-coloured, soft, stratified sandstone of the Great Winterberg is described as equivalent to the Sneeuberg beds, as well as the Tarka beds with pisolitic iron-ore (?) and Dicynodons. Possibly, however, the higher portions of the series in the Sneeuberg and Winterberg Heights may be outliers, belonging to the next or Stormberg beds; if so, the *Palæoniscus* of Styl Krantz, and the Reptile with serrated teeth from the Sneeuberg, belong to the next series.

4. The *Stormberg Beds* (Huxley††), or the white and yellowish sandstones, with grey and reddish shales, of the Stormberg and of

* See Mr. Stow on the Rhenosterberg, Quart. Journ. Geol. Soc. vol. xv. p. 194.

† Some at least of these nodular masses are penetrated by greenstone, numerous dykes and beds of which abound throughout the "Karoo Series."

‡ *Iridinæ*, &c., Transact. Geol. Soc. 2nd ser. vol. vii. p. 225.

§ Eastern Prov. Monthly Mag. vol. i. pp. 9–11; Newspaper Letter (June 1861); and Geol. Trans. 2nd ser. vol. vii. p. 56.

‖ Trans. Geol. Soc. 2nd ser. vol. vii. p. 188 & p. 227.

¶ Letter in Newspaper (Fort-Beaufort Advocate, June 1861).

** If not a derived fossil, washed in from the Devonian beds, this is inimical to the supposed *lacustrine* origin of the Karoo beds.

†† Quart. Journ. Geol. Soc. vol. xxiii. p. 5. [I have lately found that Mr. Wyley has also used the same name. July.—T. R. J.]

Bloemfontein* succeed. These have:—silicified wood and coal or lignite; *Dicynodon* (*D. testudiceps*, Owen, from the River Modder); *Euskelesaurus Brownii*, Hux., and *Orosaurus*, Hux., from Aliwal North; and *Cynochampsa laniarius* (?), O., *Massospondylus*, O., *Pachyspondylus*, O., and *Leptospondylus*, O., from Harrismith, near the Drakenberg.

Zone No. 4 comes out on the Natal side of the Drakenberg, and possibly the lower zones also. *Glossopteris*, in a good state of preservation, together with fossil wood and bones, in a calcareous rock, have been collected by Dr. P. C. Sutherland† from the upper strata of the Coal-series of Natal.—T. R. J.

III. Uitenhage Series.

a. *Fossil Flora of the Geelhoutboom Beds (the "Wood-bed Series" of Atherstone).*

The plants from the Geelhoutboom series have been obtained by Dr. Atherstone and Dr. Rubidge at various dates; they have been derived from two kinds of deposit (forming part of the "Wood-bed"):—

1. A soft grey sandy shale, and yellowish sandstone (the remains of the leaves are sometimes calcareous).
2. A dull, compact, splintery, bluish-grey, argillaceous limestone, lying below the marly sandstone. Of this rock there are two layers ("strata of ferns" in Dr. Atherstone's section ‡).

No. 1. contains *Palæozamia Morrisii*, *P. Rubidgei*, *Athrotaxites* (sp.), Cycad stems, *Sphenopteris Antipodum*, *Pecopteris Africana*, and *P. Rubidgei*.

No. 2. contains *Palæozamia recta*, *P. Africana*, seeds and a portion of a cone belonging to Cycadaceous plants, and *Pecopteris Atherstonei*.

The following species are common:—*Asplenites lobata* and *Cyclopteris Jenkinsiana*.

Description of the Species.

A. *Cycadaceæ.*

1. Palæozamia (Otozamites) recta, spec. nov. Pl. V. figs. 7 *a*, 7 *b*.

Frond pinnate, elongated. Pinnæ alternate, lanceolate, tapering gradually to an acute apex, patent; base semicordate; veins distinct, forked, nearly parallel.

The foliage of this species, so far as it is known, was exceedingly coriaceous; many of the pinnæ are mined with serpentinous galleries, as by the larvæ of Insects. A frond of *P. recta* in the Geological Society's Museum measures 17 inches in length; its apex is wanting; but when entire, it must have exceeded 2 feet 6 inches.

* These are described by Mr. A. Wyley in a Report (addressed to the President of the Free State) on the ineffectual search for gold near this place: 'Bloemfontein Gazette,' January 1856.

† Quart. Journ. Geol. Soc. vol. xi. p. 466.

‡ Provincial Magazine, vol. i. pp. 580, 581 (1857).

P. recta differs from *P. gigas*, Lindley and Hutton, in its linear lanceolate pinnæ, and approaches nearer to *P. lanceolata*, Leckenby, from which it is distinguished by its straight pinnæ, and by their proportionate length and breadth. The length of a pinna of *P. recta* is about six times the breadth.

2. Palæozamia (Podozamites) Morrisii, spec. nov. Pl. V. fig. 4.

Frond bipinnate (?); pinnæ somewhat approximate, patent, ovate-lanceolate; apex acute; base contracted. Length from $2\frac{1}{2}$ to $3\frac{1}{2}$ times the breadth; venation obscured.

This well-marked species is dedicated to Professor John Morris, F.G.S., who many years since paid attention to the fossil flora of South Africa.

3. Palæozamia Rubidgei, spec. nov. Pl. V. figs. 3*a*, 3*b*.

Frond pinnate, rachis straight, broad; pinnæ alternate, long, slender, lanceolate, tapering gradually to an acute apex; base slightly contracted, and decurrent (?); veins about ten, prominent, parallel.

The substance of the pinnæ was apparently thin; the plant being either succulent, or possessing a much less coriaceous cuticle than is found usually among Cycads allied to *Zamia*.

Palæozamia Rubidgei is related to *Zamites lanceolatus*, Lindley and Hutton; but the pinnæ are not so distant, and are more lanceolate.

4. Palæozamia (*vel* Pterophyllum) Africana, spec. nov. Pl. V. fig. 5.

Frond —— ? Pinnæ very long, lanceolate, tapering gradually; apex —— ?; base —— ?; veins few (about six), prominent, parallel.

This species is founded on a portion of a frond, the full length of which is not seen, nor the insertion and termination of the pinnæ. The longest pinna, in its incompleteness, measures $5\frac{3}{4}$ inches.

The long, slender, and nearly parallel-sided pinna is not referable to any other African Cycad, nor, as far as I know, to any *Palæozamia*; it may, however, prove to belong to the genus *Pterophyllum*; in which case *P. Africana* finds an analogue in *Pt. Morrisianum*, Oldham, from the Coal-measures of Rajmahal, India; but it differs from the latter by its more slender form, and its fewer and coarser veins. The same characters would distinguish it from *Podozamites longifolius*, Emmons.

B. *Filices.*

1. Pecopteris Atherstonei, spec. nov. Pl. V. figs. 2*a*, 2*b*.

Frond possibly bi- or tripinnate; pinnæ long, pinnatifid, with close, alternate, decurrent segments, which are oblong and slightly oblique; medial vein nearly straight, prominent; secondary veins oblique, forked once near the midrib.

This species is closely allied to *P. Indica*, Oldham and Morris, but is of a more robust habit; the pinnules are broader and blunter.

2. Pecopteris Rubidgei, spec. nov. Pl. V. figs. 1*a*, 1*b*.

Pinnæ long, pinnules attached to the rachis by their whole base and to each other, close, alternate, falcate, acute; median vein strong, prominent; secondary veins oblique, forked once near the midrib.

The arched and acutely pointed pinnules serve to distinguish this species from *P. Atherstonei*.

3. Pecopteris Africana, spec. nov. Pl. VI. figs. 1*a*, 1*b*.

Pinnæ long; pinnules attached by a contracted base, distant, patent, elongate-oblong, blunt or subacute; medial vein strong; secondary veins oblique and bifurcating, or simply forked.

4. Asplenites lobata, Oldham, 'Palæontologia Indica,' p. 52, pl. 28. fig. 1, pl. 29, pl. 30, pl. 36. figs. 6, 7: 1860.

This fern is the most abundant of the plants of the Geelhoutboom marls; it also occurs in a dark-grey subcrystalline limestone at Geelhoutboom.

Of *A. lobata*, described from the coal-series of Rajmahal, India, the diagnosis is as follows:—

"Frond bipinnate; pinnæ oblique, long, alternate; pinnules ovate, alternate, distant, contracted at the base, lobed; lobes obtuse, deep, 4 to 8 on each side; midrib stiff and proceeding to the end of the pinnule, secondary veins flexuous and divided once or twice (?); sori oblong or oblong-triangular, very large."—*Oldham*.

The African specimens do not exhibit any traces of fructification.

5. Sphenopteris antipodum, spec. nov. Pl. VI. fig. 3.

Frond bipinnate, with linear, long, acute, dentated, alternate segments, each of which has one vein: the primary pinnæ on slender stalks, elongated, oval.

This species has great analogy to *S. Fulgeri*, Ettingshausen, from the Wealden at Deister, and from the Inferior Oolite in Yorkshire; but its pinnules are not so membranous and laciniated as in that species.

6. Cyclopteris Jenkinsiana, spec. nov. Pl. VI. fig. 4.

Frond obovate-oblong, rounded and obtuse at the apex, somewhat attenuated below; the veins, which are numerous and delicate, are radiate, dichotomizing from the base.

The length of the largest specimen is $4\frac{5}{8}$ inches, and the greatest breadth $3\frac{2}{8}$ inches.

"In the overlying sandstone they are often 5 or 6 inches long and 3 inches broad" (Dr. W. G. Atherstone, MS.). The base is not preserved, but was apparently simply attenuated.

This species occurs both in the argillaceous limestones and in the laminated sandstones of Geelhoutboom.

I have much pleasure in dedicating this species to my colleague, Mr. H. M. Jenkins, F.G.S., as a slight acknowledgment of the services he has rendered me in the issue of this paper.

7. In addition to the above-enumerated species there are associated with them portions of a Coniferous stem closely allied to *Athrotaxites Indicus,* Oldham, of the Rajmahal coal-series; parts of stems, presenting longitudinal tuberculated ridges, probably Cycadaceous; and ovules of *Palæozamia,* and the under surface of the base of a cone, perhaps of the same.

b. *General Remarks on the Fossil Plants from Geelhoutboom.*

The plant-bearing beds of Geelhoutboom are (according to the observations of Bain and others) younger than the "Karoo Series," or "Dicynodon strata," the flora of which is described above (p. 140); but they are inferior in position to those strata on the Sunday's River (the "Trigonia-beds") that yield marine fossils of undoubted Jurassic age. Accepting the conclusions arrived at respecting the age of the beds newer and older than the plant-bearing strata of Geelhoutboom, any evidence that an examination of these plants may afford as to the Jurassic aspect of this flora will be very valuable as a confirmation of its age, already inferred from the stratigraphical position of the beds themselves. That the flora does bear evidence of such a Jurassic relationship, I will proceed to point out.

The specimens collected by Dr. Rubidge in 1845, at the Sunday's River (Geelhoutboom), were examined by Prof. Morris*, who gave as his opinion that they "are essentially 'Secondary' in character, from the preponderance of the remains of *Cycadeæ,* and probably represent a Triassic or a Jurassic flora." The same plants were exhibited at the Ipswich Meeting of the British Association (1851), on which occasion Dr. Harvey stated that "the species of *Pecopteris, Neuropteris,* and *Sphenopteris* chiefly resemble those of the coal of Australia, whilst the presence of *Zamia* in abundance impresses an Oolitic aspect on the flora"†.

Though the collection of these plants has been greatly increased by the further liberality of Dr. Atherstone and Dr. Rubidge, yet the views advanced by Prof. Morris are still applicable; but Dr. Harvey's statement must be accepted with some limitation.

The collection, though rich in individuals, is poor in species, and has yielded the following:—

4 species of *Palæozamia.*
1 ,, *Athrotaxites.*
1 ,, *Cyclopteris.*
1 ,, *Sphenopteris.*
1 ,, *Asplenites.*
3 ,, *Pecopteris.*

* British Assoc. Rep. 1851, Trans. Sect. p. 68.

† [Trans. Geol. Soc. 2nd ser. vol. vii. p. 227, note. There was for some time considerable doubt respecting the real localities of the Fossil Plants referred to in the foot-notes at p. 185 & p. 227, vol. vii. Trans. Geol. Soc. 2nd ser. The same specimens are alluded to in these two notes. Most of them came from Geelhoutboom; but some were from the Karoo Beds at Jackal's Kop, on the eastern side of the Stormberg (Quart. Journ. Geol. Sec. vol. xii. p. 237); and these latter do not appear among those that ultimately came into the possession of the Society, and which Professor Morris examined.—T. R. J.]

The four species of Cycadaceous plants which constitute the bulk of the flora are founded on fronds. One of these belongs to the section *Otozamites* of the genus *Palæozamia,* species of which characterize Jurassic rocks, and are chiefly found in the Lias and Lower Oolites. They greatly resemble, though quite distinct, several species from the plant-bearing beds of the Yorkshire coast.

The presence of Cycads in the "Uitenhage Series" of South Africa is of interest when we regard the distribution of these vegetables in time. Hitherto plants with Cycadeous affinities, and belonging to the Jurassic epoch, have been met with only in the northern hemisphere. Their discovery in South Africa in beds of the same age that have yielded them in Europe, India, and North America demonstrates the wide geographical range of the Order Cycadaceæ during Jurassic times—an order now somewhat limited to tropical and subtropical climes, and which has only continued to exist in one of these areas—namely that of South Africa.

Of the four species of *Pecopteris,* one is not satisfactorily distinct from *P. lobata* of India; and two others are closely allied to *P. Indica,* also from the Jurassic plant-beds of the Rajmahal Hills.

In reviewing the few species of this ancient flora of South Africa, one cannot fail to be struck by the paucity of species in proportion to the abundance of specimens; and though limited in numbers, as the distinct forms are, yet there can be no doubt of their Jurassic character, seeing that some of the species are comparable with certain others from the Jurassic series of England and India. Thus *Palæozamia recta, P. Rubidgei, Pecopteris Atherstonei, P. Rubidgei,* and *Sphenopteris antipodum* represent, as it were, *Palæozamia lanceolata, Zamites lanceolatus, Pecopteris Indica,* and *Sphenopteris Fulgeri* of the European and Indian Jurassic rocks; whilst *Asplenites lobata* is common to these Indian and African strata: and though with one exception they are distinct, yet on the whole the Jurassic Plants of South Africa recall those of Scarborough and the Rajmahal Hills.

The following Table exhibits the affinities of some of the African species:—

Species from South Africa.	Species analogous to those of South Africa.	Localities where the species of South Africa or their analogues occur.	Age of the beds in these localities.
Palæozamia recta ...	Palæozamia lanceolata, *Leckenby* .... P. gigas, *Lindl. & Hutt.*	Scarborough ..	Inferior Oolite.
P. Rubidgei	Zamites lanceolatus, *Lind. & Hutt.*	Scarborough ...	Inferior Oolite.
Athrotaxites, sp.	Athrotaxites Indicus, *Oldham*	Rajmahal	Jurassic.
Pecopteris Rubidgei P. Atherstonei	Pecopteris Indica, *Oldham*	Rajmahal	Jurassic.
Asplenites lobata, *Oldham*	....	Rajmahal	Jurassic.
Sphenopteris antipodum	Sphenopteris Fulgeri, *Ettingsh.*	Germany .... Yorkshire	Wealden. Inferior Oolite.

c. *Synopsis of the Uitenhage Series.*

The Jurassic strata are well seen in the Uitenhage district, and may therefore with propriety be designated the "Uitenhage Formation" for convenience of reference. They are exposed by the rivers traversing the several basins of these rocks in the Eastern Province, especially in the upper part of the Bushman River, and the lower parts of the Sunday's, Koega, Zwartkop, and Gamtoos Rivers. The strata differ somewhat in the several basins. The following comparative Table of this *Uitenhage series* has been compiled chiefly from Dr. W. G. Atherstone's "Lecture on the Geology of Uitenhage," in the 'Eastern Province Monthly Magazine,' vol. i., 1857.

Zwartkop River.	*Sunday's River.*	*Bushman River.*
3. Yellowish sand (green-grained) and calcareous rock, with some bands made up of fossils (upwards of 100 feet thick, Krauss*). ft. in. Disintegrated rock ... 12 0 Hard ferruginous rock, very rich in fossils (Trigonia &c) ...... 1 6 Sandstone .... 16 4 Sandstone: fossils ... 1 6 Sandstone .... 16 0 Greyish sandstone (all the sandstones of this series are more or less glauconite): fossils in its lowest beds ...... 60 0 Trigonia band 4 0	3. Greenish-grey, calcareous, sandy, green-grained, fossiliferous rock (sometimes limestone, sometimes sandstone ¶).	3. Red, purple, and yellow marls and clays (130 feet and more).
2. (*d* and *c*?. Lignite at Bethelsdorp, &c.). *b.* Fossiliferous dark ferruginous sandstone † (Ostrea &c.), in bands a few inches thick, alternating with *saliferous* shales and sandstones ‡ (Atherstone). Friable grey sandstone (alternating with ferruginous nodular bands, 1 foot thick), 20 feet. Greyish hard band, full of small Shells, mostly crushed, such as Dentalium, Turritella, Ostrea, Nucula, and Astarte(?), with Cidaris spines: 3 or 4 inches §. *a.* White and variegated sandstone ‖ (in the upper part of the Zwartkop River). The "*Zwartkop Sandstone*" of Atherstone.	2. *d.* Light-brown sandstone, with lignite, jet, amber, and large reptilian bones. *c.* Grey sandy beds, with *upright* trunks of coniferous trees, and leaves of Zamiæ and Ferns, and containing two blue argillo-calcareous bands, rich with Ferns, also thin seams of lignite. *b.* Thin oyster-bands, alternating with thin sandstones and *saliferous* shales, with gypsum. *a.* Hard grey and brown sandstone. This part of the formation (2 *a–d*) is the "*Wood-bed series*," as seen at Geelhoutboom, where the Witwater joins the Sunday's River.	2. Brown pebbly green-grained sandstone, with numerous prostrate tree-trunks (some calcareous, some lignitic), drifted and bored by Gastrochæna, and bones of great Reptiles, including one with teeth like those of the Iguanodon. This is the "*Wood-bed series*" of Atherstone, and is here perhaps 500 feet thick.
1. Quartzose pebbles, loosely packed in red clay and sand, 300 feet. The "*Enon Conglomerate,*" Atherstone. Unconformable on quartzite and schist.	1. The "*Enon Conglomerate,*" lying unconformably on old slates and schists.	1. The "*Enon Conglomerate,*" unconformable on the old schists **.

* Quart. Journ. Geol. Soc. vol. vii. Miscel. p. 121, a translation from the Nova Acta Acad. Carol.-Leop. vol. xxi. part 2. p. 439 *et seq.* See also Trans. Geol. Soc. 2nd ser. vol. vii. p. 201.

† On the Koega River also.

‡ This is the rock termed "Lowest Strata of the Zwartkop Crag" in the Trans. Geol. Soc. 2nd ser. vol. vii. p. 203.

§ Krauss, *loc. cit.*

‖ Also on the Gamtoos River. These strata, 2 *a*, of the upper part of the Zwartkop basin may be equivalent to a portion of 2 *b* of the lower part of the river.

¶ See Trans. Geol. Soc. 2nd ser. vol. vii. p. 201. These beds ("No. 3") and their equivalents may be termed the "Trigonia-beds."

** Mr. Bain's section and remarks at p. 58, vol. vii. of Trans. Geol. Soc. 2nd ser., appear to point also to this conglomerate, and some overlying portion of the "Wood-bed series," in Lower Albany, north of the Bushman River.

d. *Description of some Fossils from the Jurassic Strata, or "Uitenhage Formation," on the Sunday's and Zwartkop Rivers, South Africa.*

AMMONITES SUBANCEPS, spec. nov. Pl. VII. figs. 3 *a*, 3 *b*.

Shell small, somewhat compressed, deeply umbilicated. Whorls 4, narrow, depressed, inflated laterally by the development of the tuberculose costæ. Last whorl ornamented with ten tubercules; ten costæ arise from the inner margin of the whorl; these are directed slightly forward, and bifurcate or trifurcate from a salient pointed tubercle in the middle line of the whorl; the ribs proceeding from the tubercle are inflected forwards, and interrupted upon the middle of the back, terminating there in a slightly pointed tubercle, but are otherwise continuous with a similar bundle of ribs developed on the opposite side. Back convex, with a smooth, shallow furrow in the middle. Mouth large, rounded.

Dimensions. Diameter ·75 inch; diameter of outer whorl ·3 inch; thickness of outer whorl ·3 inch.

Observations.—It is doubtful whether this be not a mere variety of *A. anceps*, Reinecke, of the Middle Oolites. I have not been able to compare it with a specimen of its size, or a figure of a young shell of that species; it differs from *A. anceps* in the more compressed form, and in the ribs ending on the back in tubercles. The species bears much resemblance to *A. Hookeri*, Blanford, of the Jurassic beds of Niti, India.

Loc. With *Alaria coronata* in a greenish-grey sandy limestone on the Sunday's River.

HAMITES AFRICANUS, sp. nov. Pl. VII. figs. 5 *a*–5 *d*.

Shell presenting an elliptical section, slightly compressed at the sides; the undulating, oblique, encircling ribs are acute, very regular, and separated by deep furrows.

The five fragments in the Collection vary much in size, and consequently in the direction of their annular foldings. In the largest portion, which measures 1·7 inch in circumference, the uninterrupted rib has a slight curvature on the ventral surface, rises with a gentle sweep, at an angle of 70°, to the back, forming there a slight tubercle, a little without the mesial line. In portions of less diameter, the ribs are not so oblique and acute.

Obs.—This species has the lobes of its chamber-partitions apparently as in *Hamites*, and not as in *Ancyloceras*; but the character afforded by the septal lines is not always reliable, and the differences between these genera are of a doubtful nature; and though I refer the African form to the more characteristically Cretaceous genus, yet I attach very little value to its presence as indicative of Cretaceous age, unless it be supported by more restricted genera.

Loc. In a greenish-grey sandy limestone at Prince Alfred's Rest, and in a greenish sandy limestone at Sunday's River Mouth (Rubidge). Dr. W. G. Atherstone, of Graham's Town, who has also sent a specimen of this Hamite to England, says (in a letter, dated

June 16th, 1859), "I have found the Hamites in the same formation with the Trigonias, not in distinct beds overlying them."

BELEMNITES AFRICANUS, spec. nov. Pl. VII. figs. 2 *a*, 2 *b*.

This Belemnite belongs to the section *Canaliculati*, species of which, though ranging from the Inferior Oolite to the Kimmeridge Clay, are eminently characteristic of the Lower Oolites. This species differs but slightly from *B. Aucklandicus*, concerning which Von Hauer writes that "it resembles so much the well known and widely spread *B. canaliculatus* that it is almost impossible to give a sufficient diagnosis of it."

If *B. sulcatus* be distinct from *B. canaliculatus*, then the former is decidedly the analogue of the South-African and New-Zealand species; for in both *B. Africanus* and *B. Aucklandicus* the ventral groove does not extend to the point, a character that allies them to *B. sulcatus* and separates them from *B. canaliculatus*. They both, however, differ from *B. sulcatus* in being slightly compressed from back to front, presenting sectionally a subquadrate outline, as in *B. canaliculatus*, and not from side to side as in *B. sulcatus*. But, on the other hand, the external aspect of the two antipodean species is that of the last-mentioned species.

A second extra-European species allied to *B. Africanus* is *B. Grantianus*, D'Orb.*, of the Oolites of Cutch, which Sowerby† referred to *B. canaliculatus*, Schloth., but which was regarded as distinct by the former author, who applied to it the specific name here adopted. This species has the form and the wide ventral groove of *B. Africanus*, but agrees with *B. canaliculatus* in having the furrow continuous to the point.

It does not appear, perhaps, allowable to admit of three species intermediate between the closely allied *B. canaliculatus* and *B. sulcatus*; yet I feel justified, from a careful comparison of specimens of all the species, in the course here pursued.

The relationships of these stand thus:—*B. Grantianus* is a subspecies of, or is closely allied to, *B. sulcatus*. (The sulcation is broader and deeper than in the European *B. sulcatus*.)

B. Africanus and *B. Aucklandicus*, the representative species of *B. sulcatus*, are allied, and pass, through *B. Grantianus*, to *B. canaliculatus*. These species might, if allowable, be expressed thus:—

B. antipodum, α. *Aucklandicus*.
" " β. *Africanus*.

Belemnites Africanus is the only species that links the Jurassic fauna of South Africa to that of the Secondary rocks of New Zealand, which Von Hauer regards as either of Jurassic or of Lower Cretaceous age. They contain an *Aucella*, two *Inocerami*, and *B. Aucklandicus*, the only species comparable with a European form, the affinities of which have been pointed out; the genus *Aucella* is confined to the St. Cassian beds and the Oolites; and as a Triassic

* Prodrome, vol. i. p. 327. † Trans. Geol. Soc. 2nd ser. vol. v. p. 329.

fauna is well represented in New Zealand, there is presumptive evidence that the strata which in that island are superior to the latter are of Jurassic age.

Loc. Sunday's River Mouth (Rubidge).

ALARIA CORONATA, spec. nov. Pl. VII. fig. 7.

Shell fusiform, whorls 5 or 6, each with an acute, undulate, spinous, mesial carina; the last whorl with 2 subordinate, obtuse carinæ, which are somewhat rugulose, not spinous; whorls with alternately large and small transverse rugulose striæ, crossed by very fine oblique striations.

The wing and digitations are not preserved in this unique specimen.

Dimens. Length (excluding canal) $1\frac{1}{2}$ inch, breadth (without the wing) 1 inch.

The genus *Alaria* *, eminently, but not exclusively, characteristic of the Jurassic rocks, contains no known species which can be confounded with the present one.

Loc. In light-grey sandy shell-rock on the Sunday's River, associated with *Ammonites subanceps*.

TURRITELLA RUBIDGEANA, spec. nov. Pl. VIII. figs. 6 *a*, 6 *b*.

Shell turreted, spire elongated; whorls 8, angular; suture deeply impressed. Upper half of each whorl with two mesial carinæ, the superior carina tuberculate, the inferior one imperfectly so. Each whorl is ornamented with about twenty elevated oblique ribs, which proceed from the suture to the tubercles of the upper carina, are continued longitudinally to the ill-defined tubercles of the lower carina, and are there lost. The lower half of the last whorl with three or more angular carinæ.

Dimens. ·35 inch in length; breadth of last whorl .125 inch.

Loc. Several specimens, collected by Dr. Rubidge in a very sandy shell-band, with Ostrea, Astarte, &c., at Bethelsdorp Salt-pan. These belong to the "Lowest Strata of the Zwartkop Crag," probably a part of the "Wood-bed series" (see p. 149).

PATELLA CAPERATA, spec. nov. Pl. VII. figs. 1 *a*, 1 *b*.

Shell interruptedly conical; apex obtuse, excentric, and inclined to one side; the base is elliptical, and the periphery is irregular and slightly sinuated; ornamented by numerous radiating ribs, which are a little irregular in direction, and appear but as wrinklings of the surface, crossed by close-set lines of growth, conformable with the edge of the shell, adding to that appearance which I have sought to express by the specific title, *caperata*.

* In a short paper published in 'The Geological and Natural History Repertory,' on the so-called *Rostellariæ* of the British Cretaceous Rocks, I have referred three species to the genus *Alaria*; Zekeli and Stoliczka enumerate five species from the Gosau formation as belonging to this genus; and thus eight species have been recorded from beds of Cretaceous age.

Dimens. Length of longer diameter 2·8 millimetres; shorter diameter 2·1 mill.; height ·9 mill.
Loc. In a reddish shell-rock, Prince Alfred's Rest? (Rubidge).

CHEMNITZIA AFRICANA, sp. nov.

Shell subulate, turreted; apex acute; whorls 9, very slightly constricted in their upper part; the longitudinal ribs, of which there are about twenty in a volution, arise from tubercles; the ribs are depressed and smooth, and become broader inferiorly. Suture deeply impressed; aperture elliptical.
Length 7 lines.
This species is allied to *Ch.* (?) *vetusta* of the Great Oolite of England.
Loc. The specimen, which is unique, was obtained from the Zwartkop River.

TURBO STOWIANUS, spec. nov.

Shell turbinated, whorls convex; upper half of each whorl encircled by six bluntly acute ribs, alternating with similar smaller ones; lower half with the same ornamentation. Aperture round. Axis imperforate.
Dimens. Length 1·35 mill., breadth ·46 mill.
T. Stowianus is related to *T. Bainii*, Sharpe.
Loc. Two specimens were collected by Dr. Rubidge at Prince Alfred's Rest.

AMPULLARIA ? IGNOBILIS, spec. nov.

"Ampullaria ?, undetermined," Sharpe, Trans. Geol. Soc. 2nd ser. vol. vii. p. 203 & p. 232, pl. 28. fig. 21.

Shell very minute, globular, apex subacute, spire very short, composed of 3 inflated whorls, last whorl almost enveloping the spire. Mouth oval.
Loc. Lowest strata of the Zwartkop Crag.

PHASIANELLA ? SHARPEI, spec. nov.

"*Natica*, undetermined," Sharpe, *loc. cit.* pl. 28. figs. 2, 3.

Shell very minute, ovate, globose; spire short; whorls 3, narrow, convex; last whorl large; aperture large and round.
Loc. Lowest strata of the Zwartkop Crag; and Sunday's River.

ACTÆONINA MORRISIANA, spec. nov.

"*Ampullaria* ?, undetermined." Sharpe, *loc. cit.* pl. 28. fig. 20.

Shell very minute, ovate, cylindrical, apex acute; spire short, conical, composed of four cylindrical whorls, the last of which occupies $\frac{10}{11}$ of the whole length of the shell; aperture ovate-oblong, rounded in front, acute behind.
The species is named in compliment to Prof. J. Morris, F.G.S.
Loc. Lowest strata of the Zwartkop Crag.

ACTÆONINA SHARPEANA, spec. nov.

"*Cylindrites*?, undetermined." Sharpe, *loc. cit.* pl. 28. f. 24.

Shell very minute, truncated, cylindrical; spire depressed, obsolete; vertex large, flattened; last whorl with somewhat inflated sides, base contracted, short; aperture elongated, moderately expanded towards the middle, subacute at the extremities.

Loc. Associated with the above.

ACTÆONINA JENKINSIANA, spec. nov.

"*Actæon*?, undetermined." Sharpe, *loc. cit.* pl. 28. fig. 25.

Shell minute, elliptical; apex acute; spire of four whorls, elongated, regularly conical; aperture elongate, attenuated before and behind.

Loc. Lowest strata of the Zwartkop Crag, and Sunday's River.

OSTREA (EXOGYRA) JONESIANA, spec. nov. Pl. VIII. figs. 3 *a*–3 *c*.

Shell ovately orbicular, depressed, the larger valve only known, with a large adhering surface, or simply attached by the small involute umbo. Attached valve with a few strong and somewhat rounded ribs, which indent the margin.

Dimens. Length 1·57 mill., height 1·37.

This species belongs to the section *Exogyra*, and but for that might have been referred to *Ostrea costata* of the Lower Oolites of Europe.

Loc. Salt-pans of Bethelsdorp, with *Cidaris Africana* (Rubidge).

OSTREA IMBRICATA, Krauss, sp.

The species *Exogyra imbricata*, Krauss, was referred by Sharpe to the genus *Gryphæa*; I have placed it in that of *Ostrea*, because the numerous specimens in the Society's museum exhibit gradations from one to the other of the so-called genera; in fact this species affords a good illustration of the mere sectional value (which cannot at all times be employed) of the groups *Exogyra* and *Gryphæa*.

The gryphoid form of *Ostrea imbricata* is closely related to an undescribed species of *Gryphæa* from the Oxford Clay of Weymouth.

Loc. Sunday's and Zwartkop Rivers.

PLACUNOPSIS IMBRICATA, spec. nov. Pl. VIII. fig. 7.

The unattached valve only is known; it is thin, ovate, oblique, and convex; the apex is acute and marginal; the dorsal margin of the valve is straight; the surface has concentric imbricating lamellæ, which towards the front of the valve occupy the ridges of the smooth undulations.

Dimens. Length 2·45 mill., height 1·64 mill.

The general aspect of this species is that of *Pl. semistriata*, Bean, of the Cornbrash of Yorkshire; but the ornamentation of the shell of that species is very distinct.

Loc. In a brick-red shell-rock. One specimen from Prince Alfred's Rest (Rubidge).

PLACUNOPSIS SUBJURENSIS, spec. nov. Pl. IX. figs. 1 *a*, 1 *b*.

Shell orbicular, irregular, thin; free valve rather oblique, exceedingly gibbous; umbo submarginal, obtuse, and depressed; ornamented by numerous, fine, regularly nodulous, waved costæ, crossed by numerous delicate concentric striæ, and a few well-marked lines of growth.

Dimens. Length $1\frac{1}{8}$ inch. Height $1\frac{1}{4}$ inch.

The species of the genus *Placunopsis* have such a general resemblance one to another, both in form and ornamentation, being moreover necessarily more or less variable in shape, that it is often difficult to recognize constant distinctive characters. The present species has for its representative *P. Jurensis* of the Lower Oolites of Europe, and differs from it in its greater gibbosity and obliquity, and in possessing regular knotted ribs.

Loc. Collected by Dr. Rubidge in some abundance at the Zwartkop River Heights, in a yellowish sandy shell-rock.

PLACUNOPSIS UNDULATA, spec. nov. Pl. IX. fig. 2.

Shell orbicular, thin, irregular, nearly equilateral; convex, gibbous or depressed; apex marginal, obtuse, and depressed, ornamented by numerous concentric waved rugæ.

Dimens. Length $1\frac{1}{5}$ inch; height $\frac{9}{10}$ of an inch.

Loc. In yellowish-grey limestone, Mouth of Sunday's River (*Rubidge*); and four specimens adherent to a piece of mineralized wood (calcareous with glauconitic grains) perforated by *Gastrochæna dominicalis* *, Sharpe.

PECTEN RUBIDGEANUS, spec. nov. Pl. VII. fig. 11.

Shell inequivalve, ovately orbicular, convex, with nine or ten equal, large, elevated, subacute and distantly arranged costæ; the intervals are wide and ornamented with very fine concentric striæ, which are continued over the ribs. Auricles large and unequal.

Dimens. Height $\frac{7}{20}$ of an inch; breadth $\frac{6}{20}$ of an inch.

This Pecten presents the appearance, less the spinous processes, of *P. subspinosus*, Schloth., which ranges from the Inferior Oolite to the Coralline Oolite of Nattheim; other slight differencescan be pointed out.

Loc. Dr. Rubidge has found this *Pecten* to be one of the most frequently occurring shells, in a yellowish sandy shell-rock with greenish-grey patches here and there, at Prince Alfred's Rest.

PECTEN PROJECTUS, spec. nov. Pl. IX. fig. 6.

Shell oblique, ovately orbicular, moderately convex, equivalve; remarkably inequilateral, the umbone being slightly curved anteriorly and the anterior side projected forwards. Valves ornamented with closely arranged dichotomous lines curving outwards; the interstitial spaces subpunctated. Auricles unequal, the anterior one

* The specimen figured in Geol. Trans. 2nd ser. vol. vii. pl. 23. fig. 4 *a*, is *wood*, and not "bone," as stated at p. 198, *op. cit.*—T. R. J.

large and concentrically rugose; the posterior one small, the striations of the valve are continued upon it.

Dimens. Height $\frac{7}{8}$ of an inch; breadth $\frac{4}{5}$ of an inch.

P. projectus is closely related by its general outline and ornamentation to *P. lens*, Sow., and *P. arcuatus*, Sow., of the Lower and Middle Oolites of Europe; but the obliquity of the shell and the relatively excentric position of its apical portion are characters by which *P. projectus* is at once separated from them.

P. projectus is allied in form to an undescribed species which I have collected in the upper beds of the Inferior Oolite at Cold Comfort, near Cheltenham, and which I propose to call *P. Tylori*; the latter, however, is more depressed and smooth, except near the margin, where the shell is concentrically striated and crossed by radiating sharp indented lines. *P. Tylori* is a shell that has been confounded, I believe, with *P. cinctus*, Sow., which belongs to the Lower Greensand and not to the Inferior Oolite.

Loc. Collected by Dr. Rubidge in a soft, yellowish-grey, sandy limestone at the Zwartkop River Heights, and at Prince Alfred's Rest; in both localities it is frequent.

Lima neglecta, spec. nov. Pl. VII. figs. 5 *a*, 5 *b*.

"*Lima*, sp. (undeterm.)," Sharpe, Trans. Geol. Soc. 2nd ser. vol. vii. p. 201 (1856).

Shell oblong, transverse, slightly convex, ornamented with numerous acute ribs, the sides of which are longitudinally striated, two or three stronger striæ occupy the central portion of the interspace; under a magnifying glass the surface is seen to be covered with closely set, regular, transverse striations.

Dimens. Height $\frac{5}{8}$ of an inch, breadth $\frac{7}{8}$ of an inch.

L. neglecta belongs to a section of the genus exemplified by *L. duplicata*, Sow., in the Oolites, and *L. parallela*, Sow., in the Lower Greensand.

Loc. In a grey, coarse-grained, sandy and shelly limestone, Sunday's River (*Atherstone*).

Lima obliquissima, spec. nov. Pl. IX. fig. 5.

Shell elongated, depressed, very oblique, umbo acute; hinge-line obliquely truncating the shell; the whole surface ornamented with narrow waved sulci, interspaces punctated.

Dimens.—Height 1 inch; breadth $\frac{7}{8}$ of an inch.

In its elongated and oblique form, *L. obliquissima* resembles several Jurassic *Limæ*; in the character of its sulcations it approximates to *L. rigidula*, Phil.; in its punctated surface it is allied to *L. ovalis*, Sow.; it is, however, characterized by the broad and flat ribs, and the narrow interstitial spaces, angularly waved and punctated.

Loc. In a yellow shell-rock from the Zwartkop River Sandstone, and with *Platynopsis undulata* and fossil wood (*Rubidge*).

Mytilus Jonesi, spec. nov. Pl. VIII. figs. 4 *a*, 4 *b*.

Shell nearly triangular, smooth, shining; hinge-margin straight and long; anterior margin elevated in its median portion; umbo terminal, acute, depressed, ornamented with closely arranged, imbricating, concentric folds.

Named in compliment to Prof. T. Rupert Jones, who has taken part in the elucidation of the geology of South Africa, and whose kind assistance I gratefully acknowledge.

Dimens. Greatest length 1·9 millimetre; greatest breadth 1 millimetre.

Loc. In a greenish, coarse-grained sandstone with calcareous cement, Sunday's River (*Rubidge*).

Mytilus Stowianus, spec. nov. Pl. IX. figs. 3*a*, 3*b*. [Subgenus *Lithodomus.*]

Shell pod-shaped, cylindrical, elongated, rather depressed, umbones small, contiguous, slightly inflated, anterior side narrow, posterior side wider and less compressed, upper and lower margins straight and nearly parallel; concentric plications few and delicate; radiately striated.

Loc. In a fine-grained, grey, sandy limestone, Sunday's River (*Atherstone and Rubidge*).

Mytilus Rubidgei, spec. nov. Pl. IX. fig. 11. [Subgenus *Modiola.*]

Shell transversely elongated, with a straight dorsal edge; anterior part narrow and curved; posterior tapering at the end, divided into two portions by a very obtuse angle; superior and posterior part with numerous oblique plications, which are continued to the keel, and numerous slender folds which are coincident with the plications, but on reaching the keel continue parallel to the ventral margin.

Dimens.:—	Total length	5·25 millimetres.
	Length of posterior side ...	5·18 ,,
	Height	0·9 ,,

This shell is very distinct in its ornamentation from *Modiola Bainii*, Sharpe; but in that respect has a greater resemblance to *Mytilus Sowerbyanus*, D'Orb.; both, however, are straighter shells than *M. Rubidgei*.

Loc. In the greenish sandy limestone of the Sunday's River; many specimens (*Rubidge*).

Astarte Pinchiniana, spec. nov. Pl. IX. figs. 7*a*, 7*b*.

Shell small, ovately orbicular, depressed; umbo acute, postmesial, but directed somewhat forwards; anterior side rounded, its upper margin slightly excavated; hinge-line straight and oblique; lunule small; ornamented by obtuse, closely arranged, regular rugæ, which are slightly undulated on the anal side; the interstitial spaces very narrow.

Dimens. Height and lateral diameter equal, or about 1·45 millimetre.

This species has considerable resemblance in form and ornamentation to *A. pumila*, Sow., and *A. excentrica*, Morr. and Lycett, but differs in its larger size, greater obliquity and straightness of the cardinal line, and in the more excavated dorsal margin of the anterior side. This species is dedicated to Mr. Pinchin, a brother-geologist, from whom Dr. Rubidge has received much assistance in his researches.

Loc. In a grey sandy limestone, weathering yellowish, Sunday's River (*Rubidge*).

Astarte Longlandsiana, spec. nov. Pl. VIII. figs. 5 *a*, 5 *b*.

Shell obovate, slightly convex; anterior side rounded, front curved, posterior side angularly truncated, hinge-line nearly straight or slightly arched; umbones depressed, obscure; lunule lanceolate; ligamental pit narrow and deep, bounded by sharp edges that nearly approach each other. Valves nearly flat, ornamented with numerous subacute, equidistant, slightly elevated ridges of growth.

Dimens. Length 3 inches, width $2\frac{1}{4}$ inches, thickness $\frac{3}{4}$; length of anterior side 1 inch, of posterior 2 inches.

Loc. The unique specimen was found by Mr. H. Longlands (to whom the species is dedicated) in a shelly band of the Zwartkop River limestone, October, 1859.

Pinna Sharpei, spec. nov. Pl. IX. fig. 4.

A drawing* of a *Pinna* found by Mr. Pinchin is comparable with the figures of *P. cancellata*, Morris and Lycett, and *P. Galliennei*, D'Orb.; but as a description on such material must be incomplete, I merely reproduce the drawing, and propose the specific name of *Sharpei*, in memory of the late Mr. D. Sharpe, who described a former series of South-African fossil shells.

Loc. Sunday's River.

Trigonia Cassiope, D'Orb.

Shell ovately trigonal, longer than wide, depressed; umbo anterior, prominent, acute, recurved; the anterior border is rounded; the posterior is truncated, with a large oblique flattened area, which is plicated by close-set, longitudinal, denticulated ribs; the dorsal surface has twenty large, smooth, gracefully curved costæ, separated from the curved, smooth (?) keel by a transversely wrinkled narrow sulcus.

Dimens. Length 2 inches, width $1\frac{1}{2}$ inch, length of carina $1\frac{3}{4}$ inch.

This costated *Trigonia* approaches closely the well-known *T. costata*, from which it is distinguished, however, by the greater length proportionate to the width of the shell; the front also is more curved, and the posterior area is less oblique. *T. costata* is represented in the Scindian Oolites by the varieties *pulla* and *elongata*, the former of which is closely related to *T. Cassiope*. I unhesitatingly refer the African shell to this European species, which

* Made by Mr. Stow, and presented by him to the Geological Society.

occurs in the Great Oolite of Luc (Calvados), Vezelay (Yonne), Grange-Henry, near Nantua, France*, and is moderately abundant in the Cornbrash of Yorkshire†.

Loc. Zwartkop River (*Mr. H. Longlands*). The specimen is unique.

Trigonia vau, Sharpe (*juvenis*), et T. ventricosa, Krauss, sp. (*juvenis*). Pl. VII. fig. 8.

The character of the ornamentation clearly underwent a continuous change during life in these two species of *Trigonia* (*T. vau* and *T. ventricosa*); I have therefore thought it necessary to figure these species in their earliest stage of growth.

Trigonia Goldfussi, Ag. (*juvenis*). Pl. VII. fig. 6.

Associated with the foregoing is the probably young shell of *T. Goldfussi*, Agassiz: certainly I should not be justified in assigning it another appellation; for the African shell is identical with figure 18*a*, plate v. of Morris and Lycett's 'Monograph of the Great Oolite Mollusca.' Hereafter, however, it may be found to be the young of a distinct species.

Loc. In a yellowish sandy shell-rock (a mass of Bivalves with green and grey sand) on the Sunday's River (*Rubidge*).

Corbula? Rockiana, spec. nov. Pl. VIII. fig. 8.

Shell subglobular, smooth, shining; umbones large, obtuse, mesial, erect; anterior side rounded; lunule large, concave; posterior side very short, with a well-marked oblique carina and a truncated posterior border; the surface has numerous, delicate, irregular folds of growth.

Obs.—The above diagnosis is nearly word for word that of *Corbula Agatha*, D'Orb., as given by Lycett in his 'Supplement to the Great Oolite Mollusca,' p. 65. That species, however, is of minute size; its posterior side has a *faintly* marked carina, and its surface a few folds of growth.

Dimens. Length 1·19 millimetre, breadth 1·04 millimetre.

Loc. In a yellowish-grey sandstone with calcareous cement, Zwartkop River (*Atherstone and Rubidge*).

Obs.—The dentition of *Corbula? Rockiana* is unknown; and the species may hereafter be found to belong to *Isocardia* or to *Cyprina*; but, on account of its close affinity to *Corbula Agatha*, I prefer to let it remain with that generic title.

The species is dedicated to Major Rock, who, with Mr. Stow, collected and communicated several fossils from the Uitenhage Formation, and whose name I take this opportunity of associating with South-African geology.

* D'Orbigny, 'Prodrome,' vol. i. p. 308 (1850).

† Lycett, 'Supplement to the Mollusca of the Great Oolite,' Palæont. Soc. (1863), p. 49.

CRASSATELLA COMPLICATA, spec. nov. Pl. IX. fig. 8.

Shell oblong, very much compressed, very inequivalve, the posterior side truncated; anterior side rounded; lip smooth or crenulated; lunule ill-defined; umbo subacute, ornamented with acute costæ, which diverge from the umbo, the angles of the ribs succeeding each other in an oblique direction, a little anterior or posterior to the middle line of the valve; the set of costæ directed towards the anterior side are slightly reflected; the series directed towards the posterior side are straight, the superior costæ of which form another group of diverging ribs; the angles of these are more acute and are directed from the umbo; a few straight costæ occupy the remaining portion of the anal area, and denticulate the hinge-line, which is straight.

Dimens:—	1.	1*.	2.	3.	
Length (entire)	3·17	2·44	1·9	1·44	millims.
Breadth	1·7	1·28	1·0	·9	,,
Length of posterior side..	2·46	1·9	1·5	1·2	,,

The diverging ribs of this species connect it with *C. Robinaldina*, D'Orb.*, of his "Néocomien inférieur" of the Parisian basin, and serve to distinguish it from all other species of the genus. *C. complicata* differs from its European representative in its straighter hinge-line, its truncated posterior side (in *C. Robinaldina* the anal side is slightly acuminated), in its more arched anterior side, and in having only about one-half the number of ribs. These two species present in their remarkable ornamentation a wide departure from the genus, the greater number of species of which have smooth shells; in others they are concentrically furrowed.

Species of the genus characterize tropical seas, and they are well represented in the Tertiary deposits in various parts of the northern hemisphere. During the Cretaceous epoch they appear to have been few in number, as not more than eight or nine are known ranging upwards from the lowest marine bed of that system.

The restricted range of the genus *Crassatella* favours the supposition that the Secondary fauna of Uitenhage may be of Cretaceous age; but the opinion that too much value must not be placed on an isolated case is confirmed by the discovery of a true *Crassatella* in the Inferior Oolite of Rodborough, near Stroud, England; and though it be not of the type to which *C. complicata* belongs, yet the value of the genus as evidence of a Cretaceous facies is thereby lessened.

Loc. Sunday's River (*Atherstone*); and in a yellowish-grey sandy shell-rock at Prince Alfred's Rest (*Rubidge*).

CYPRICARDIA NIVENIANA, spec. nov. Pl. VII. fig. 10.

Shell elongated, subtrigonal; umbo placed anteriorly to the middle of the valve, rather elevated and subacute; anterior side rounded, its upper margin slightly excavated, its lower extremity pointed; the posterior side slopes obliquely downwards, and has an

* Pal. Franç. Terr. Crét. vol. iii. p. 75, pl. 264, figs. 10–13.

imperfectly defined obtuse angle; it is ornamented with delicate, elevated, closely arranged and regular concentric rugæ.

This species is named after Mr. Niven, a fellow-worker with Dr. Rubidge in the geology of the Cape.

Dimens. Length $\frac{9}{10}$ of an inch, height $\frac{13}{20}$ of an inch, length of posterior side $\frac{13}{20}$ of an inch.

Loc. In grey sandy limestone, Sunday's River.

Cyprina Borcherdsi, spec. nov. Pl. VIII. fig. 2.

Shell ovate-oblong, transverse, inequilateral, somewhat inflated; posterior side angulated, the margin truncated; anterior side rounded; front margin slightly arcuate; umbones large, oblique, slightly recurved; ornamented by irregular-sized and close-set lines of growth coincident with the margin. [Named in memory of the late Mr. M. Borcherds, Civil Commissioner at Fort Beaufort, who warmly assisted the late Mr. A. G. Bain in his early researches in South-African Geology.]

Dimens. Length 4·1 millimetres, height 3·1 millimetres.

Loc. Zwartkop River (*Rubidge*).

Cucullæa (Macrodon) Atherstonei, Sharpe, sp.

Arca Atherstoni, Sharpe, Geol. Trans. 2nd ser. vol. vii. p. 196, pl. 22. fig. 10.

If *Cucullæa* and *Arca* be regarded as generically distinct, then the former name should be applied to this species, as I have determined by an examination of the type specimen that the hinge-teeth are longitudinal towards the margin. It belongs to the group *Macrodon.*

Cucullæa Kraussii, spec. nov.

Cucullæa? cancellata, Krauss (non *Arca cancellata*, Sow., nec *Cucullæa cancellata*, Phillips).

As the above-quoted specific name given by Krauss to an Arca-like shell is preoccupied, not only for *Arca*, but for *Cucullæa*, I propose the name "*Kraussii*" instead.

Very perfect specimens collected by Dr. Rubidge on the Zwartkop and Sunday's Rivers exhibit the hinge-characters of this species; its position in *Cucullæa* is incontestable.

Arca (Cucullæa?) Jonesi, spec. nov. Pl. IX. fig. 9.

Shell rhomboidal, convex; umbones slightly anterior to the middle of the valve, large, depressed, and approximate. Anterior side short, its margin rounded; posterior side with an acute carina, posterior to which is a slightly concave surface; the inferior margin is nearly straight. Radiating costæ flat, slightly nodulous; elevated upon the anterior and posterior portions of the valves; much larger, more distant, and acute upon the anterior side; decussated by numerous concentric lines and striæ.

Dimens. Height 1·2 millim.; length 1·8 millim.

Loc. In a greenish-grey sandy marl, rather hard and very calcareous; near the Bridge on the Zwartkop River.

CARDITA NUCULOIDES, spec. nov. Pl. VII. figs. 8 *a–d*.

Shell quadrangular, subglobose, ornamented with fine, closely arranged, radiating lines interrupted by a few crenulated regular plications and fine concentric striæ; umbones anterior, directed forwards, involute; lunule small, flat.

Dimens. Length ·8 millimetre, height ·58, thickness ·73.

Loc. Sunday's River (*Rubidge*). The matrix is a greenish coarse sandstone of quartzose and glauconitic grains with calcareous cement.

BERENICEA ANTIPODUM, spec. nov. Pl. VIII. figs. 1 *a*, 1 *b*.

Polyzoon encrusting, rampant, composed of a single layer of cells. Cells elongated, smooth, nearly cylindrical, but somewhat flattened, quincuncially disposed; terminal portions prominent. Peristomes circular, remote, and separated by about equal distances from one another. The bases of the cells subelliptical, of unequal sizes, irregularly arranged.

Obs.—*Berenicea antipodum* is allied to *B. striata*, J. Haime, of the Lias of Valière, in its elongated and distant cells, and in the great diameter of the peristome. The cells of the African species are smooth; while in *B. striata* they are striated, and are less regularly disposed.

B. antipodum is the only Polyzoon hitherto known in the Secondary rocks of South Africa.

Loc.—In a yellowish shell-rock, with grey patches here and there, Prince Alfred's Rest; encrusting *Trigonia vau*, and *Placunopsis undulata*, from the mouth of Sunday's River; collected by Dr. Rubidge.

ISASTRÆA RICHARDSONI, M.-Edwards & J. Haime, var. nov. *antipodum*.

Corallum massive, or somewhat gibbous; calices polygonal, very unequal in size, shallow, and separated by a moderately strong wall. Fossula distinct; no columella. Septa thin, unequal in size, and forming three cycles; the six primary cycles are much larger than the others, and become thicker near their inner edges; but sometimes the secondary cycles are almost as much developed.

Largest diameter of the calices one and a half line.

The African form of the species differs from the type only in the smaller size of the calices, thinner walls, and more gibbous state of the coral-mass. It is the first recorded fossil Coral from South Africa; one example only is known.

Isastræa Richardsoni occurs in the Inferior Oolite of England, and resembles in its general aspect *I. limitata* and *I. explanulata* of the Great Oolite of the Anglo-Norman basin.

Loc. Discovered by Mr. G. W. Stow in the Uitenhage formation on the Zwartkop River.

SERPULA (VERMILIA) PINCHINIANA, spec. nov. Pl. IX. figs. 10 *a*, 10 *b*, 10 *c*.
"*Serpula*, sp. Large single tube" (Sharpe, Geol. Trans. *l.c.* p. 202).

Tube round, partly attached by a slightly expanded surface; rampant; free portion straight; surface with transverse irregular plications. The outer diameter of the free portion equals 84 millims.

The unattached portion resembles the same part of the tube of *Serpula quadristriata*, and of *S. volubilis* of the Oolites; but in each of these the fixed part is convoluted. It has close affinity to *Vermilia ampullacea* and *V. antiquata* of the Cretaceous rocks, but differs from the former in being very perfectly round, and from the latter by the absence of annular rings.

Loc. On *Trigonia Herzogii*, Sunday's River (*Bain and Atherstone*); Sunday's River Mouth (*Rubidge*).

SERPULA FILARIA, Goldfuss.

Sunday's River (*Rubidge*).

SERPULA PLICATILIS, Goldfuss.

Sunday's River (*Bain*).

CIDARIS PUSTULIFERA, spec. nov. Pl. VIII. figs. 9 *a*, 9 *b*.

The materials at my disposal, illustrative of this species, are many interambulacral plates, some with portions of the ambulacral areas, exhibiting the poriferous zones, and numerous primary spines.

The *ambulacral areas* are narrow, with two rows of small granules; poriferous zones narrow, pores circular, and the septum between the pores forming an elevated moniliform line.

Interambulacral plate (fig. 9 *b*) large and thick; boss prominent, and its summit smooth; the areola is elliptical, around the margin of which are a great number of closely set, imbricating, scrobicular granules, which diminish in size towards the edge of the plate. Interambulacral *polar* plates (fig. 9 *a*) thin, the areolæ circular.

Primary spines cylindrical; margin of acetabulum smooth; head of spine with a prominent finely crenulated ridge; stem of spine cylindrical, covered with granules or spiny tubercles having a linear arrangement.

Loc. Saltpans near Uitenhage (*Rubidge*).

The species described above belongs to that type of the genus characterized by the smooth and uncrenulated bosses of the tubercles; species of this type exist at the present time, and are found in Tertiary and Cretaceous rocks; species of the type with crenulated bosses characterize Oolitic deposits. There are, however, some exceptions to these rules; and for the present the African species may be regarded as another exceptional example.

FUCOIDES CLAVATUS, spec. nov.
"Fucoid?", &c., Sharpe, *op. cit.* p. 202.

Frond cylindrical, dichotomous; branches one inch in length, nearly equal, clavate.

Loc. In grey sandy limestone, Sunday's River.

The following Reptilian remains may be noticed among the fossils from Uitenhage.

1. A small serrated Tooth resembling some belonging to ACANTHOPHOLIS (Huxley, Geol. Mag. vol. iv. p. 65, pl. 5. fig. 4). It was sent to the Geological Society several years ago by Dr. Atherstone. It is imbedded in a greyish sandstone (reddish in part) with calcareous cement, and is from the "Wood-bed Series."

2. A small and imperfect femur of a Lacertilian, from the Zwartkop River Heights (*Dr. Rubidge*).

e. *General Remarks on the Fauna of the Uitenhage Formation.*

The collections of Jurassic fossils from South Africa acquired by the Society since the publication of Mr. Daniel Sharpe's descriptions of Messrs. Bain and Atherstone's specimens contain many new forms, and some few specifically identical with extra-African species. By the aid of these new materials, I have been enabled to arrive at a nearer approximation as to the age of the beds which have yielded them.

The donors to whom the Society is indebted for these valuable acquisitions are Dr. Rubidge, F.G.S., Messrs. Stow and Longlands, Major Rock, and Capt. Harvey.

The earliest publication of any fossils of Secondary (Jurassic) age from the Cape of Good Hope was by Hausmann in 1837; the two species mentioned by him were subsequently figured and described by Goldfuss. Krauss increased this number by the addition of 7 species. Mr. D. Sharpe added 22 species to those previously described; and the species added by the foregoing descriptions make up a total of 74 species for the Jurassic rocks of South Africa.

Krauss proposed to place the beds yielding *Trigonia Hausmanni*, *Astarte Herzogii*, &c. in the Cretaceous series; and the evidence afforded by the few species at his command warranted that arrangement, the *Trigoniæ* having affinities with Post-jurassic species. But since then undoubted Cretaceous fossils have been discovered in Natal; and these have no affinity whatever with those found to the south in the Uitenhage district. The late D. Sharpe's opinion, that the Secondary fossils from this part of South Africa were comparable with those which are found in 'the middle and lower part of the Oolitic series,' is much strengthened by the nature of the additional material.

The great mass of the fossils are Bivalves, which constitute two-thirds of the entire fauna, as far as known. Cephalopods are represented by six species; but individuals are rare; the Gasteropoda are fairly represented. A *Berenicea*, three *Serpulæ*, a *Cidaris*, and a Coral are the only representatives (as far as our collection serves) of the several classes to which they respectively belong.

The extreme rarity of the remains of Cephalopods, Polyzoa, Echinodermata, and Madreporaria calls to mind the conditions of life which prevailed during the deposition of the Great Oolite, and in a less degree of the Forest-marble and the Cornbrash, in this country.

The generic grouping is such as obtains in the Jurassic strata; and though no genus present in the Uitenhage series is exclusively of that age, yet the following point to such an age:—*Belemnites* (of the section *Canaliculati*), *Actæonina*, *Neritopsis*, *Alaria*, *Pleuromya*, *Placunopsis*, *Gervillia*, and *Isastræa*.

The genus *Alaria* is eminently, but not exclusively, characteristic of Jurassic rocks; eight species, however, have been recorded from beds of Cretaceous age. I have no knowledge of the genus *Placunopsis* having ever been identified from rocks newer than the Lower Oolites, though its occurrence in the Coal-measures of Illinois has lately been recorded by Messrs. Meek and Worthen: and though *Isastræa* ranges from the St. Cassian beds to the Tertiary, yet it is a good Jurassic genus.

On the other hand, *Hamites* and *Crassatella*, which are represented in the Uitenhage beds, may be thought to indicate Cretaceous affinities; yet I attach very little value to their presence as indicative of Cretaceous age, unless they be supported by more restricted genera. Such a one apparently is *Crassatella*, which hitherto has not been met with below the Lower Greensand; and its restricted range favours the supposition that the Secondary fauna of Uitenhage, or a part of it, is of Cretaceous age; but that too much value should not be placed on an isolated case receives confirmation in the newly ascertained occurrence of a *Crassatella* (*C. oolitica*) in the Inferior Oolite of England: the presence of the genus as marking a Cretaceous facies is materially lessened by this discovery.

The Uitenhage fauna under notice does not contain a single genus unknown in the Jurassic Series. Krauss, it is true, created the genus *Anoplomya* on South-African shells; but it is clearly synonymous with *Pleuromya*.

None of the fossils enumerated by the late D. Sharpe are identical with any known European species; but amongst those subsequently added to our collection are two European forms, *Trigonia Cassiope*, D'Orb., and *T. Goldfussi*, Agassiz. *Serpula filaria* and *S. plicatilis* are the other European species.

A very large number of the Jurassic Mollusca of South Africa have their representatives in the Oolites of Europe and the equivalent beds in India. The following Table exhibits those from Uitenhage which are analogous to Secondary species in other parts of the world.

Species of Mollusca &c. fossil in the Uitenhage Formation, South Africa.	Secondary species analogous to those of Uitenhage.	Localities, besides South Africa, where the Uitenhage species or their analogues occur.	Age of the beds in extra-African localities.
Ammonites Atherstonei ...	Am. macrocephalus, *Schloth.*	England; France; Russia; Cutch, India.	Kelloway Rock; Oxford Clay; Jurassic.
Ammonites Bainii.........	Am. Brackenridgei, *Sow.*	Europe	Great Oolite.
	Am. lingulifer, *D'Orb.* ...		Inferior Oolite.
Ammonites subanceps ...	Am. anceps, *Rein.*.........	Europe	Kelloway Rock; Kimmeridge Clay?
	Am. Hookeri, *Blanford* ...	Niti Pass, India	Jurassic.
Belemnites Africanus ...	B. sulcatus, *Miller*	France; England	Inferior Oolite.
	B. Grantianus, *D'Orb.*.......	Cutch, Spiti, and Niti, India	Jurassic.
	B. Aucklandicus, *Hauer* ...	Auckland, New Zealand	
Chemnitzia Africana	Ch. vetusta, *Mor. & Lyc.* ...	Scarborough	Inferior Oolite.
Ostrea Jonesiana	O. costata, *Sow*............	England; France	From Inferior Oolite to Cornbrash.
Pecten projectus	P. lens, *Sow.*	England; France; Germany	From Inferior Oolite to Great Oolite.
	P. Tylori, *Tate*	Coteswolds............	Inferior Oolite.
Pecten Rubidgeanus.........	P. subspinosus, *Schloth.* ...	England; France; Germany	From Inferior Oolite to Coral-rag.
Lima obliquissima.........	L. ovalis, *Sow.*	Gloucestershire; Somersetshire	From Great Oolite to Cornbrash.
	L. rigidula, *Lycett*	Normandy	
Corbula Rockiana............	C. Agatha, *Lycett*	Wiltshire; Boulogne	Forest-marble and Cornbrash.
Placunopsis subjurensis ...	P. Jurensis, *Römer*	England; Germany	From Inferior to Great Oolite.
Placunopsis imbricata	P. substriata, *Lyc.*	Scarborough; Gloucestershire............	Inferior Oolite and Cornbrash.
Trigonia Cassiope.........	T. Cassiope, *D'Orb.*	Scarborough; Normandy............	Cornbrash.
	T. pulla, *Mor. & Lyc.*	Europe; Cutch............	Lower and Middle Oolites.
Trigonia Goldfussi	T. Goldfussi, *Agas.*	England; France; Germany	Great Oolite.
Crassatella complicata	C. Robinaldina, *D'Orb.* ...	France	Lower Neocomian.
Pinna Atherstonei............	P. Hartmanni, *Ziet.*.........	Europe	Middle Lias.
Pinna Sharpei	P. cancellata, *Mor. & Lyc* ...	England............	Great Oolite.
Mytilus Bainii	M. Sowerbianus, *D'Orb.* ...	Europe	From the Inferior to the Great Oolite.
Pholadomya dominicalis	P. Hausmanni, *Goldf.* ...	Europe	Lower and Middle Lias.
	P. similis, *Agas.*	France; Germany; Spain	Oxford Clay.
	P. decemcostata, *Röm.* ...	Europe	
Astarte Pinchiniana	A. pumila, *Goldf.*.........	England; Germany	Great Oolite.
	A. excentrica, *Mor. & Lyc.*		
Berenicea antipodum	B. striata, *Haime*	France	Lower Lias.
Serpula filaria, *Goldf.*	S. filaria, *Goldf.*	England; Germany; France	Inferior Oolite.
Serpula plicatilis, *Münst.*...	S. plicatilis, *Münst.*		
Isastræa Richardsoni, var. antipodum	I. Richardsoni, *M.-Edwards*	Dundry, Somerset............	Inferior Oolite.

From the above Table the following conclusion may be deduced:—

That the fauna of the strata (Trigonia-beds) overlying the plant-bearing beds of Geelhoutboom presents a decided Oolitic facies; and, though few species are common to these South-African strata and the European Oolites, yet from the large number of species in these strata at Uitenhage having analogues in the Lower and Middle Oolites, and the species in common pointing in the same direction, the fossil fauna of the Sunday's River and Zwartkop River Limestones represents that of the Oolitic rocks of Europe, and approximates to that of the Great Oolite.

IV. *Observations on the Secondary Strata of South Africa, and on their foreign equivalents.*

The Secondary strata now determined for South Africa are as follows:—

Strata.	Localities.	Age.
I. Limestones &c. with fossils (Quart. Journ. Geol. Soc. vol. xi. pp. 453 &c.)	Umtafuna River, NATAL*	Cretaceous.
II. UITENHAGE FORMATION.		Jurassic.
1. Limestones and shelly sandstones of UITENHAGE (with abundance of marine fossils)	Bushman's River, ALBANY ......; Sunday's, Zwartkop, and Gamtoos Rivers, UITENHAGE.........	
2. (Lower strata of the Zwartkop Crag) Wood-bed series........................	Bushman's River, ALBANY.........; Bethelsdorp; Zwartkop River, Geelhoutboom on the Sunday's River, UITENHAGE	
3. Enon Conglomerate	Bushman's River, ALBANY.........; Enon, Sunday's River, ALEXANDRIA ....; Zwartkop River, UITENHAGE......	
III. KAROO SERIES.		Triassic.
1. Stormberg Beds............	Drakenberg Range, ORANGE RIVER FREE STATES and NATAL.; Bloemfontein, ORANGE RIVER FREE STATES ....; Stormberg Range, ALBERT &c. ...	
2. Beaufort Beds	BEAUFORT; GRAAF REINET; COLESBERG; CRADOCK; FORT BEAUFORT, &c.	
3. Koonap Beds...............	WORCESTER; SOMERSET, &c.	
4. Ecca Beds	WORCESTER; ALBANY; VICTORIA, &c.	

The study of the affinities of the fossils of Secondary age in South Africa has led me to consider the distribution of the lower members of the Mesozoic rocks over the surface of the earth, and the laws that apparently were in operation during their deposition.

The Upper Trias presents, in the majority of the countries in which it has been carefully examined, a remarkable uniformity with

* The names in capital letters are names of Provinces.

the European type. In the Niti Pass* and Spiti Valley (N.W. Himalayas), New Zealand†, California‡, and New Caledonia §, Triassic rocks have yielded many of the characteristic marine fossils of the Upper Trias of Austria, where this formation is typically developed. In South Africa, rocks of this age present somewhat exceptional characters; and if we regard the Keuper of Europe as indicating a condition of things approximating to fresh water or brackish water ‖, the lacustrine deposits of the Karoo Desert will be analogous to it.

The Jurassic series, which has its fullest development in Western and Central Europe, is reduced, in the Mediterranean basin, to beds representing the Lower and Middle Jurassic beds, from the Lias to the Oxford Clay inclusive; and in Russia the Jurassic rocks constitute but one formation. In extra-European countries, containing representatives of the Jurassic rocks, there is, as in Russia, no division into formations as in Western Europe; and the fauna represents not that of one of these formations, but is equivalent to those of the various groups of rocks, recalling, however, on the whole, the forms of life prevalent in the Middle and Lower Oolites, as strikingly illustrated by the Jurassic fauna of Cutch, India, of that of the Niti Pass, of Thibet—in a less degree by that of New Zealand, and even that of Spiti; for though Dr. Stoliczka has endeavoured to establish a definite succession of strata analogous to several members of the European Juras, yet, in my opinion, he has failed to establish a true correlation; for the fossils which in Europe belong to determinate stages in the geological scale are confusedly associated together in the various members of the Spiti equivalents of the Jurassic rocks. Trautschold divides the Jurassic rocks of Moscow into three zones; but in each occur fossils of various Jurassic formations, rendering it impossible to pronounce on the equivalent of any one of them. This appears to be the case with the Spiti beds. The marine Jurassic strata of South Africa do not show any evidence of a departure from the conditions that determined the distribution of life in extra-European areas during Jurassic times.

This remarkable world-wide distribution of the animal life of the Middle Jurassic rocks is paralleled by that of the associated vegetable remains¶; for accompanying the Jurassic faunas of Cutch and Uitenhage are plants generically identical with those of the phytiferous beds of the Yorkshire coast, which occupy an horizon near to the base of the Lower Oolites, and contain the most complete flora of the Jurassic epoch.

This relationship of the faunas and floras of extra-European

* Mem. Geol. Surv. India, vol. v. pt. 1. p. 35 *et seq.*

† Paläontologie von Neu-Seeland.

‡ Palæontology of California, vol. i. p. 19 *et seq.*

§ Bull. Soc. Linn. Normandie, vol. viii. p. 332 *et seq.*

‖ See remarks on the Lettenkohle of the Keuper and on the Triassic deposits of Virginia, Connecticut, &c., in Prof. Rupert Jones's 'Monograph of the Fossil Estheriæ,' Pal. Soc. 1862.

¶ The existence of Jurassic deposits on the east coast of Africa appears to be proved by the occurrence of *Ammonites annularis*, Rein., at Kisaludini, near Mombas, 4° S. lat. (Quart. Journ. Geol. Soc. vol. xv. part ii. p. 17, 1859).

Oolitic rocks to those of Europe shows an affinity and a correspondence in the northern and southern hemispheres which does not exist in the now-living faunas and floras, and demonstrates the contemporaneity of deposits having a wide geographical range; for, with but very few exceptions, the species in the several areas are distinct, whilst the majority of those in each of the several areas have analogous forms in the other areas; and they, as a whole, constitute but one type, approximating to that of the Lower and Middle Oolites. Is not the one formation in Cutch, in Uitenhage, and in Russia contemporaneous with the whole Jurassic period of Europe? for in this latter area, where the greatest variation of physical conditions has prevailed, there is to be found the greatest diversity of life. Now, if the condition of homotaxis had been in operation, a greater community of species between the faunas and floras of these outlyiug areas and those of the great centre of diffusion would have resulted. But little or no dispersion had taken place, as each of these provinces has its own fauna and flora, the amount of persistency of life in each corresponding to the uniformity of the forces which were in operation from the commencement to the close of the Jurassic epoch. Western Europe, having been the scene of great physical changes during this period, possesses a great variety of life, whereas South Africa during the same period of time witnessed few revolutions, and, as the forces tending to modify its life were comparatively tranquil, its fauna and flora exhibit little diversity.

I therefore would not regard the Oolites of South Africa as coeval with this or that formation, but maintain that they are the representations of the whole of the Jurassic rocks—or rather of the whole, less the Upper Oolites, since no forms analogous to those of that period have been met with beyond the confines of Europe.

It is also worthy of remark that the representative faunas of the European Cretaceous rocks, in the majority of the extra-European districts examined, exhibit a remarkable uniformity, and are analogous to the fauna of our Middle Cretaceous formations.

V. *A Table of the Organic Remains of the Uitenhage Formation.*

a. *Flora of the Wood-bed Series at Geelhoutboom.*

Order Coniferæ.

Athrotaxites Indicus?, *Oldham.*

Order Cycadaceæ.

1. Palæozamia (Otozamites) recta, *Tate.*
2. Palæozamia (Podozamites) Morrisii, *Tate.*
3. Palæozamia Rubidgei, *Tate.*
4. Palæozamia? Africana, *Tate.*

Order Filices.

1. Pecopteris Atherstonei, *Tate.*
2. Pecopteris Rubidgei, *Tate.*
3. Pecopteris Africana, *Tate.*
4. Asplenites lobata, *Oldham.*
5. Sphenopteris antipodum, *Tate.*
6. Cyclopteris Jenkinsiana, *Tate.*

b. *Fauna of the Uitenhage Formation.*

	Sunday's River Mouth.	Sunday's River.	Prince Alfred's Rest.	Zwartkop River.	Lowest strata of the Zwartkop Crag.
Acanthopholis? (Tooth.)	...	...	...	...	*?
Lacertilian bone	...	...	...	*	...
Ammonites Atherstonei, *Sharpe*	...	*	...	*	...
—— Bainii, *Sharpe*	...	*	...	...	...
—— subanceps, *Tate*	...	*	...	...	...
Belemnites Africanus, *Tate*	*	...	...	...	...
Hamites Africanus, *Tate*	*	...	*	...	...
Nautilus, undetermined	...	*	...	...	...
Actæonina Atherstonei, *Sharpe*, sp.	...	*	...	...	*
—— Morrisiana, *Tate*	...	...	...	...	*
—— Jenkinsiana, *Tate*	...	*	...	...	*
—— Sharpeana, *Tate*	...	...	...	...	*
Alaria coronata, *Tate*	...	...	...	...	*
Ampullaria? ignobilis, *Tate*	...	...	...	...	*
Chemnitzia Africana, *Tate*	...	...	...	*	...
Natica Atherstonei, *Sharpe*	...	...	...	...	*
Neritopsis turbinata, *Sharpe*	...	*	...	...	...
Phasianella? Sharpei, *Tate*	...	*	...	...	*
Patella caperata, *Tate*	...	...	*?	...	...
Trochus Bainii, *Sharpe*	...	...	...	...	*
Turbo Atherstonei, *Sharpe*	...	...	...	...	*
—— Bainii, *Sharpe*	...	*	...	...	*
—— Stowianus, *Tate*	...	...	*	...	...
Turritella Rubidgeana, *Tate*	...	...	...	...	*
Arca Jonesi, *Tate*	...	...	...	*	...
Astarte Bronnii, *Krauss*	...	...	...	*	...
—— Herzogii, *Hausmann*	...	...	...	*	...
—— Longlandsiana, *Tate*	...	...	...	*	...
—— Pinchiniana, *Tate*	...	*	...	...	...
Avicula Bainii, *Sharpe*	...	...	...	...	*
Cardita nuculoides, *Tate*	...	*	...	...	...
Ceromya papyracea, *Sharpe*	...	...	...	*	...
Corbula Rockiana, *Tate*	...	...	...	*	...
Crassatella complicata, *Tate*	...	*	*	...	...
Cucullæa (Macrodon) Atherstonei, *Sharpe*, sp.	...	*	...	...	...
—— Kraussii, *Tate*	...	*	...	*	...
Cypricardia Niveniana, *Tate*	...	*	...	...	...
Cyprina Borcherdsi, *Tate*	...	...	...	*	...
—— rugulosa, *Sharpe*	...	*	...	...	...
Cyrena? Bainii, *Sharpe*	...	...	...	...	*
Gastrochæna dominicalis, *Sharpe*	...	*†	...	...	...
Gervillia dentata, *Krauss*	...	*	...	*	...
Lima obliquissima, *Tate*	...	*†	...	*	...
—— neglecta, *Tate*	...	*	...	...	...
Mytilus Jonesi, *Tate*	...	*	...	...	...
—— (Modiola) Atherstonei, *Sharpe*, sp.	...	...	...	...	*
—— (Modiola) Bainii, *Sharpe*, sp.	...	*†	...	...	...
—— (Modiola) Rubidgei, *Tate*	...	*	...	...	...

† These seem to belong to the "Woodbed series" of the Sunday's River; and probably others of the same zone are included in this column.

	Sunday's River Mouth.	Sunday's River.	Prince Alfred's Rest.	Zwartkop River.	Lowest strata of the Zwartkop Crag.
Mytilus (Lithodomus) Stowianus, *Tate*	...	*	...	...	...
Ostrea imbricata, *Krauss*, sp.	...	*	...	*	...
—— (Exogyra), Jonesiana, *Tate*	...	...	...	...	*
Pecten projectus, *Tate*	...	...	*	*	...
—— Rubidgeanus, *Tate*	...	...	*	...	...
Perna Atherstonei, *Sharpe*	...	*†	...	...	...
Pholadomya dominicalis, *Sharpe*	...	*	...	...	...
Pinna Atherstonei, *Sharpe*	...	*	...	...	...
—— Sharpei, *Tate*	...	*†	...	...	...
Placunopsis imbricata, *Tate*	...	...	*	...	...
—— subjurensis, *Tate*	...	...	...	*	...
—— undulata, *Tate*	...	*	...	...	...
Pleuromya Bainii, *Sharpe*, sp.	...	*†	...	...	...
—— lutraria, *Krauss*, sp.	...	...	...	*	...
Psammobia Atherstonei, *Sharpe*	...	*†	...	...	...
Sanguinolaria ? Africana, *Sharpe*	...	*	...	...	*
Trigonia conocardiformis, *Krauss*, sp.	...	*	...	*	...
—— Cassiope, *D'Orbigny*	...	...	...	*	...
—— Goldfussi, *Agassiz*	...	*	...	...	...
—— Herzogii, *Hausmann*, sp.	...	*	...	*	...
—— vau, *Sharpe*	...	*	...	*	...
—— ventricosa, *Krauss*, sp.	...	...	...	*	...
Berenicea antipodum, *Tate*	*	...	*	...	...
Serpula filaria, *Goldf.*	...	*	...	...	...
—— plicatilis, *Goldf.*	...	*	...	...	...
—— (Vermilia) Pinchiniana, *Tate*	*	*	...	...	...
Cidaris pustulifera, *Tate*	...	...	...	...	*
Isastræa Richardsoni, *M.-Ed. & Haime*, var. antipodum, *Tate*	...	...	...	*	...

Postscript.—Since compiling the synoptical accounts of the Karoo and Uitenhage formation given at pages 142 & 149, Dr. Atherstone has kindly sent me the 'Notes of a Journey in two directions across the Colony, made in the years 1857–58, by Andrew Wyley, Esq.,' 4to: Cape Town, 1859. This Report contains very valuable information on the lithology and geology of South Africa; and, as an Appendix, the author gives, in a tabular form, his views of the grouping of the several formations, with their approximate thicknesses, as below. I premise, however, that Mr. Wyley's reference of some of the divisions to the European New Red Sandstone and the Carboniferous groups is not at all in accordance with the views advanced in the foregoing Memoir.

Mr. Wyley's divisions of the Karoo Beds, with the included Trap-breccia, coincide with those suggested at pp. 142, 143; but his nomenclature appears to me less applicable than that proposed in this Memoir.

† These seem to belong to the "Wood-bed series" of the Sunday's River; and probably others of the same zone are included in this column.

Mr. Wyley's Nomenclature.	Thickness in feet.	Mr. Wyley's Description of the Beds.	Nomenclature used in this Memoir.
Tertiary	100 ?	Marine clays and limestones near Oliphant's Hoek. Lignite beds and clays, and Tigervley Sandstone of the Cape Flats.	
Jurassic (Oolite)	400 ?	Sunday's River Beds, with marine shells, fossil wood, and land Plants; Koega Beds, Zwartkop Beds; Bushman River Beds.	JURASSIC.
New Red Sandstone.	300 ?	Enon Conglomerate, Bushman's River Sandstones and Conglomerates, Knysna Conglomerate.	
Coal-measures. Upper	1800	Stormberg Beds; upper beds of the Sneeuwberg, Nieuwveld, and Roggeveld, &c. Distinct tiers of sandstone, separated by shales: abundance of land Plants, beds of coal and graphite (altered coal); reptilian remains, but not abundant.	STORMBERG BEDS. (KAROO SERIES.)
Coal-measures. Middle......	1700	Proper Reptilian or Dicynodon Beds; purple, greenish, and grey shales, with fewer sandstone beds: Reptilian bones, Fish teeth, Plants.	BEAUFORT BEDS. (KAROO SERIES.)
Coal-measures. Lower	1500	Brown sandstone and shales, greenish do.: with Plants pretty common, especially in the upper part of the scarp of the Kleine Roggeveld, Fish River, and at Fort Brown.	KOONAP BEDS. (KAROO SERIES.)
Coal-measures. Upper Karoo Shale.	1200	Shales usually dark-grey, with few sandstone beds: Karoo plain; Fort Brown Flats; Ecca Shales: impressions of land Plants.	UPPER ECCA BEDS. (KAROO SERIES.)
Trap-conglomerate.	500 to 800	Trappean conglomerate, or hardened trap-ash, with numerous rounded and angular fragments of the older rocks, from the smallest grain to two feet in diameter, conformable as a mass to the beds above and below; having a rude cleavage nearly at right angles to the general bedding.	TRAP-BRECCIA. (KAROO SERIES.)
Carboniferous shale ? Lower Karoo Shales.	800	Lower Karoo Shales; dark shales, usually contorted, like the sandstone below them; of small thickness, though seen both at Pienaar's Kloof and the Zuurberg. (Marine shells [?], *Bain.*)	LOWER ECCA BEDS. (KAROO SERIES.)

Mr. Wyley's Nomenclature.	Thickness in feet.	Mr. Wyley's Description of the Beds.	Nomenclature used in this Memoir.
Carboniferous Limestone.	1000	Witteberg and Zuurberg, Graham's Town and Winterhoek Sandstone. Sandstones of a white or yellowish colour, a few beds of red or yellow shales. Plants, Lepidodendron &c.	
Old Red Sandstone. Upper Devonian.	1100	Dark-grey and brownish shales, with fossils abundant, of a Devonian or Carboniferous Limestone type; beds of brown rippled sandstone, with long-winged *Spiriferi.*	
Old Red Sandstone. Lower Devonian.	4000	Table-mountain Sandstone, and sandstones of the littoral range of mountains generally; grey sandstones, conglomeratic at base, reddish shaly below.	
Silurian	unknown	Slate and grits, usually of a greenish, grey, or brownish colour; beds, as usually seen, vertical, or at high angles, broken through and altered by granite.	
Metamorphic ...	....	Gneiss, granitic gneiss, and metamorphic schists, limestone, &c.; Namaqualand, Bushmanland, Kalihari Desert, and a great part of the interior. Copper, iron, &c.	
Granite	....	Granite of Table-mountain; Cape, Paarl, Malmesbury, and George Districts, Namaqualand, &c. (Minerals—schorl, garnet, kyanite, fluor-spar, &c.)	
Greenstone	....	Greenstone, syenitic greenstone, basaltic greenstone, amygdaloid, &c., occurring chiefly in beds and dykes in the 'Middle' and 'Upper Coal-measures' and in the gneiss. Minerals—calc-spar, sulphate of barytes (in one place only), asbestos, epidote, prehnite, agate, chalcedony, &c. The crystalline felspar-trap, associated with the copper of Namaqualand, is more of a greenstone than granitic in character. A peculiar felspar-trap-conglomerate occurs in the Roggeveld Spitz.	

EXPLANATION OF PLATES V.–IX.

Illustrative of Fossils from South Africa.

Plate V.

Fig. 1. *Pecopteris Rubidgei*: *a*, portion of a frond, natural size; *b*, pinnule magnified.
2. *Pecopteris Atherstonei*: *a*, portion of a frond, natural size; *b*, pinnule, magnified.
3. *Palæozamia Rubidgei*: *a*, portion of a frond, natural size; *b*, leaflet, magnified.
4. *Palæozamia Morrisii*: portion of a frond, natural size.
5. *Palæozamia Africana*: leaflet, natural size.
6. *Phyllotheca*, sp.: portion of stem, natural size.
7. *Palæozamia* (*Otozamites*) *recta*: *a*, portion of a frond; *b*, leaflet magnified.
8. *Rubidgea Mackayi*: a frond, natural size.

Plate VI.

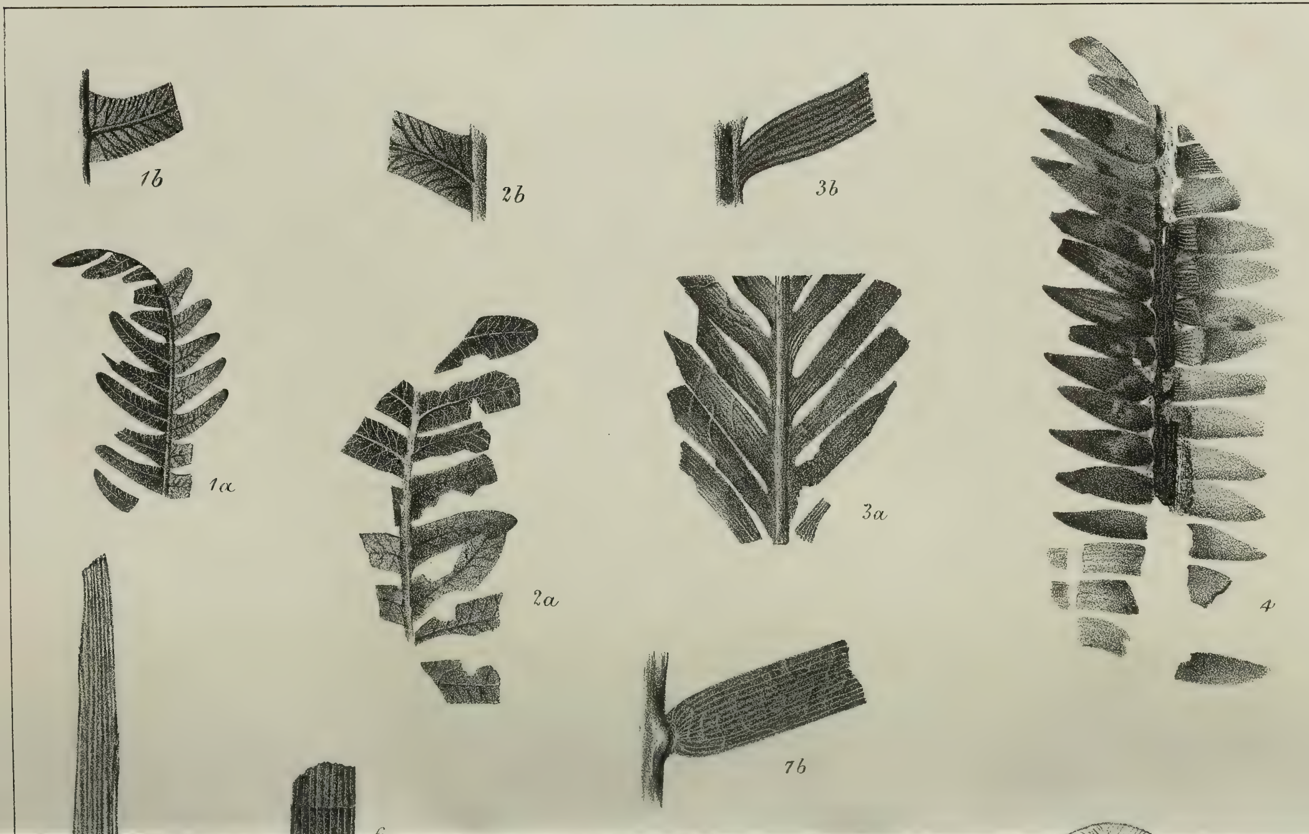
Fig. 1. *Pecopteris Africana*: *a*, portion of a frond, natural size; *b*, pinnule magnified.
2. *Glossopteris Sutherlandi*: *a*, portion of a frond, natural size; *b*, magnified.
3. *Sphenopteris antipodum*: portion of a frond, natural size.
4. *Cyclopteris Jenkinsiana*: portion of a frond, natural size.
5. *Glossopteris Browniana*: *a*, upper portion of a frond, natural size; *b*, lower portion, natural size.
6. *Dictyopteris? simplex*: portion of a frond, natural size.
7. *Glossopteris Browniana*: *a*, portion of a broad frond, natural size; *b*, portion of the same, magnified.

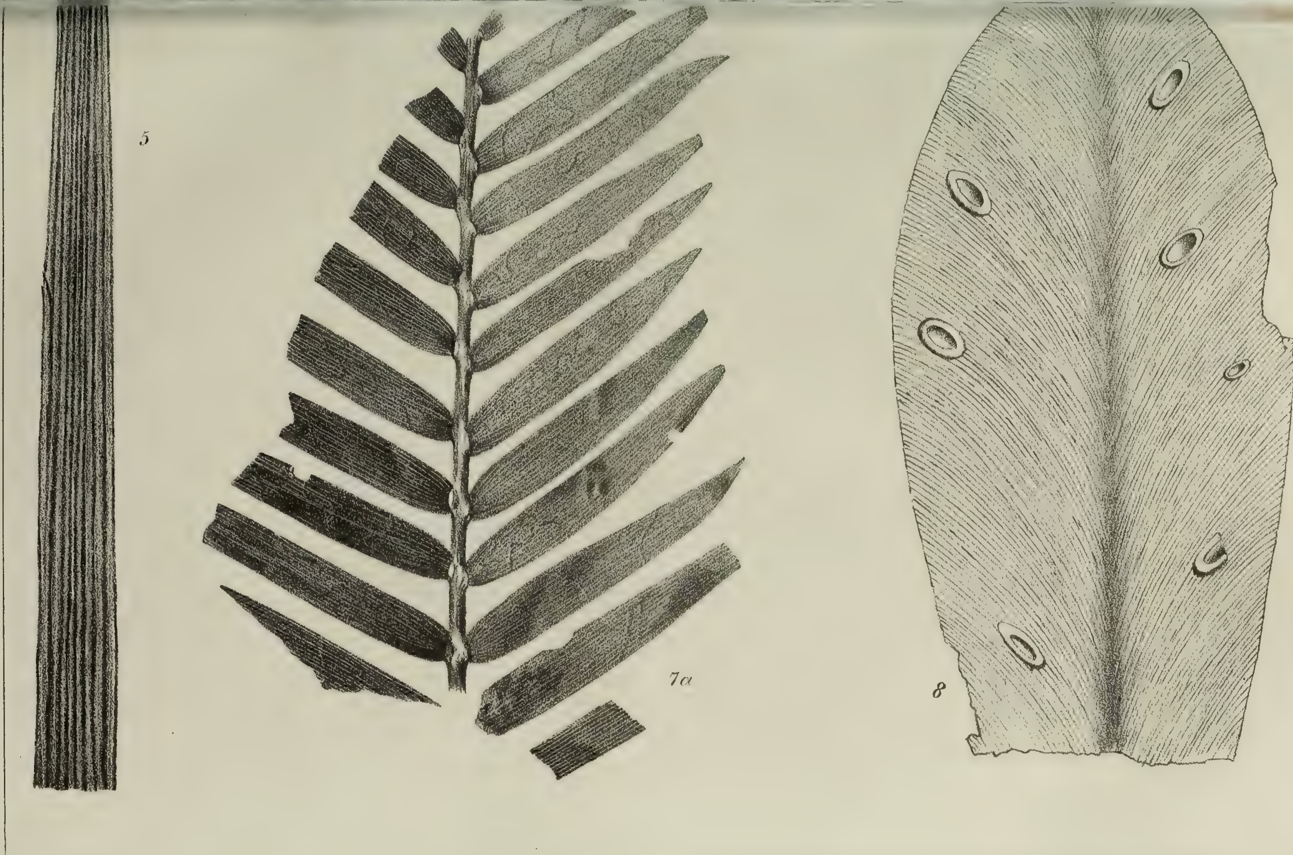
Plate VII.

Fig. 1. *Patella caperata*, natural size: *a*, side view; *b*, view from above.
2. *Belemnites Africanus*, natural size: *a*, ventral aspect; *b*, transverse aspect of the alveolar region.
3. *Ammonites subanceps*, natural size: *a*, view showing the back; *b*, side view.
4. *Hamites Africanus*, natural size: *a*, lateral view, with a portion of the shell to exhibit the foliations; *b*, lateral view of a portion of a shell of large diameter; *c*, ventral view of a small specimen; *d*, ventral view of specimen *b*.
5. *Lima neglecta*: *a*, shell, twice the natural size; *b*, a portion of the shell, magnified.
6. *Trigonia Goldfussi*, enlarged three times.
7. *Alaria coronata*, natural size.
8. *Cardita nuculoides*: *a*, viewed from above; *b*, from the front; *c*, side view: all enlarged two times; *d*, portion of the shell, much magnified.
9. *Trigonia ventricosa*: young shell, twice the natural size.
10. *Cypricardia Niveniana*, natural size.
11. *Pecten Rubidgeanus*, twice the natural size.

Plate VIII.

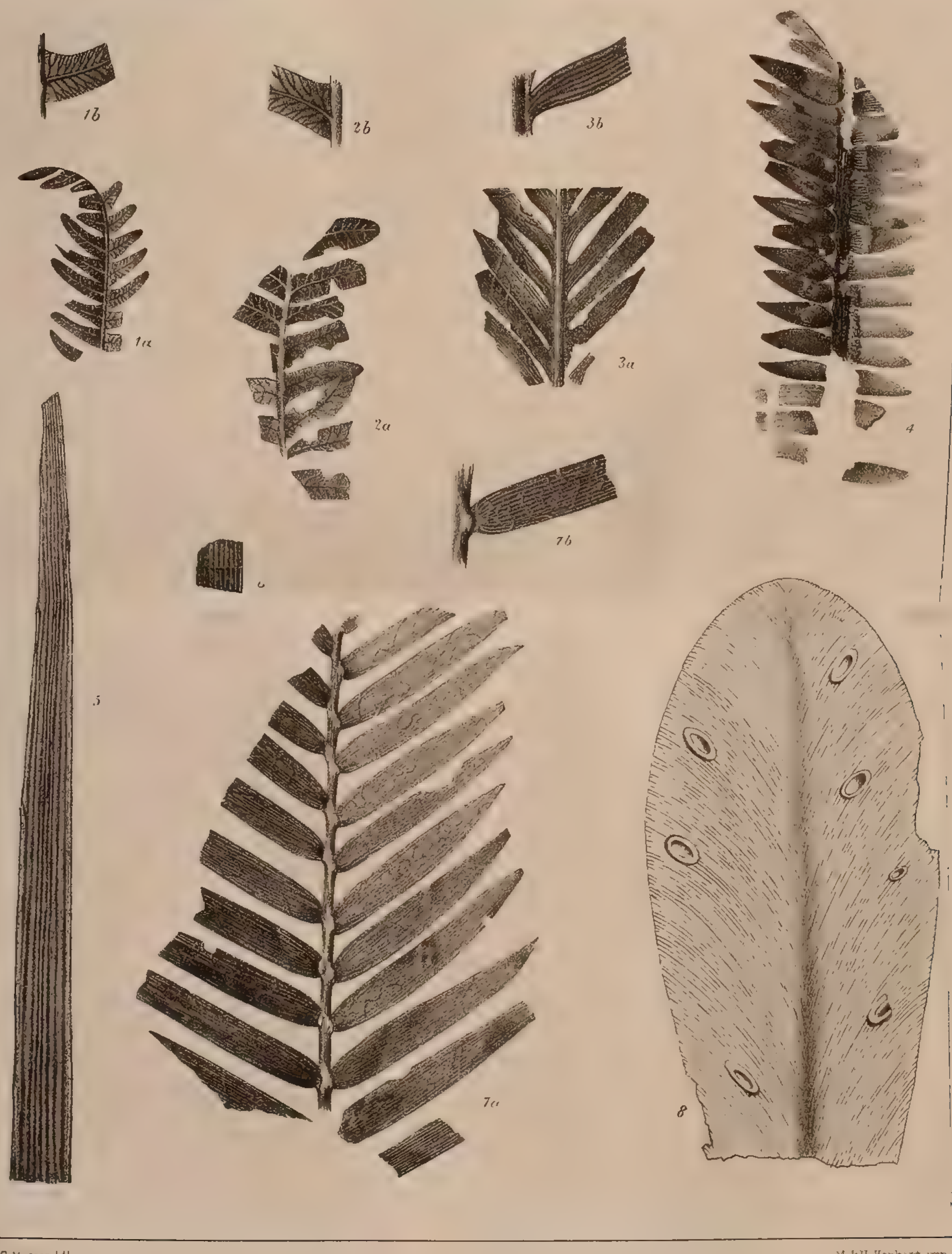
Fig. 1. *Berenicea antipodum*: *a*, natural size; *b*, a portion highly magnified.
2. *Cyprina Borcherdsi*, natural size.
3. *Ostrea* (*Exogyra*) *Jonesii*: *a*, exterior of an attached valve; *b*, interior of another specimen; *c*, exterior of the same; all slightly enlarged.
4. *Mytilus Jonesii*: *a*, lateral view; *b*, side view: natural size.
5. *Astarte Longlandsiana*: *a*, side view; *b*, dorsal aspect of the closed valves.
6. *Turritella Rubidgeana*: *a*, natural size; *b*, enlarged three times.
7. *Placunopsis imbricata*, natural size.
8. *Corbula Rockiana*, slightly enlarged.


1b
2b
3b
1a
3a
2a
4
7b
6



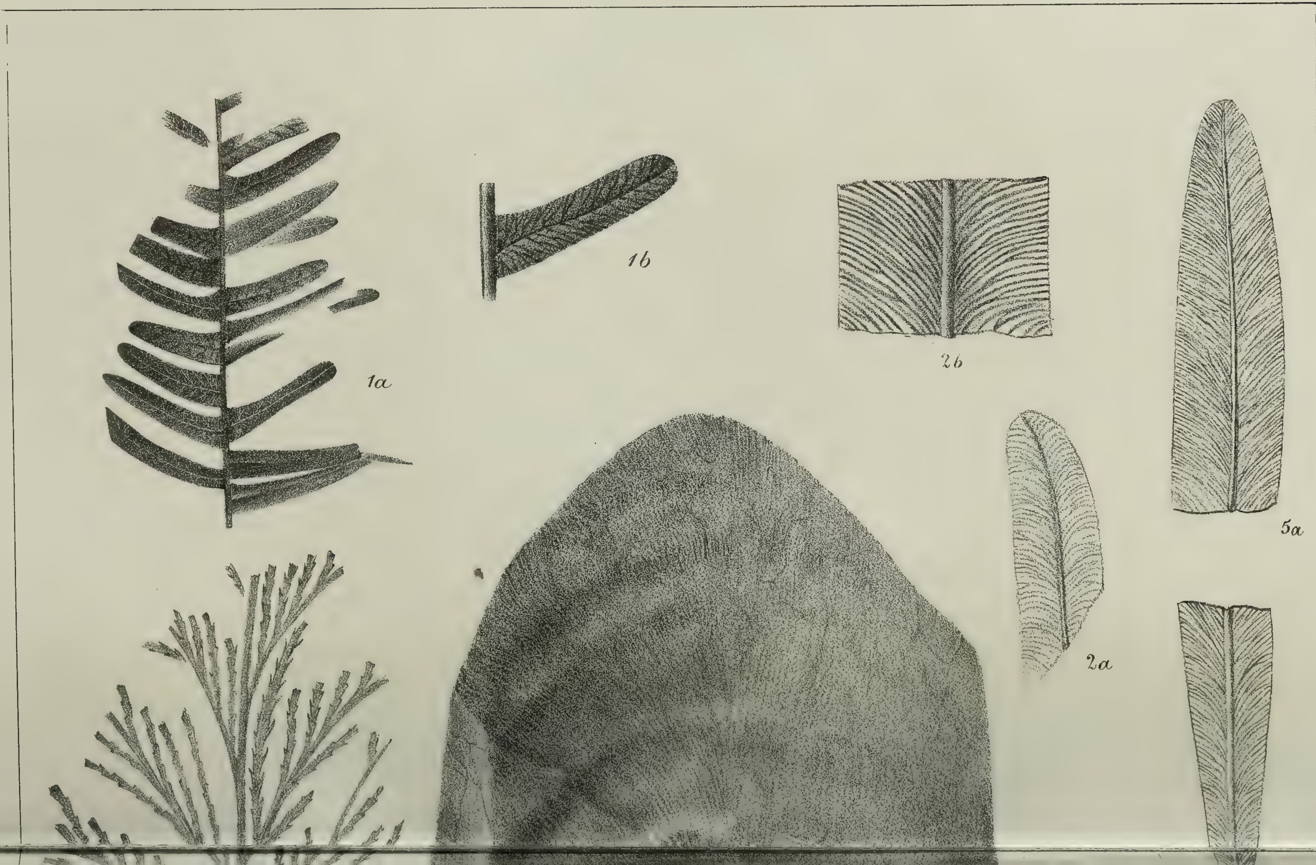
G. Massee lith. M & N. Hanhart imp

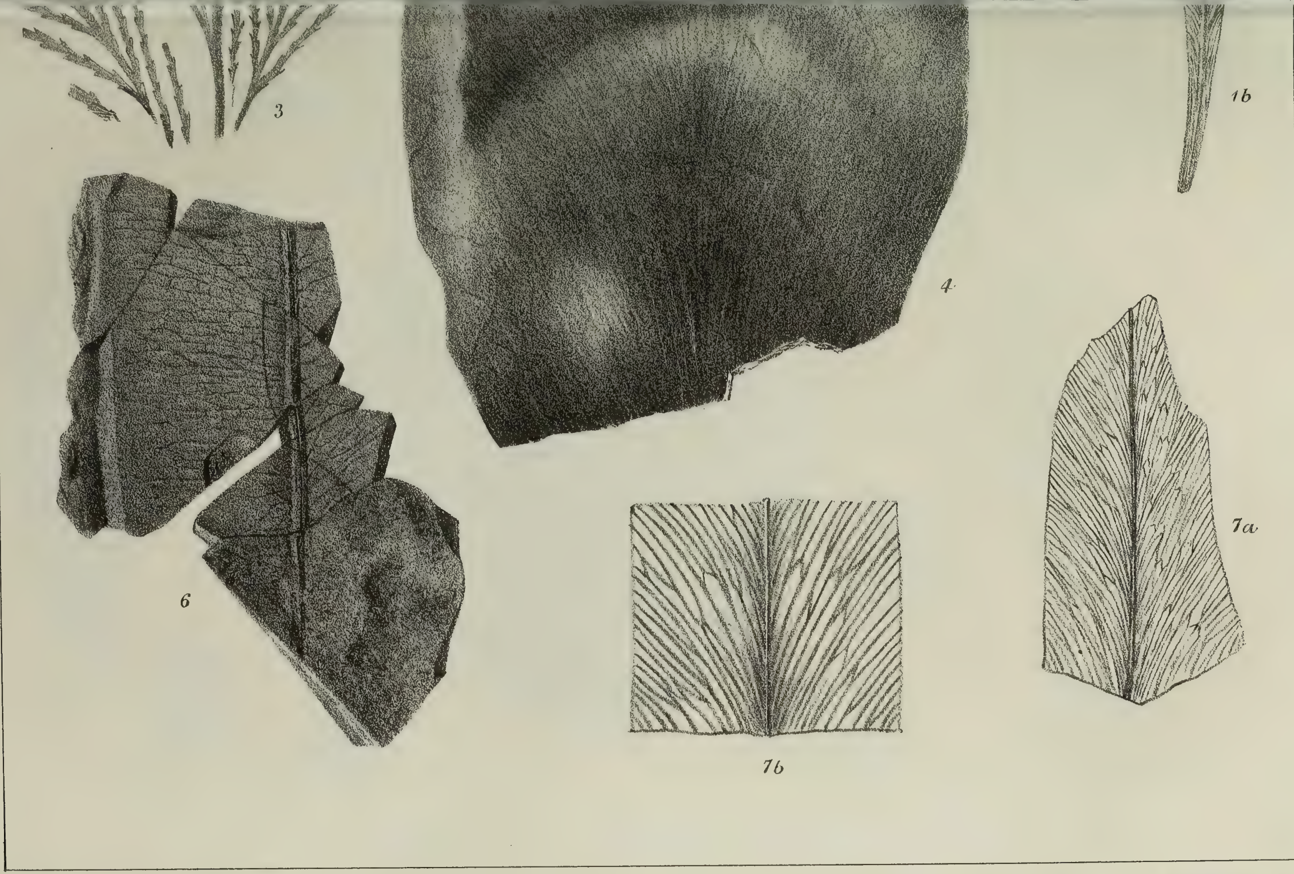
FOSSIL PLANTS FROM SOUTH AFRICA.



G. Massee lith.   M & N Hanhart imp.

FOSSIL PLANTS FROM SOUTH AFRICA

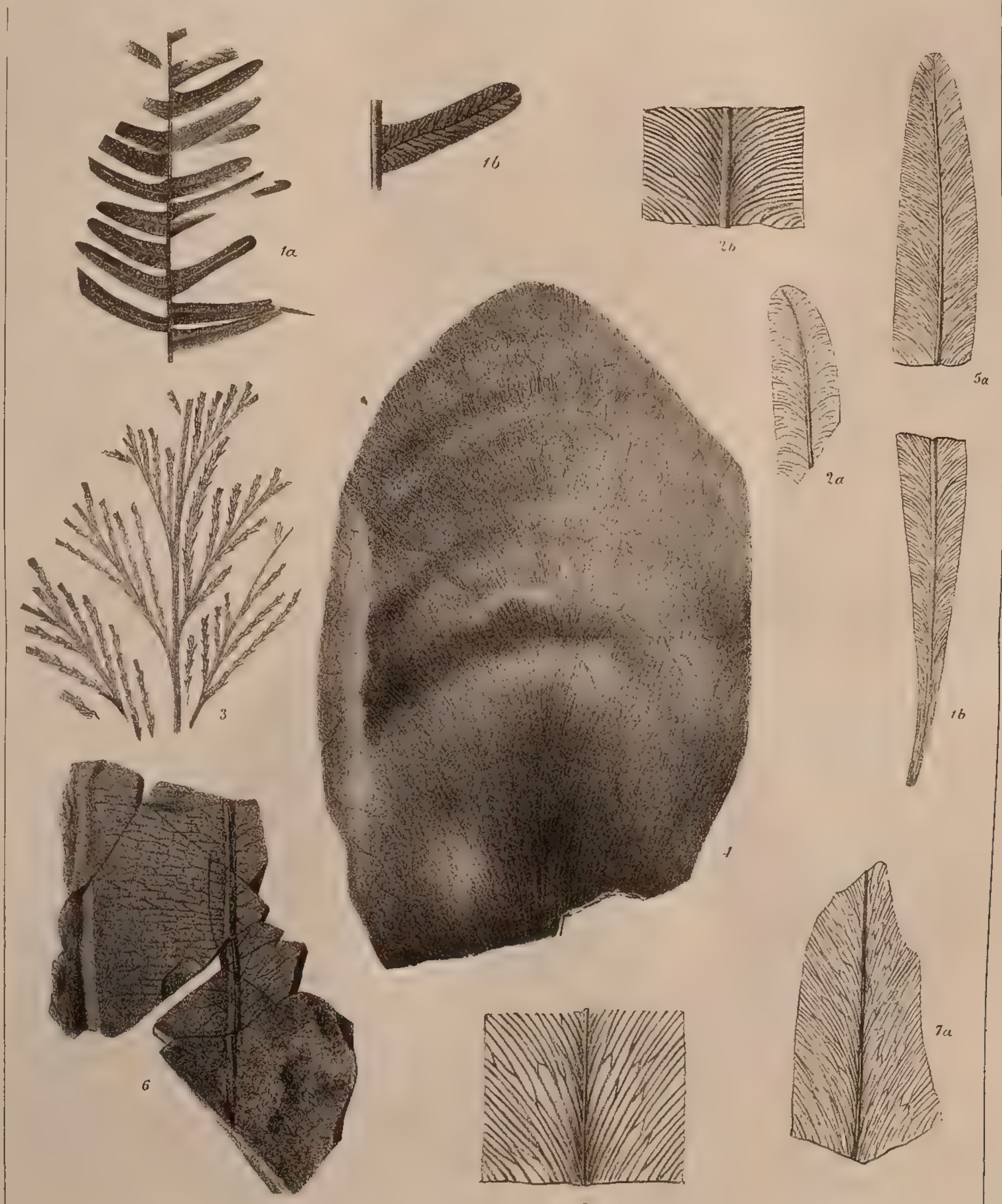

1a
1b
2b
2a
5a



G. Massee lith.

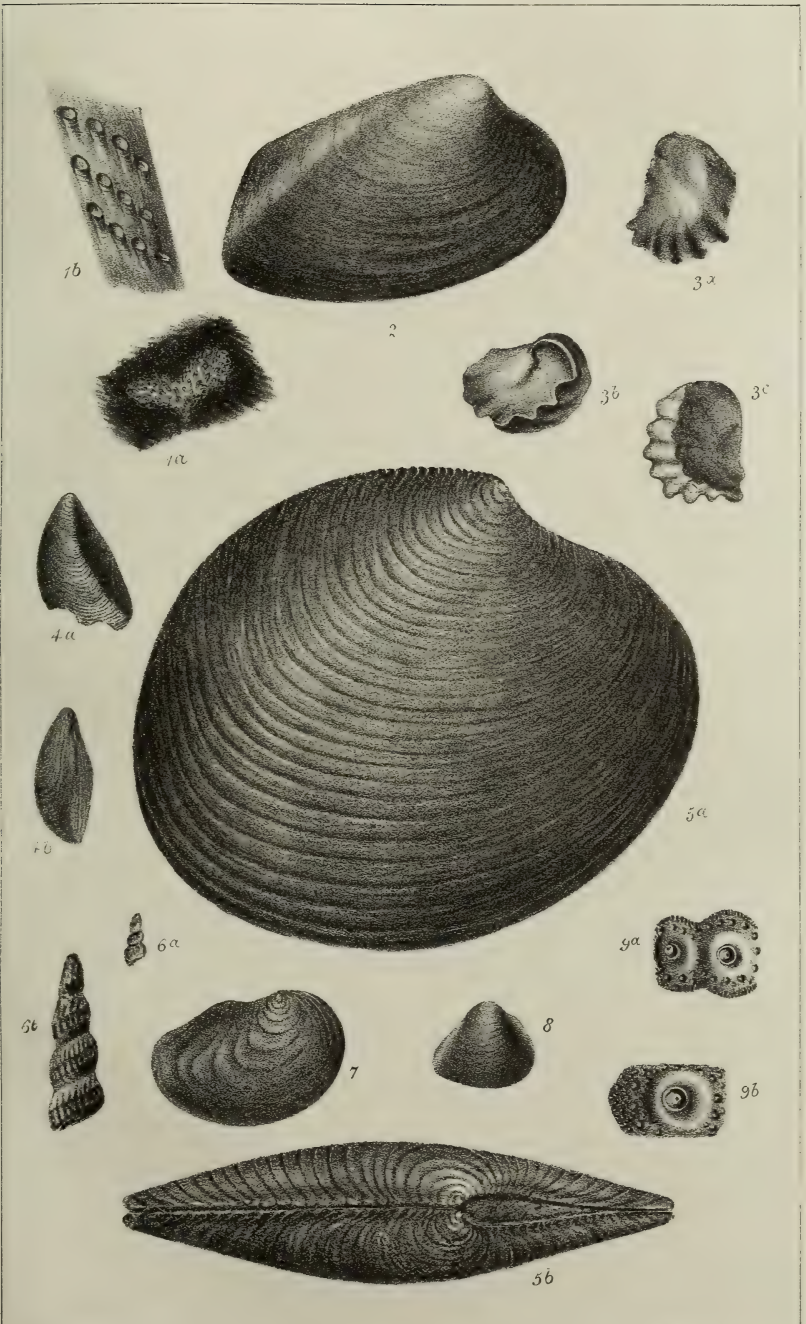
M & N. Hanhart imp.

FOSSIL PLANTS FROM SOUTH AFRICA.



C Massee lith. M&N Hanhart imp

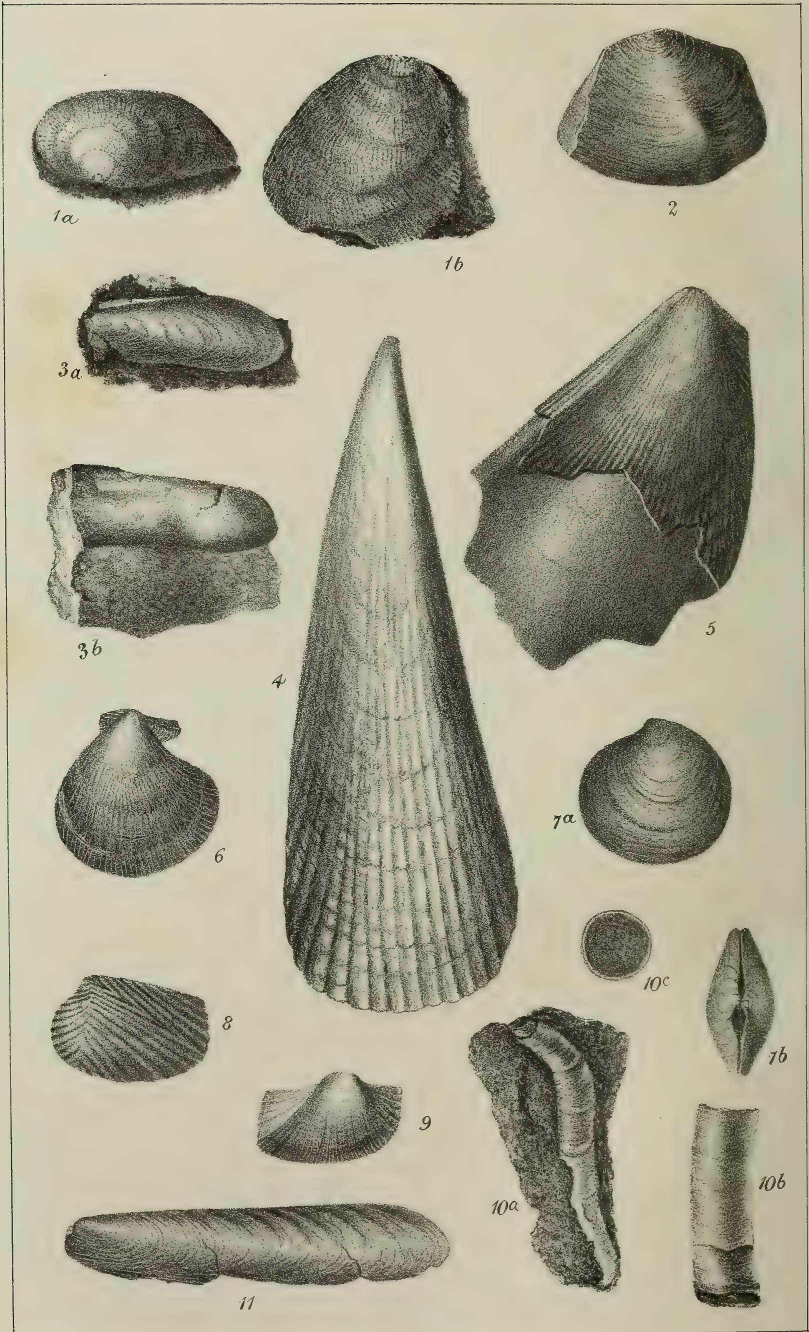
FOSSIL PLANTS FROM SOUTH AFRICA



G. Masse del. et lith.

M & N Hanhart imp.

JURASSIC FOSSILS FROM SOUTH AFRICA



G. Massee del. et lith.   M. & N. Hanhart imp.

JURASSIC FOSSILS FROM SOUTH AFRICA.

PLATE IX.

Fig. 1. *Placunopsis subjurensis*: *a*, umbonal aspect; *b*, lateral aspect: natural size.
2. *Placunopsis undulata*, natural size.
3. *Mytilus* (*Lithodomus*) *Stowianus*: *a*, posterior moiety of the shell; *b*, anterior of another specimen: both of the natural size.
4. *Pinna Sharpei*, natural size.
5. *Lima obliquissima*, natural size.
6. *Pecten projectus*, natural size.
7. *Astarte Pinchiniana*: *a*, lateral aspect; *b*, view of the dorsal region; natural size.
8. *Crassatella complicata*, natural size.
9. *Arca Jonesii*, natural size.
10. *Vermilia Pinchiniana*: *a*, attached portion; *b*, free portion; *c*, transverse section of the same: natural sizes.
11. *Mytilus Rubidgei*, natural size.

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2. FURTHER REMARKS *upon the* RELATION *of the* CHILLESFORD BEDS *to the* FLUVIOMARINE CRAG. By the Rev. O. FISHER, M.A., F.G.S.

(Abstract.)

THE author dissents from the interpretation of two pit-sections, one on Aldringham Common, the other near Henham Park Farm, given by Mr. Searles Wood in his paper "On the Structure of the Red Crag." Mr. Fisher admits that the former is at a higher level than the Thorpe Crag-pit, and the latter than the Wangford Crag; but he denies that the loam on Aldringham Common is Chillesford clay, and is doubtful whether even that at Henham Park Farm belongs to that deposit. Granting, however, that the loam in the latter case is really Chillesford clay, the author states that it is probably carried under the Wangford Crag by a northern dip. Thus he considers that neither of these sections contains indisputable evidence of the superposition of the Chillesford clay to the Fluviomarine Crag. He also expresses a doubt of the crag at Bulchamp being a continuation of the Wangford bed, and states that it much more resembles the Mya-bed as seen at Yarn Hill.

P.S. A subsequent examination of the neighbourhood of Norwich in April 1867, led the author to admit the identity of the *Mya*-bed with the Upper Crag of Mr. Taylor, as seen at Toft Monks and Bramerton; and consequently to abandon such of his published opinions as are inconsistent with that conclusion.—O. F.

FEBRUARY 20, 1867.

The Right Hon. the Earl de Grey and Ripon, 1 Carlton Gardens, S.W.; Frank Clarkson, Esq., 27 Oakley-street, S.W.; James Diggens, Esq., Secretary to the Royal Albert Idiot Asylum; and Joseph Lucas, Esq., of the Geological Survey of Great Britain, Museum, Jermyn-street, S.W., were elected Fellows:—

The following communications were read:—

1. *On the* British Fossil Oxen. Part II. Bos longifrons, *Owen*. By W. Boyd Dawkins, Esq., M.A. (Oxon.), F.R.S., F.G.S.

Contents.

1. Introduction.

In the first part of this essay I have traced the gigantic Urus from the earliest Pleistocene times through the Prehistoric period, at least as far down as the 12th century after Christ. Now I propose to pass on to the consideration of the small British Short-horn, the *Bos longifrons* of Professor Owen, which, had it not been inserted among the Pleistocene Mammals in the recognized text-book, would not now be brought before the notice of the Geological Society. The accurate definition of a species and its range in space and time is of the highest importance. "Every form," says Dr. Falconer, "well ascertained becomes a powerful exponent, while ill-determined it is a fertile source of error." The truth of this is proved by the present case. Professor Owen's verdict has been accepted in England from the time of its publication in 1846; and *Bos longifrons* has been considered universally as much a Pleistocene Mammal as the Urus or Bison. Under these circumstances I feel bound to give my reasons for believing that the evidence in support of this conclusion is altogether insufficient, and that the name ought therefore to be struck out of all Pleistocene catalogues.

2. Characters.

Bos longifrons, as compared with *B. urus*, is characterized by Professor Owen by its small size, by the different curvature of its small and short horns, by the smaller concavity, and often the flatness, of the forehead, and by the greater extent of the frontals beyond the orbits, before they join the nasal bones *. In addition to these there are other points of difference and agreement, considered by Dr. Rütimeyer † and Professor Nilsson ‡ of specific value, which have eluded my search on the comparison of a very large number of specimens. The small size and the single upward curvature of the horn-cores are the only two salient points that I can recognize, on placing its remains side by side with the Urus and the larger domestic Oxen; and even these vanish on its comparison with the smaller domestic breeds. A very large number of skulls from the Irish turbaries, in the museum of the Royal Dublin Society, show a marked gradation in size and form, and constitute an unbroken series, with the *Bos frontosus* § of Nilsson at one end, and the more

* Brit. Foss. Mam. p. 508.

† Fauna der Pfahlbauten der Schweiz. 4to. Basel.

‡ "On the extinct and existing Bovine Animals of Scandinavia," Annals and Mag. Nat. Hist. 2nd ser. vol. iv. 1849, p. 351.

§ *Op. cit.* p. 349.

common variety of *Bos longifrons* at the other. The truth of the great variability of the so-called species, first brought home to me in Dublin in 1864, is amply confirmed in all the other cases of a large quantity of the remains having been brought together for comparison, as in the British and Oxford Museums, and in that of the Royal College of Surgeons. In consequence of this I am unable to assign any characters of specific value to the animal. Specific distinctions, indeed, based on size of horn, or of frontal sinuses, are proved to be totally devoid of value by the history of the Galloway breed of polled cattle, for which I am indebted to the Right Hon. the Earl of Selkirk, F.R.S.* One hundred and fifty years ago that breed was possessed of horns; but, owing to the greater market value of the few polled varieties among them, the latter were encouraged at the expense of the horned, until the whole breed became possessed of its present characters. The last trace of the horn in the breed is furnished by the Rev. W. Bingley, in 1809. "Some few of the animals," he writes, "in every other respect polled, have two little useless horns from two to four inches long, which hang down loose, and are not, as in other cattle, inserted into the skull"†. At the present day, in the purely bred Galloway beast, there is no trace of horn. Thus we have clear proof of the metamorphosis of a horned into a hornless breed, and, therefore, that even the possession of horns is not essentially characteristic of a given race of cattle.

For full details of the osseous structure of *Bos longifrons* I must refer to those of the domestic Ox, *Bos taurus*, in the various books of Natural History, instead of bringing irrelevant matter before the notice of the Society.

3. Synonyms.

The *Bos longifrons* of Owen is also termed the *B. brachyceros*, Owen, under which name the animal is known in France and Ger-

* "I have no distinct written record about the way the horns of the Galloway cattle were 'bred out,' as we cattle-breeders would say. The breed, a hundred and fifty years ago, was not generally 'polled' *i. e.* without horns, though there were always a good many polled ones among them. Polled ones are found in every breed. My informant was an old man who died about thirty years ago, he being then near ninety. He was the son of the man who tended the cows for my grandfather, and had been employed among cattle all his life: in his old age, while still able to work, he tended my cows. His name was James Mc Kinnan, and he was a man whose recollections seemed always remarkably clear. He had been with cattle as far as Norfolk, to St. Faith's fair. He told me that, in the days of his childhood, a Norfolk feeder, who bought many of the Galloway cattle, fancied those without horns, and would give 2*s.* 6*d.* or so more for a polled than for a horned beast. This set the fashion; and the people began first to look for polled bulls and none other; then they preferred the polled cows, &c. &c. to breed from; and thus the change was effected in, I believe, from 50 to 60 years. The horns of the Galloway beasts were very ugly, drooping, and as thick at the point as at the root. I have myself seen one or two beasts with horns like that; but now-a-days when horns appear, they are generally traced to some cross with an Irish brute. Those that are born polled, have a bump in the centre of the forehead, which is very hard and will break another bull's skull for him."—Extract from a letter of the Earl of Selkirk, dated 6th March, 1867.

† Memoirs of British Quadrupeds, p. 418. 8vo. London.

many. This latter also was first proposed by Professor Owen in 1830, and in consequence of the name having been applied by Dr. Gray to an existing African species, was subsequently exchanged for the former. The *Bos frontosus* of Nilsson is proved by the series in Dublin, as stated above, to be a mere variety. All species, indeed, founded upon the greater or less development of the frontal sinuses, which is, in truth, the result of different age, sex, and habitat, must necessarily fall to the ground, whether they be Bears or Oxen.

4. Measurements.

The detailed measurements of the teeth and long bones I must reserve for the Table at the end of Part III., for the sake of comparison with those of the Urus and Bison. The skulls present great variations in size; but all can be distinguished at a glance from the gigantic ones of the Urus, with which they are found in Britain and Germany. In the following Table a few measurements, in inches, are given of two skulls, the one dredged up from the alluvium of the Thames, near Purfleet, the other derived from the peat-bogs of Scania, and described by Professor Nilsson*. The small size of the head of *Bos longifrons* can be realized by comparing it with the corresponding table of skull-measurements of Urus in the Quart. Journ. Geol. Soc. vol. xxii. p. 395.

Measurements of two Skulls of *Bos longifrons*.

	Dredged at Purfleet.	Peat-bog of Scania.
Occipital crest to premaxillary	15·0	16·0
Horn-cores to anterior edge of premaxillary	14·0	13·33
Outer course of horn-core	3·5	4·0
Breadth of forehead between base of upper part of horn-cores	5·0	5·33
,, ,, ,, ,, lower part of horn-cores	5·5	
,, ,, ,, orbits, upper part	6·5	7·0
,, ,, ,, ,, lower part	4·8	
Distance between tips of horn-cores	10·4	
Circumference of base of horn-cores	4·7	4·25
Length of forehead	7·0	7·5

The horn-cores present very considerable variations in size and form, dependent probably on different age and sex. The first three measurements below are the maximum, mean, and minimum ones of upwards of forty-five horn-cores found at Richmond, Yorkshire, in a refuse-heap associated with the remains of Dog, *Ursus arctos*, Wild Boar, Horse, Red-deer, Fallow-deer, Sheep, and two varieties of Goat †. The fourth I found within a Romano-British tomb at Hardham ‡; the

* *Op. cit.* p. 353.
† See Quart. Journ. Geol. Soc. vol. xxi. p. 493.
‡ Sussex Archæol. Trans. vol. xvi. pp. 52–64.

next two are taken from Professor Nilsson's valuable work, and the last two from the specimens in the British Museum.

Measurements of Horn-cores.

	Richmond.			Hardham.	Scania.	Scania.	Clacton.	Walton.
Maximum length	5·3	3·9	2·6	4·5	—	3·0	4·0	4·0
Basal circumference ...	4·0	3·9	3·4	5·1	7·1	4·18	4·5	

The horns themselves are found in the peat-bogs of Ireland. Two in my possession, for which I am indebted to the Right Hon. the Earl of Enniskillen, F.R.S., have respectively a basal measurement of 10·5+ and 6·0 inches, and are 15·0 and 8·0 inches long. The one is of a dark and the other of a light brown colour. Another instance, also, of the horn being preserved is afforded by a specimen dug up in an old channel of the Cam, near Waterbeach, and now in the Oxford Museum. It also is of a brown colour. Professor Nilsson estimates the length of the animal in Scania as 6 feet 8 inches, exclusive of the tail *. Unfortunately there are no materials for estimating its length and height in Britain. The size, however, of its bones proves it to have been the smallest of the Ox tribe.

5. Range in space and time.

I must now pass to the consideration of the claims that the animal has to be inserted in the list of Pleistocene Mammals. Professor Owen writes that he found in the collection of the late Mr. John Brown, of Stanway, "some indubitable specimens of the *Bos longifrons* from freshwater deposits which are rich in the remains of Elephas and Rhinoceros." These consist of two skulls, the one from the "newer Pliocene deposits at Clacton," and the other from Walton—two localities on the Essex shore, which have furnished vast stores of the remains of the extinct Pachyderms. His argument is based on the supposition that all the fossil bones washed up by the sea at these two places are derived from the same beds, and are therefore of the same geological age. In the 'Introduction to the British Pleistocene Mammals,' in 1865, I expressed my doubts about the soundness of this view, which have been amply confirmed by a visit to Walton in the autumn of 1866. The mammaliferous stratum lies at the bottom of the low cliffs between the high- and low-water mark; but this affords only a small percentage of the fossil remains. The great majority are left by the sea at low water, lying on a plateau of London Clay along with large Septaria, the wreck of the Red Crag, and waifs and strays of all kinds, and may have been washed out of deposits of two or three distinct ages. The condition of the remains I obtained with my own hands indicated at least two distinct

* *Op. cit.* p. 352.

origins. Some but lately washed out of the grey clay were of a pale grey colour, nearly devoid of gelatine, and to a certain extent mineralized; while others, light and porous, contained a large percentage of gelatine, and were of a reddish or sepia colour, which is invariably that assumed by remains imbedded in alluvial mud. The latter were probably derived from the alluvium hard by. Among them were a metacarpal of Goat or Sheep, and a small bovine humerus. A third class of remains were very heavy, stained black, and incrusted with a pyritous deposit, termed "pan," closely resembling that in the fossils from the Preglacial Forest-bed of Norfolk. How far this latter condition may be owing to the presence of large quantities of peroxide of iron (derived from the Red Crag) in the mud in which they were lying, and whether it be a chemical result of the decomposition of organic remains in sea-water full of peroxide, are points on which I can hazard no opinion. The skull from Walton, presented to the British Museum by Mr. Brown, of Stanway, and quoted by Professor Owen, is in precisely the same condition and of the same reddish colour as the bovine, caprine, and ovine remains above mentioned, and therefore was probably derived from the same source, whatever that may have been. It is not only waterworn, but also contains a few pebbles of shingle in one of the horn-cores, which proves that it was most certainly washed up by the sea. Its mineral condition forbids its derivation from the grey clay, and it cannot be classed with the black remains; therefore it probably was washed out of the alluvium close by, which, throughout Western Europe, is full of the remains of the same animal. The presence of the Sheep or Goat affords collateral proof of this, as neither of these animals has been found in any Pleistocene deposit up to the present day; and both apparently passed into Europe after the disappearance of the Cave-Hyena, Cave-Bear, and all the extinct mammals, the Irish Elk being excepted. They characterize the Prehistoric deposits of France, Germany, and Scandinavia. The skull in question is therefore in all probability also of Prehistoric age, but not of equal antiquity with the *Elephas antiquus*, leptorhine Rhinoceros, and *Hippopotamus major*, cast up by the sea on the same shore. The argument that would prove that it was in this particular case coeval with those extinct animals, might also be applied to the other waifs and strays, sea-weed, bits of wood, shells and the like, left between high- and low-water mark. The skull of *Bos longifrons*, found at Clacton, preserved also in the British Museum, falls into the same category as that of Walton. If, then, there is no direct evidence of the exact *gisement* of these skulls, the mere accident of their being associated with the remains of the extinct Mammals on the shore cannot be conclusive of their geological age; and therefore Professor Owen's view, founded on this assumption, must fall. A third locality is cited in the 'British Fossil Mammals,' of its occurrence with the Urus and Bison at Bricklehampton Bank, near Cropthorne, in Worcestershire*. Unfortunately I have sought in vain for the remains on which the determination is based, as they are neither named nor

* *Op. cit.* p. 512.

the museum mentioned in which they are to be seen *. In the Hunterian Catalogue, Professor Owen has rightly ascribed the small bones from this locality to the Bison, the larger to the Urus; and they constitute a large and valuable series, affording a means of separating the former from the latter species. In no other museum can I find any other Bovine remains from this deposit. In the 'Life and Papers of H. E. Strickland' †, published by Sir W. Jardine in 1858, there is no mention of the *Bos longifrons* among the animals he found at Bricklehampton. The small sizes of the metacarpals and metatarsals of Bison, which closely resemble those of the British Shorthorn, may perhaps have caused Professor Owen, between the publication of the Hunterian Catalogue and that of the 'British Fossil Mammals,' to ascribe some of these to the latter animal. The horn-cores, which, in a disputed point, such as this, are alone to be relied upon, belong to the Bison; and therefore it is highly probable that the equivocal remains which, in the absence of horn-cores, might perhaps have been considered to be those of *Bos longifrons*, belong also to the former. Precisely the same argument applies to the *Bos longifrons* of Kirkdale ‡, which is proved by the horn-cores to be the small variety of Bison—the *Bison minor* of Professor Owen. A fifth locality is given of its occurrence with the extinct Mammals, the gravel-pits of Kensington. In the absence, however, of direct proof that the remains of *Bos longifrons* were derived from the same undisturbed gravel as the Mammoth, the fact that the disturbed soil round London is full of the bones of *Bos longifrons*, which was the principal food of the inhabitants of the metropolis of Roman Britain, would strongly suggest that those in question were found in the superficial soil, and not in the gravel below. A parallel instance at Peckham, on a very careful examination, I found to be explained in this manner.

In the list of Mammals found at Fisherton §, *Bos longifrons* is quoted as having been found in association with the Lemming, Spermophilus, Marmot, Tichorhine Rhinoceros, and other characteristic Postglacial species; but the remains ascribed to this animal and preserved in the Salisbury Museum, consisting of teeth and bones and not characteristic horn-cores, in truth belong to the smaller variety of Bison, *B. minor* of Professor Owen, which is very abundant in that locality. All the other cases quoted of its association with Pleistocene Mammals may be disposed of in the same way. The result of a careful examination of the mammalian remains in the collections of Great Britain and Ireland, is the discovery that there is no authentic evidence of the small Shorthorn having lived in Pleistocene times. It has never been found in Pleistocene deposits in France, Germany, or elsewhere in Europe. For these rea-

* Catalogue of Fossil Mammals, Nos. 1351–1393.

† *Op. cit.* p. 96. *Hippopotamus major*, *Canis*, and the Urus were also found in the gravel and clay of the section.

‡ *Op. cit.* p. 513.

§ Quart. Journ. Geol. Soc. vol. xx. p. 192, and Catalogue of Blackmore Museum, Salisbury, 8vo.

sons, therefore, I would suggest that the name be struck out of the list of Pleistocene Mammalia.

What, then, is its range in space and time? In the deposits that are termed Recent by Sir Charles Lyell, and which Mr. Sanford and myself have called Prehistoric, it is remarkably abundant. Throughout the temperate zone of Northern and Western Europe it ranged through the forests and plains in company with the Urus and the Bison. In Britain it was accompanied by the latter. It has left its bones in the lacustrine marls of Ireland, along with those of the Irish Elk and the Reindeer, and in the peat-bog of Hilgay, in Norfolk, with the Beaver. In the peaty mud near Newbury, in Berkshire, it is found along with the Wild Boar, Red Deer, Roe Deer, Wolf, Goat, Horse, Otter, Bear, Urus, and Water-rat. In the alluvia of rivers it is particularly abundant. Mr. Seeley, also, mentions its occurrence in the "older peat" of the Fenland with the same animals, under the name of *Bos frontosus*. It is commonly associated with human remains of a date anterior to the arrival of the Saxons. Dr. Thurnam's late discoveries prove that the tumuli of Wilts are full of its bones; the refuse-heaps of early Keltic villages, such as that of Stanlake*, in Berkshire, are composed of its remains. Around Roman stations and cities it is more abundant than any other animal, as, for example, Uriconium, Londinium, and Camulodunum. I have found it even in the graves of the Britons who were interred at Hardham, near Pulborough, in Sussex, during the Roman occupation†. The horn-cores and broken bones were lying in the same oaken chest which contained the ashes of the dead, drinking-vessels, garments, and sandals. Examples might be multiplied to prove its existence in large herds in Britain during the Bronze- and Stone-periods, and that it was the animal that supplied the bronze-using Kelts and their Roman conquerors with beef. In Prehistoric caverns it is very abundant, as in that of Dowkabotham‡, in Yorkshire, explored by Mr. Farrar, M.P., and in several in Somerset, explored by Mr. Sanford and myself. Its metacarpals, from a black superficial deposit in Kents Hole, I have detected in the Museums of Oxford and the Geological Society; and had not the Rev. J. McEnery§ described the bed whence he obtained them, and had not their mineral condition been different from that of older remains found in the cave, it is very possible that they might have been quoted in confirmation of the view of the coexistence of the animal with Machairodus and other extinct Pleistocene Mammals found in a lower stratum.

On the continent, as in Great Britain, it is found around the dwellings and in the tombs of the Bronze- and Stone-folk. Nowhere is there the least evidence of its having a higher antiquity than the Neolithic age of Sir John Lubbock. It has not yet even been proved to have been living in Europe at the time a people

* Quart. Journ. Geol. Soc. vol. xxii. p. 479.

† Sussex Archæol. Trans. vol. xvi.

‡ The remains from this cavern are preserved in the Leeds Museum.

§ 'Cavern Researches,' by the Rev. J. Mc Enery, edited by E. Vivian, Esq. 4to. 1859.

more closely allied to the Esquimaux* than to any other dwelt in Aquitaine, and still less in the inconceivably more remote Pleistocene age.

6. Relation to domestic races.

We have thus traced the animal through the Neolithic into the Bronze age, and thence into the period of the occupation of Britain by the Romans. Its relation to our domestic races of cattle still remains to be discussed. Professor Owen holds two contradictory opinions † on this point. On the one hand, he believes that the Roman colonists imported into Britain their "already domesticated cattle," and that our breeds are their descendants. The fact that *Bos longifrons* is the *only* Ox found in the refuse-heaps, in not one or two but *all* the camps, cities, villas, and cemeteries that bear the impress of Roman civilization in Britain is sufficient to refute this hypothesis, which is unsupported by evidence derived either from history or archæology. On the other hand, he admits the probability that the *Bos longifrons* ‡ was "the species domesticated by the Aborigines of Britain before the Roman invasion." That this animal was subject to man in the Neolithic and Bronze ages in Switzerland has been proved beyond all doubt by Dr. Rütimeyer §. In our own country, its numbers, as compared with those of the Red-deer and Roe-deer, in tumuli and Keltic villages, as, for example, in those cited above, in Wiltshire and Berkshire, prove that, probably in the Stone-age, and most certainly in the Bronze-age, it was kept in herds and slaughtered for man. When, therefore, the Romans conquered Britain, there was no need of their importing cattle from Italy; for they found a breed used to the climate and to the half-wild life which, in a country for the most part uncleared, must have been their lot. During the Roman occupation the animal was the staple meat of the country. When the Roman Empire yielded to the Teutonic invaders, who had been kept at bay for centuries by its power, and the legions in Britain were recalled for the defence of Italy, the Saxons, in a conflict that lasted for nearly 150 years, drove out the Romanized Kelts, burnt their towns and their villas, and compelled them to retreat to Wales, Cornwall, and the highlands of Scotland, taking, as far as they could, their cattle along with them. The fact

* The evidence in favour of their affinities with the Esquimaux is the following:—The identity of four of the harpoons, of fowling-spears, marrow-spoons, and scrapers; the habit of sculpturing animals on their implements; the absence of pottery; the same method of crushing the bones of the animals slain in hunting, and their accumulation in one spot; the carelessness about the remains of their dead relatives; the fact that the food consisted chiefly of Reindeer, varied with the flesh of other animals, such as the Musk-sheep; and especially the small stature, as proved in the people of the Dordogne Caverns by the small-handled dagger figured by MM. Lartet and Christy in the 'Revue Archéologique.' This combination of characters is found, so far as I know, among no other people on the face of the earth except the Esquimaux; and therefore I cannot help believing that this people in South Gaul occupies the same relation to the Esquimaux, as the Musk-sheep and Reindeer, on which they lived, hold to those now living in the northern regions.

† *Op. cit.* p. 500.

‡ *Op. cit.* p. 514.

§ *Op. cit.*

that we speak in a Teutonic and not a Romanic tongue proves how completely this depopulation of the more fertile provinces of Britain was effected. "Our forefathers," writes Mr. Freeman *, "appeared in the Isle of Britain purely as destroyers; nowhere else in Western Europe were the existing men and the existing institutions so utterly swept away. The English wiped out everything Celtic and everything Roman as thoroughly as everything Roman was wiped out of Africa by the Saracen conquerors of Carthage. A more fearful blow never fell on any nation than the landing of the Angles and Saxons was to the Celt of Britain."

The authors of the 'Pictish Chronicle' incidentally prove that the Saxons had expelled the Romanized Kelts from the Province of Valentia, that embraced the Lowlands of Scotland and part of Northumberland, when they state that the Highlanders of the seventh century, "descenderunt in Saxoniam." In this ruthless destruction of Roman civilization in Britain lies the explanation of the affinities of the small Welsh and Scotch cattle to *Bos longifrons*. They are in all probability the lineal descendants of those which the Romanized Kelts took with them in their retreat, and bear exactly the same relation to them as the modern Brit-Welsh does to the mixture of Keltic and Latin, which was the language of Roman Britain. During that war of nearly a century and a half, the variety seems to have died out in the parts of the country that were under Saxon rule; and I have sought in vain for any evidence of its reappearance from that time to the present. If I might hazard a guess at the immediate source whence our large cattle spring, I would suggest that the Lowlands between the mouth of the Rhine and Jutland, now famous for the large size of their cattle (such as those of Friesland), which was the ancient home of our Saxon ancestors, was also the place whence their cattle were imported. These larger cattle, as I have stated in my first essay, are, probably, derived from the *Bos urus*.

7. Conclusion.

The inferences to be drawn from the preceding pages are:—first, that the *Bos longifrons* has not yet been proved to have existed before the Prehistoric age, in the Bone-caves and alluvia of which it is found abundantly; and, secondly, that it is the ancestor of the small Highland and Welsh breeds. It is essentially the animal with which the Archæologists have to deal; and its only claim for insertion in Geological Catalogues is the fact of its occurrence in the most modern of all the stratified deposits.

* 'History of the Norman Conquest of England,' by E. R. Freeman, M.A., vol. i. p. 20. 8vo. Oxford, 1867.

2. *On the* Geology *of the* Upper Part *of the* Valley *of the* Teign, Devonshire. By G. Wareing Ormerod, Esq., M.A., F.G.S.

[The publication of this paper is unavoidably deferred.]

(Abstract.)

The district noticed in this paper lies to the north of Bovey Tracey. The author describes the courses of the Teign and its feeders, and the strata traversed by those streams, namely, Granite and Carboniferous Limestone. Gravels are occasionally found, which the author regards as having been deposited before the reexcavation of the valley; and he shows that these had been transported by a current from north-west to south-east. From the absence of these gravels in the gorge of the Carboniferous rocks between Hunts Tor, near Chagford, and Clifford Bridge, he considers that that valley has been opened since the time when the boulders and gravels were deposited; and he then shows that the stream from the valley of the Teign, prior to the opening of that valley, passed by Moreton Hampstead to Bovey Tracey. The paper contains notices of the minerals found in the district, and of the Granite veins in the Carboniferous rocks.

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3. *Notes on the* Geological features *of* Mauritius. By George Clark, Esq.

[Communicated by the Assistant-Secretary.]

(Abridged.)

Mauritius is well known to be of volcanic origin, as is also the neighbouring island of Réunion, where there exists a volcano in constant activity. There is this great difference between the two islands: Mauritius is surrounded by coral-reefs, which protect nearly the whole of its coast, and by their shelter form excellent harbours, while the coast of Réunion is exposed to the full force of the ocean. The action of the waves is so strong on its shores that not a particle of the basaltic sand which strews them presents an angle. Its beach exhibits nothing but a mass of pebbles, varying in size from a foot or more in diameter to particles almost imperceptible to the naked eye.

The reefs of Mauritius support various islets, which have been generally regarded as forming an integral part of them, though rising to as much as thirty feet above the sea-level.

Gabriel Islet, is partly basaltic and partly calcareous; and it is on the latter that the late Dr. P. Ayres discovered the fossilized remains of a forest, of which he gave an account at the Meeting of the Royal Society of Arts and Sciences of Mauritius, in 1860.

Egret Island stands on a calcareous bottom surrounded by sand between the reef and the shore, about a mile from the former and half that from the latter, with a depth of water varying from half a fathom to a fathom. This island, which rises to a height of about thirty feet, is formed of calcareous stone, having a western dip of about 30° and covered in many parts by coarse sandstone. This is very uneven and is traversed in various directions by veins of much harder texture, which rise above the surrounding surface, forming sharp ridges intersecting each other at various angles.

This island is nearly circular, and the outer part of its circumference is hollowed by the action of the waves and currents, leaving a projecting ledge, forming a kind of penthouse, varying in width from six to fifteen feet, and generally thinnest on its outer part. On many spots this has broken off, and the fragments have fallen on the shore, where they remain. These fractures have mostly been caused by cylindrical holes which perforate the thickness of the ledge. The substance which caused these holes sometimes remains adherent either in the persistent or the detached portion; and in other spots the ledge remains entire, with the foreign body projecting both above and below its surfaces. In the latter position, it is generally tapering at the lower end; and a portion of the same substance, of corresponding size, may be perceived at the bottom of the sea: this portion is sometimes worn to a level with the surrouuding surface by the action of the waves.

The landward side of the island is destitute of the projecting ledge which marks the seaward border, and is rent into deep fissures in various spots. Adhering to the sides of these may be perceived considerable masses of the same material as that found in the holes mentioned, which seem to have formed portions of trees, of much larger dimensions than those which are found in the holes mentioned.

The surface of the island is very unequal; and in many parts cylindrical holes are perceived which extend to the sea-level. The regularity of their form is very remarkable. Their diameter varies from 1 to 2 feet.

On the surface, in the sandstone which covers the calcareous rock, are many fissures radiating from a hollow which appears to have been caused by the base of a tree, as the fissures have been by its roots. On other spots, numerous stumps are seen, some of which are as much as three feet long, corresponding in diameter with those found on the ledge; and a much greater number of smaller size and height are scattered among them. The former have the appearance of exogenous trees; and their form and colour, when viewed from a distance of from twenty to thirty yards, might easily cause them to be mistaken for wood. The outer part is in most cases of the ashy grey seen on old dead bark. The interior is more or less hollowed, leaving an uneven border; and the inside is exactly of the colour of rotten wood, and is in every case perforated with numerous holes, bearing a resemblance to those produced by white ants, but of larger calibre. The same colour and riddled appearance is often seen on the outside of the stump, and always on the inside. The smaller stumps appear to have belonged to endogens of the Palm tribe; and in many individuals the medullary substance has entirely disappeared, leaving only the hard envelope, to which thin portions of the inside, bearing the same appearance as that of the wood of the supposed exogens, is seen adherent. These stumps are very near together in many places; and numerous examples of the adherence of two stems are seen, as may often be witnessed in living trees in this island. Everything seems to indicate that a very thick forest, of trees of various sizes and kinds, once occupied this spot. Those trees which have disappeared, leaving only the cavities they occupied, may have been of species less favourable to the process of fossilization than those which remain. In every case, the vegetable substance, how different soever in size and colour it may have been, has been replaced by carbonate of lime.

Pass Island, about two miles from Egret Island, is composed of the same calcareous rock as the latter, but is not covered by so thick a stratum of sandstone. No stumps remain on it; but some cavities show where trees have been; and a large prostrate trunk seems to indicate that one had been blown down and fossilized there; this presents the same appearance as those of the other islands. Vast numbers of fossilized roots cover the surface of this island, being particularly numerous and apparent on the face of a cliff on the seaward side. No roots are found in Egret Island; and those found in the other islands are free from the perforations which pierce the trunks. Some of them appear to have rotted in great measure before becoming fossilized, the bark alone remaining to indicate their size and shape.

Vakois Island stands a few rods from Pass Island, with which it is connected by the reef. Its structure is the same as that of the others; but there is less sandstone upon it, and the calcareous rock is crossed by more numerous veins of carbonate of lime. There are two small caverns in it, formed by the unequal inclination of masses of stone, showing the same formation within as without. At the opening of one of these caverns is a large fossil stump, apparently of some tree of the fig family, and a great number of roots of the same, all of which appear sound.

Booby Island, similarly situated with the last two, on the edge of the reef, is about six acres in area, and differs much from the others in having a considerable depression across the middle. It once contained many fossil stumps, imbedded in loose sea-sand, which covers the south end of it to a depth of from 10 to 15 feet. Most of those which remain appear to belong to some species of fig, to which their roots, which are very numerous, bear a striking resemblance.

Fossil corals, of species now existing around it, imbedded in sandstone, in which are included fragments of shells, are also found here; and under a mass of calcareous rock is a vein of carbonate of magnesia (?) in a moist state. There are several other small islands within a short distance of those mentioned, of similar formation and offering the same phenomena. One of these is called "l'Ile aux Fous," and is situated on a projecting point of the reef, which exposes it more than any of the others to the action of the surf. It is only about three rods square, and was once covered with a deeper stratum of sandstone than any of the others. This has been hollowed by the waves in a remarkable manner, leaving channels and ridges so sharp as to render walking over it a task of some difficulty. In hollows sheltered by these ridges are some stumps of exogens, the tops of which are quite level, and their substance much more solid than that of those found elsewhere. Palms of large size appear to have stood very thickly here; but not a single stump projects above the surface, the force of the waves having washed them away, while the more solid stems of the exogens resisted its action. This island has no projecting border, nor have the others on the outer side.

On the shore, immediately opposite two small islands of calcareous rock, called Monkey Island and Rat Island, is a mass of the same calcareous rock, about 400 yards in length, 50 in breadth, and 10 in height, lying on a bed of clay. Separated from this by a little shallow bay about 50 yards wide, is another mass of the same rock, about 100 yards long, and of the same width as the other. The line of separation between the limestone and the clay is clearly defined. It appears that formerly (but not at all within the remembrance of the oldest inhabitant) the projection of the limestone over the clay, seaward, was much greater than at present; and many large masses, having lost their support, have fallen off, and are lying on the shore beneath, exhibiting a perfect correspondence in surface at the point of fracture. The whole of this mass is free from the sandstone covering, and exhibits no clear traces of having borne trees. Its substance is permeated in every direction by crystals of carbonate of lime, which, on the sea side, are covered with a pink incrustation consisting of oxide of iron. At the base of the superincumbent mass is a bed of crystals of carbonate of lime, six or eight inches in thickness; and stalactites of curious forms depend from its overhanging parts on the land side, where this mass abuts on a small plain of ferruginous clay, in which are elliptical boulders of basalt, which serve as nuclei to concentric layers of sand, hardened into stone by a large portion of oxide of iron. This spot is overflowed at high water; and these nuclei project above the surrounding surface, showing a clear section of their several enclosures.

On various parts of the coast of Mauritius, masses of calcareous stone, such as are here mentioned, are seen lying on the sand, but always, I believe, in close proximity to the sea. Two such masses exist at "Anse Bambou," in Grand Port, and one at Turtle Bay, on the north-western side of the island; and an islet at the entrance of the Grand Port, called "l'Ile des Roches," is of the same formation. This last is exposed to the action of powerful currents on both sides, and has been considerably diminished in size within fifty years.

Great masses of coral, some of forty or fifty tons' weight, are seen on various spots on the shores of Grand Port, at a distance of a quarter of a mile from the sea, and at least fifty feet above its level. These are of a species not now found here in a living state.

Near the Chamarel Falls, at Blackriver, at about 900 feet above the sea, is a large quantity of old coral, of species still existing here;

and not far from this spot is a mountain consisting in great part of a soft aluminous stone, of a greyish colour. A road cut along the side of this mountain exhibits in this stone a number of concentric rings from one to twenty feet in diameter, coloured with oxide of iron.

The most extraordinary feature, perhaps, in the Geology of Mauritius is a double-headed mountain adjoining the range which separates the districts of Grand Port and Flacq. This is about a thousand feet high, and the heads are rounded in a very remarkable manner. It consists entirely of hexagonal prisms, from one to five feet in diameter, composed of aluminous rock, of a light greenish grey, with minute black spots. It is so soft as to be easily cut with a chisel or saw.

The facility with which this stone is wrought induced some persons to employ it for a time; but it is not suited for building-purposes, as it crumbles away very rapidly under the action of the atmosphere.

In various parts on the coast of Grand Port may be seen masses of columnar basalt, the prisms of which vary in diameter from six to fifteen inches; these have evidently been detached from the "Lion" Mountain, at the foot of which they lie. One such mass, of sixty or eighty tons' weight, is to be seen on the side of a mountain at least two miles from any similar formation.

In many places a mass of molten stone has been poured down on a bed of clay, itself overlying a stratum of stone.

In the north-eastern part of the island is a spot comprising an area of ten or twelve square miles, called "la Plaine des Roches." This is covered almost entirely by a band of rock, generally becoming thinner towards the sea, where it is from six to ten inches in thickness. This stratum lies on a bed of loam of about equal thickness with itself. Its surface bears the appearance of water rippled by the wind. In many spots there occur spaces of some hundreds of square feet without a fissure, forming what are locally and aptly called "pavés." In other spots conical mounds are observed, varying in size and height, which have evidently been formed by some upheaving force exerted in the centre, whence radiate cracks extending to the circumference. Such mounds are often seen in other parts of the country, but are nowhere so frequent as on this spot. They offer most convenient stones for building, the upper and lower surfaces being parallel, and a little breaking at the edges being all that is required to prepare them to form symmetrical walls. They are largely employed in the wall skirting the railway.

The fertile soil beneath this great extent of rock enables trees and grass to flourish wherever a fissure admits their seeds: and in some places cane-holes are broken through the overlying stone; and the plantations made there thrive well in wet seasons. This part of the country offers numerous other proofs of the disturbance of the upper strata by subterranean forces.

Oxide of iron in pisiform nodules occurs in many spots, and was thought of sufficient importance to cause the establishment of foundries by Governor Labourdonnais. These supplied a great portion of the iron employed by him in ship-building; but the rapid destruction of wood necessary to keep up these works caused their speedy abandonment. A large quantity of scoriæ from these furnaces was found during the construction of the railway, and even some pigs of iron. Thin veins of hepatic iron-ore occur in many places. It is usually coloured scarlet on its under surface, and has been found by experiment to contain more than 70 per cent. of pure metal.

In the northern part of the island, at a spot called "Mapou," and in one or two other places, is found a white soft earth locally termed "boue blanche," which supplies the cottars with both plaster and whitewash. It appears to be formed of a mass of decomposed madrepores, but possesses more consistence than would be expected from such a material.

I now venture to put forth a conjecture as to the probable cause of the existence of the fossil-bearing islands, and the masses of calcareous rock similar to that which forms them on the shores.

As fossilization could not have taken place in the air, there must have been a subsidence of the land-bearing forests, carrying them below the water-line; and during the period of their submersion a deposition of sand, which has since formed sandstone, took place. This, probably, only reached to a portion of the height of the trees, and that part which remained exposed to the air rotted away. Whether the perforations are the work of lithophagous or xylophagous mollusks I cannot pretend to say; but I think it probable that the latter were the agents, as I have seen wood in the sea hollowed in a manner much resembling that in which they are riddled. Petrifaction having taken place, upheaval followed. As the calcareous formation is of considerable antiquity, and is found at the extremities of the island and beyond its proper limits, it may have constituted part of an island larger than Mauritius itself, and of greater antiquity. I have ascertained by careful observation and examination, that the present extent and elevation of Mauritius have undergone no perceptible change since the first regular surveys, made upwards of a hundred years ago.

In conclusion, I may observe that, on most parts of the coast, the land rises, immediately before reaching the sea, to a height of from 6 to 20 feet. In the lower parts this rise is occasioned by sand dunes overlying basalt, and in others by basalt overlying sand. This appears to me to indicate that after a considerable deposit of volcanic matter, at a period long anterior to the formation of Mauritius as it now is, a second outpouring took place, over the spots where the basalt is on the surface, and the fluid mass was partially arrested in its downward course by the sand-hills on the shore. The looseness of the heaps of scoriæ, which form the elevations mentioned, appears to favour this hypothesis.

MARCH 6, 1867.

Robert Henry Scott, Esq., M.A., Hon. Sec. R.G.S.I., Director of the Meteorological Department of the Board of Trade; and Elijah Walton, Esq., 144 Kent-road, S.E., were elected Fellows.

The following communications were read:—

1. *On some* SEA-WATER-LEVEL MARKS *on the* COAST *of* SWEDEN. By the Right Hon. the EARL of SELKIRK, F.R.S., F.G.S.

DURING a short tour in Sweden in the summer of 1866 I had an opportunity of examining the sea-marks, which are supposed to show some change in the relative level of land and water, both in the Gulf of Bothnia and on the west coast among the islands off Göteborg. The general belief among the people on the coast that the land is rising, or, as they term it, the water receding, adds a good deal to the difficulty of the inquiry, every one naturally wishing to show something to corroborate the general belief.

The first marks I saw were two, both off the harbour of Gefle. On Tuesday, 3rd July, 1866, I went in a sailing-boat, with two pilots and a young gentleman of the place, who spoke English well, and who volunteered to accompany me. We had a brisk wind from west and south-west, and made a quick run over to Löfgrund, which is one of the outer range of islets off the harbour, and is, I suppose, some twelve English miles from the town. I was at once shown the mark described by Sir Charles Lyell, which is said to have been cut by one Rudberg, a pilot. I call it "Rudberg's mark." It is a date, 1731, with a line under it; and two feet six inches (old Swedish measure) lower down there is another date, 1831, with another line under it; but the last figure is not very distinct, and *may* be a 4; and when I saw it, the water was one foot below this lower line. It appears to me that the mark is not upon a rock, but upon a boulder-stone; and I should, though I feel much hesitation in differing from such an authority as Sir C. Lyell, have called it gneiss rather than mica-schist. My reasons for believing it to be a stone, not a rock are:—that all the rocks I saw in the neighbourhood, where I could distinctly see that they were rocks, were much more smoothed and rounded off at the top; and also that nearly every other stone I saw in the island was sandstone, or conglomerate, of a reddish or brown colour. I could see nothing that I could be sure was rock *in situ* in the Island of Löfgrund. The bay is rather on the north than the east side of the island, and the place where the mark is seems to me open to the Gulf of Bothnia. There can be no doubt, however, that it is the same mark seen by Sir Charles Lyell: it is near the shore of the bay opposite to where the houses are; the place is a summer station for pilots and fishermen, and is uninhabited in winter, but is sometimes visited by parties coming over the ice. I was told that sometimes no open water is to be seen here at all, and that the ice becomes from five to eight feet thick; this I conceive must be by one sheet sliding over the top of another; it is said, too, to carry about stones of several hundredweight frozen into the ice. The pilots said that the water was somewhat low in the harbour this day. I also found the marks of pitch oozing from the conglomerate, described by Sir Charles Lyell, on one or two large blocks that lie on the outer (or eastern) shore of the island.

After spending an hour on the island, I sailed again for St. Olof's Stone, in Edskösund. This is an enormous boulder, some forty or fifty feet high above the water; it lies a few yards from the shore, which is covered with loose stones of no great size; it is of gneiss, I think; and at no great distance (say 50 to 100 yards) there are rocks *in situ* of the same, very much rounded by glacial action, but a good deal split, apparently by subsequent frost. A date (1820) is clearly seen upon it, on the side of the stone furthest from the shore near which it lies; but there is no horizontal line near the date. A little to the right of a person looking at it, and about two feet lower than the date, there is a horizontal line, which can be more easily felt than seen. This line, as near as I could measure (but the water was not quite still) was fifteen inches above the water. I could not find out whether this was the mark Sir Charles Lyell saw. The horizontal line is upon the most projecting part of the stone, which overhangs below.

On the 5th July I went to examine the mark on the Island of Gräsö, put there by a person of the name of Olof Flumen, who was superintendent of the pilots on the coast, and was, I believe, a Swedish naval officer. This I call Olof Flumen's mark. The Island of Gräsö is a long and not very broad island that runs along the coast, having a navigable channel within it. The north end of the island is some eight English miles from the town of Oregrund, which is nearly abreast of the middle of the island. The mark is some four miles to the southward of the town, and just about the place where the channel is narrowest and most encumbered with rocks and islands. It is on the perpendicular face of a small precipice that looks rather as if it had been quarried (but I do not believe that it has been so); it is exactly as Sir Charles Lyell describes it, and is on this day (5th July, 1866) about six inches (not more than seven certainly) above the level of the water, which was not quite still. Sir Charles Lyell, in 1834, saw it five inches above the water. Though there is no perceptible lunar tide here, there is a good deal of rise and fall of the water. I was told that about two years ago it rose two feet and a half in a few hours; a heavy gale followed, but not on the same day. Near Oregrund I saw a lagoon, which had a narrow channel about thirty yards long, that seemed to have been cleared out to let a small boat pass. On the 5th July the water was running *into* the lagoon from the sea, on the 6th the current was running *the other way*—in neither case strongly. This was all I observed connected with the sea-marks on the east coast of Sweden.

On the west coast I examined four marks: the one furthest to the north is one put upon a rock by Sir Charles Lyell at the pilot-station at Gulholmen, about eighteen to twenty English miles to the north of Marstrand. It is upon a rock at the entrance of a small creek that runs up close to the village, and is to the south of the Post-house, as Sir Charles calls it, which is the only tolerable house in the village, and is also the Inn as well as the Steam-boat Agency. On the 18th July, 1866, the water-line belonging to the mark was just three inches above the surface of the water. The innkeeper, who showed me the mark, said that he considered the water at present rather high for the season; but the men of a sailing-boat, in which I returned to Marstrand, said, on the contrary, that they thought it rather low. The other three marks I saw were near Marstrand, though none were on the Island of Marstrand itself. The first I saw, which was the one furthest to the north, is on a rock just abreast of the northernmost part of the town. This mark is a row of four jumper-holes, each about an inch deep, and placed between 1 and 2 inches apart in a horizontal row, with the date 1821 over them. I call it the Four-Holes Mark. I have since heard that it was put there by one Nils Brunskrona; there is an N.B. over it. On the 17th July, 1866, the water was just up at the hole; on the 19th it was six inches lower, as near as I could measure it; but, the rock not being perpendicular, it was difficult to measure accurately. This mark is not mentioned at all by Sir Charles Lyell. The rock upon which this mark is placed is a hard gneiss rock, and as little like anything bituminous as any rock I ever saw; and yet it had the appearance of black pitch oozing from it. I thought at first that some recently pitched boat must have rubbed against it; but the pitch seemed too much ingrained for that. On looking closer, however, I saw that the rocks bore marks of fire, and I found afterwards that on May Day, or Midsummer, or some such festival, they were in the habit of burning a tar-barrel now and then on the top of this rock. The other two marks were put, as I was told, by a Captain Cronstadt, a Swedish engineer officer (and I shall call them Captain Cronstad's marks), in the year (A.R.) 1770, when taking levels with a view to cutting a canal, which, however, was never finished, and for which another is now substituted. The first I saw was on the island of Bakkaholm, close to the landing-place, and just facing the village of Marstrand; it is upon a very shelving rock, nearly flat, in fact, which made it difficult to measure; but the mark was, on the 19th July, seven inches perpendicular above the actual level of the water, and about fifteen above a place to which, from the appearance of the weed, it seems generally to retire in summer. This mark seems not to have been observed by Sir Charles Lyell. The last mark I saw was the one observed by Sir Charles Lyell, and is, if I am not mistaken in my estimate of the distance, an English mile from the town of Marstrand, on the island that faces the town at the opposite side of the harbour, called the Island of Koon. It is at the foot of a precipice some fifty feet high, I suppose, south-east of the town. The letters are shaped in the way that he describes, owing to the way in which the gneiss is stratified, for the convenience of carving the letters on a material of uniform hardness and similar grain. Without his measurement I could never have found the proper mark. I found a line just twenty-one inches below the cypher, and that line is now (19th July, 1866) just seven inches above the water-level. He gives it on 19th July, 1834, as being ten inches above the water; so that the water is actually three inches higher against the rock than when Sir Charles Lyell observed it. There is another line, apparently cut since, at the distance of nine inches above the old one; and there is another sixteen inches below it, and nine below the present water-level; and there is a date between them (1847); but I did not hear who had put it there or cut these lines. I think the old line and the date must have been refreshed at the same time. The water must have been a good deal lower when this last line was cut than now (19th July, 1866); for I can scarcely imagine a person cutting this mark under the water, nor can I divine an object for doing so. These are all the marks I saw.

I heard a curious story at Marstrand *à propos* of change of level. There is an island called Steningsön, on which stands a church called Norum. A hill not far off partly conceals the church from the top of another hill beyond; both hills are, and always have been, bare rocks at the top. It is said by some of the old people that half a century ago or more only the top of the spire was visible; but now the roof of the church can be seen. The gentleman who, in reply to my inquiries, gave me the names of the places, and to whom the story was familiar, though he seemed inclined to laugh at it, hinted that the level of a man's head above the ground was not the same at ten years old and at twenty. I could hear nothing of any earthquakes ever having been felt in this part of Sweden.

Among some people in Sweden an idea prevails that while the north part of the country is rising from the sea, the south is sinking under it; but if I am not mistaken, the state of the water in the ditch of the citadel of Malmö contradicts this idea, as there seems to have been no serious change of level during the centuries this ditch has existed; if I am not misinformed, it was here that Hepburn, Earl of Bothwell, ended his days in confinement.

Though not immediately connected with the sea-marks, I may mention another very curious phenomenon that I saw at Marstrand. The rocks here are hard gneiss, and very much marked with those scratches generally attributed to glacial action. A number of round holes exist, like those sometimes worked by the water near waterfalls, or by the waves on the sea-shore, and which are made, in fact, by loose stones moved by the current or the waves. They were of different sizes, from a foot and a half to above six feet in diameter. I could not ascertain the depth, as the bottom was full either of water or of earth and rubbish, which I had no means of removing; but I saw one that was certainly over six feet deep. Were I to theorize about how the water that moved the stones that bored these holes was itself set in motion, I would suggest that the glaciers that may have made the scratches may have had holes analogous to those called "moulins," I believe, in Switzerland, down which water falls with some force, and which I believe are always in the same place, though the glacier moves forward bodily; but this is mere conjecture.

I have now detailed all that I have seen of these marks, and what I heard from people on the spot. I would wish to leave the inferences to be drawn from these observations to others more competent to reason on these subjects; but if I am asked what I think of them myself, I must say that they prove nothing. The truth is that the daily and weekly alterations in the level of the water caused by changes of the wind, and sometimes, I believe, by winds not felt at the spot where the change of level takes place, are so very considerable that anything that may have taken place in thirty years is almost imperceptible in comparison. For instance, I was at Marstrand, and saw the water up to the four-holes mark on the 17th July, 1866; on the 18th I saw the water three inches below the mark Sir Charles Lyell cut at Gulholmen, which lies only twenty miles to the northward; and on the 19th the water was six inches below the four-holes mark. Now, had I seen Sir Charles Lyell's mark on the 17th it is quite possible that I might have seen the water exactly at his mark; and it is equally possible that on the 19th I should have found it six inches lower. From this I infer that until the average level is more clearly ascertained, no inference can be drawn from these marks. When I first saw the marks at Gefle, especially Rudberg's mark, I imagined that there was proof positive of the regular change of level; but there are considerable elements of uncertainty about them. The mark on St. Olof's stone is so indistinct, that it can only be of use in connexion with other marks; and there are two circumstances connected with Rudberg's mark that interfere materially with any certain inference from it. There is no written document I could hear of, to ascertain the fact that the original mark was not placed to mark some unusually high level of the water; indeed there is no clear evidence that I have met with that the horizontal line was cut at the water-level. Besides this, if I am right in my conjecture that it is a loose *stone*, and not a *rock*, may not that stone rest upon a shelving rock, up which the pressure of the ice from the Gulf of Bothnia may have moved it? If a stone, it is clearly too large to have been lifted from its place by being frozen into any modern ice-field; but the pressure of a mass of ice extending for many miles, coming in urged by a strong gale from the Gulf of Bothnia, may easily be conceived to have moved it a little way up an inclined plane. I merely mention these things as being sufficiently *possible* to throw a great amount of doubt over the inference to be drawn from the present position of this mark relatively to the level of the water.

I think I saw fir and spruce-trees, near the east coast of Sweden, growing so little above the present level of the water that, had it been as much higher in 1731 as Rudberg's mark would indicate, they must have begun to grow from under water, a thing of course impossible. But to ascertain this accurately I should have required a levelling instrument, as well as permission to cut the trees to find out their age.

Since writing the most of this, I have received from Sweden a translation of a report by Mr. G. Widell upon the marks at Marstrand. I was happy to find that he had come to the same conclusion with myself as to the uncertainty of any inferences to be drawn at present from these marks. He mentions in this paper an appearance of a daily rise and fall of the water, which, if I understand him right, takes place at the same hour, and therefore cannot be a lunar tide, but must depend on a sort of land- and sea-breeze. I did not observe this, though it may have taken place. I may mention, at the same time, that I was under great obligations to that gentleman, who is the Rector of the Academy at Marstrand, and kindly assisted me in looking for the marks.

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2. *On a* Post-Tertiary Lignite, *or* Peat-Bed, *in the* District *of* Kintyre, Argyllshire. By His Grace the Duke of Argyll, K.T., D.C.L., F.R.S., F.G.S.

[The publication of this paper is postponed.]

(Abstract.)

A section of the Peat-bed was seen in a bank cut through by a small stream near the village of Southend. The bank appears to belong to the "Old Coast Line," which is so well-marked a feature around most parts of the west coast of Scotland. The Peat at the point described is 3 feet 9 inches thick; above it is a bed of fine clay, from 13 to 14 inches thick, containing hazel-nuts, followed by a bed of fine yellow sand 4 feet thick, which is succeeded by a bed of coarse gravel, with small boulders of the thickness of 14 feet.

About 400 yards further up the stream there is a bed of fine black-blue clay with Mussel-shells.

These beds appear to furnish evidence of some five or six different changes of level. (1) The Peat-bed was depressed under shallow and very muddy water, depositing the bed of fine clay; (2) a further depression subjected this mud to an inroad of the sea, bringing with it the sand which overlies the clay; (3) a further depression, or possibly a partial elevation, exposing the same surface to some strong current or littoral action, brought down upon it the bed of coarse gravel; (4) all these beds were consolidated and re-elevated above the sea; (5) another depression enabled the sea to erode the valley of which the "Old Coast Line" forms the boundary, and in which this section is exposed. A long period seems to have followed, during which this Old Coast Line formed the coast of Scotland; and during that period the upper Mussel-bed seems to have been deposited. (6) A final elevation of the land determined the present coast-line, and left the old one as it now appears—subsequently modified by atmospheric action, and cut through by streams. All these changes occurred during what, geologically, must be

called the existing period, as the vegetable remains in the Peat, and in the Clay, seem to be all referable to existing species.

MARCH 20, 1867.

James Danford Baldry, Esq., 2 Queen's Square Place, Westminster, S.W.; and Coutts Trotter, Esq., 16 Cadogan Place, S.W., were elected Fellows.

The following communications were read:—

1. REPORT *on* RECENT DISCOVERIES *of* GOLD *in* NEW BRUNSWICK. By W. S. SHEA, Esq.

[Communicated by the Rt. Hon. the Earl of Carnarvon.]

(Abstract.)

MR. SHEA gives in his report a detailed account of his explorations into the gold-bearing gravels of certain river-valleys in the counties Victoria, Northumberland, Carleton, and York, in Central New Brunswick. He has been enabled therefrom to draw the following inferences:—(1) That the gold in these alluvial deposits is derived from the quartz-veins penetrating the rock of the district; (2) that the gravel, which contains pebbles of all sizes, is derived from the disintegration of the rocks of the district; and (3) that, judging from the richness in gold of paying drift in California, it is probable that these auriferous gravels will pay also.

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2. *On the* DISCOVERY *of* COAL *on the* EASTERN SLOPE *of the* ANDES. By W. WHEELWRIGHT, Esq.

[Communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., &c.]

(Abstract.)

IN this paper the author reports the occurrence of beds of Coal on the eastern slope of the Andes, between the cities of Cordova and San Juan, about 25 leagues east of the latter city.

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3. *On the* PRESENCE *of the* PURBECK BEDS *at* BRILL, *in* BUCKINGHAMSHIRE; *and on the* SUPERIOR ESTUARINE SANDS *there and at certain places in* OXFORDSHIRE *and* WILTSHIRE. By the Rev. P. B. BRODIE, M.A., F.G.S.

THE existence of the Purbeck beds at Brill * not having been yet accurately determined, it seems desirable to notify the fact of their occurrence there between the estuarine sands (or Hastings sands) of

* [*Vide* Mem. Geol. Survey, Explanation of Sheet 45, p. 47.—EDIT.]

Professor Phillips, and the Portland stone below. In a visit I lately paid to that well-known locality for Portland fossils, I saw there several masses lying about of a close-grained, concretionary, drab-coloured limestone, very different lithologically from the Portland Oolite, which attracted my attention. The average thickness of the blocks was from six to eight inches; and on the upper surface, which was coarser and somewhat sandy, I detected *Cypris* and abundance of fish-bones and scales, including two entire fish-jaws with teeth; but I could not find any shells. The aspect of this limestone was so decidedly that of a freshwater deposit, and so similar to certain of the Purbeck strata which I have studied in Wilts and Dorset, that, without having discovered a single fossil, I should have felt satisfied that it was not of marine origin and was quite distinct from the Portland Oolite. It has a very irregular, splintery, and uneven fracture, and resembles the "cap" of the Island of Portland, to which no doubt it may be referred, and forms a reduced equivalent. It seems also to resemble the lower and harder portion of the "pendle" at one of the pits at Whitchurch, described by Dr. Fitton *, which contains bones and scales of fish.

The stone had evidently been procured from the base of the estuarine sands, though, unfortunately, the excavation had been so filled up that it was impossible to detect this undoubted remnant of the Purbeck formation *in situ*. However much reduced in bulk these freshwater strata are in this direction, it is interesting to know that they are not altogether absent here, as they had not been previously noticed either by Dr. Fitton † or Professor Phillips ‡, and, although I have paid several visits to Brill, I never before was able to detect them.

There is also a considerable development of the estuarine sands above the Purbeck beds, forming the summit of the hill. In the intercalated ironstone bands which are usually associated with these sands, I found a small *Paludina*, coarsely but strongly ribbed, and apparently distinct from any figured and described by Professor Phillips. I have also obtained *Paludina subangulata*, Phill., and *Cyrena media* in the same sands at Wheatly and Horsepath, in Oxfordshire, and also *Paludinæ*, many years ago, in the Vale of Wardour, in Wiltshire, there associated with *Cyclas* or *Cyrena*, and a portion of the carapace of a Tortoise, perhaps *Trionyx*. Whether these sands are really the equivalents of the Hastings Sand, or of the estuarine beds intercalated in the Lower Greensand, as suggested by Professor Phillips, it is certain that they contain definite species of freshwater or estuarine shells over a wide-spread area, and deserve a more careful examination in all the districts where they occur. The *Uniones* are so rare that I have never yet been fortunate enough to find one; but *Paludinæ* and fragments of Plants are not uncommon—and the latter occur at Brill and Wheatly, not only in the iron-

* Trans. Geol. Soc. 2nd series, vol. iv.

† "Memoir on the strata below the Chalk." Trans. Geol. Soc. 2nd series, vol. 4.

‡ Quarterly Journal of the Geological Society, August, 1858.

stone, but also in the more marly portion of the sands. On one side of the former hill these sands are let down, and appear at a much lower level; for, as a rule, they cap the hill. In the Vale of Wardour they seem to have been mostly denuded; but blocks of ironstone derived from them are scattered about the fields in places, in the same way as the chalk-flints are, owing to the previous denudation of the chalk hills.

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4. *On the* Lower Lias *or* Lias-Conglomerate *of a part of* Glamorganshire. By Henry W. Bristow, F.R.S., F.G.S., of the Geological Survey of Great Britain.

On the 6th December, 1865, a paper was read before the Society, by Mr. E. B. Tawney, "On the Western Limits of the Rhætic Beds in South Wales, and on the position of the 'Sutton Stone'"*.

The chief object of the above communication was (to quote the author's own words), "to discuss the 'Sutton Stone' as to its stratigraphical, lithological, and palæontological relations; to show from organic remains that its affinities were with the Triassic formation, and not with the Lias, as commonly supposed, and then to claim it as Rhætic, and in so doing to extend, for the first time in England, the range of Ammonites down into the Rhætic series" (p. 70).

In order to render his views still more intelligible, the author reiterates (at p. 72 of his Memoir), "These beds I now claim as Rhætic, and would unquestionably separate from the Lias. As developed on the coast, they are between 80 and 90 feet in thickness: to the lower half of this the term 'Sutton Series' may apply; and for the upper half I propose the name of 'Southerndown Series,' as they are best seen in the fine cliff-exposure under the hamlet of Southerndown."

In further elucidation of the views already expressed, the author gives two sections at p. 75—one a vertical section representing, in the lower part, 39 feet of the "Sutton Series" overlain by a thickness of 50 feet 9 inches of "Southerndown Series," which, again, is surmounted by acknowledged Lias, represented by the zone of *Ammonites Bucklandi*, the lowest part of that series.

I have considered it necessary, thus fully, to remind the Society of the bearing of Mr. Tawney's communication, in order that the remarks which I wish to bring before them, in reference to this very interesting series of deposits, may be more clearly understood.

On resuming my duties in the field, in the course of the past summer, for the purpose of extending the survey of the Penarth or Rhætic series westward of the district where I had been compelled, by stress of weather, to abandon their examination at the close of the previous year, I was induced to give the preference to the locality treated of by Mr. Tawney, rather than to Watchett (where I had examined and measured the sections in detail, with my colleague, Mr. Etheridge, in order to map the strata in question), and while

* Quart. Journ. Geol. Soc., vol. xxii. p. 69.

doing so to acquire a knowledge which might, possibly, assist me in surveying their westernmost extension, where I had already made a cursory examination of them two years previously, in company with the Director General of the Geological Survey.

In tracing the coast-section from west to east, *i. e.* from the River Ogmore to Dunraven Point, instead of the strata being divisible into two separate and distinct series, as described by Mr. Tawney in his memoir, and represented in the engraved sections which accompany it, there is, in my opinion, but *one* series; that is to say, there is not a Sutton Series (seen at the cliff at Sutton), and *another* or Southerndown Series (seen in the cliffs under the hamlet of that name) intervening between the Sutton Stone and the acknowledged Lias; but the beds occupying the cliffs at Sutton pass, in their horizontal extension, into those forming the cliffs of Southerndown; so that there is, in fact, but *one* series, by whatever name it may be called, the so-called Southerndown Series being merely the easterly prolongation and the representative of the Sutton Stone of Sutton.

That this is the case becomes equally apparent on examining the coast-section from east to west, from Dunraven Point to Sutton. The error fallen into by Mr. Tawney has been caused, perhaps, by the exceptional and peculiar character of the stone exposed in the quarries at Sutton, where it is soft, white, and tufaceous, and assumes the texture of a freestone. Such a stone it is, in fact; and a favourable specimen of its excellent quality and appearance is displayed in the pulpit of the church at St. Brides Major, which is carved out of Sutton Stone.

Within a very short distance of the houses east of Sutton, the stone becomes blue and hard, and assumes a closer texture; but beyond that point and up to the caves which have been worn out of the Carboniferous Limestone, upon the upturned edges of which it has been deposited, the Sutton Stone is again white and tufaceous: in an easterly direction from the caves it assumes a close texture, a blue or blue-grey colour, and becomes extremely hard and tough. Perhaps this change of character may, in some degree, be owing to the influence of the sea-water, which washes the base of the cliffs between the caves and Dunraven Point; while westward of the former the Carboniferous Limestone and Dolomitic Conglomerate form the cliffs, and the Sutton Stone at the quarries recedes from the shore, and is removed from the influence of the sea-water*. The effect produced upon the strata by the sea-water has been to silicify them, and to render them so hard that it is exceedingly difficult, and often next to impossible, to hammer the fossils out of the rock; while the calcareous shells of the fossils themselves, between high- and low-water-mark, have sometimes been replaced by chalcedony somewhat resembling that form of it which has received the name of Beekite.

But, irrespective of this supposed action of the sea-water, the strata themselves are naturally much impregnated with siliceous matter,

* It there forms the southern slope of the hills and rising ground which extend from the shore in a northerly direction.

not only mixed with them mechanically in the form of fragments of chert derived from the neighbouring Carboniferous Limestone, but as a contemporaneous deposit. One of the lower hard beds in the upper part of the series has an interrupted and irregular, but very persistent and marked, layer of black chert near its base.

The whole of the beds up to the acknowledged Lias may be described as more or less conglomeratic, the uppermost 11 feet under Southerndown being notably so. And, as Mr. Tawney states (at p. 74), this latter stone differs lithologically from that of Sutton in the beds being much harder and more irregularly [?regularly] bedded.

The whole thickness of these conglomeratic beds, from the normal Lias down to the Carboniferous Limestone, is displayed in the cliffs on either side of the caves already mentioned. The annexed diagram* has been constructed from very careful measurements of the cliffs, bed by bed, and checked by measurements made at different times and at different points. The thickness of the beds varies slightly in different places, as is usually the case with deposits formed in an area that is undergoing slow depression; and the lower part is especially irregular, conforming itself to, and filling the hollows and irregularities in, the denuded surface of Carboniferous Limestone, upon the upturned edges of which it has been deposited. After the cliff-section had been measured bed by bed, with the assistance of Mr. Gibbs, of the Geological Survey, I measured the vertical thickness of the beds, between the Carboniferous Limestone and the lowest thick bed, in one measure (at a spot about ½ an inch eastward of the left-hand extremity of Mr. Tawney's longitudinal section, fig. 2), and found it to be about 25 feet, certainly not more, if so much; and this measurement was tested at the caves by means of another, with which the former closely agreed.

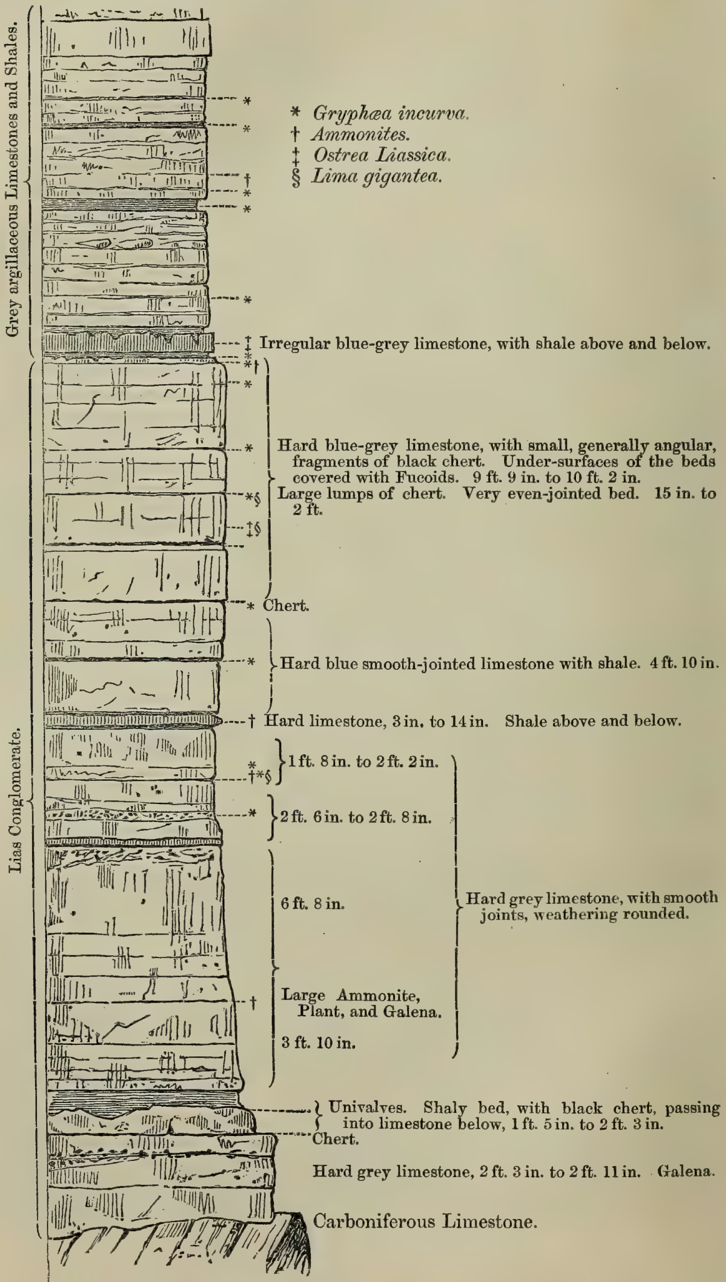
This, according to my measurements, makes the total thickness of the conglomeratic beds (the Sutton and Southerndown series of Mr. Tawney) to be from 35 to 37 feet; while Mr. Tawney represents the aggregate thickness of the same beds to be 89 feet 9 inches.

From the high ground of Sutton the beds gradually decline eastward, until at the caves they come to the base of the cliffs, a short distance beyond which they are partly concealed from observation in consequence of an undulation in the Carboniferous Limestone, until they reappear at Dunraven Point, where the latter is brought up by a fault.

As the Sutton Stone reposes on the upturned edges of the Carboniferous Limestone, the irregularities and undulations of which it fills up, the thickness is somewhat variable in different places; and it is possible that the lower beds of Mr. Tawney's vertical section, above and below the "Conglomeratic band of chert," which I believe

* An attempt is made to show, in profile, the way in which the beds have been acted upon by the sea. The upper part of the section represents the lower part of the cliff under Southerndown—the remaining the subordinate portion of the series as displayed further west, down to the Carboniferous Limestone.

Vertical Section of the Lias Conglomerate, &c., as exposed on the Glamorganshire Coast. Scale ¼ inch to 1 foot.



to be those exposed at the line of old quarries between Sutton and Craig-yr-eos, may come in thus.

Whether this be the case, or not, will not affect my argument, the object of which is merely to prove that the beds between the Carboniferous Limestone and the common argillaceous Lias limestone and shale, which cover a large area between Sutton and Cowbridge (at Ewenny, Brocastle, Llangan, Pentre Meirig, and other places), form a part of the Liassic series, the difference in the lithological character being due to the prevalence of special conditions at the period of their deposition.

Having satisfied myself, thus far, that the Sutton and Southerndown series of Mr. Tawney are stratigraphically part of one series, I directed my attention more particularly to the fossils; and the result enables me to assert that the group of strata in question is true Lias from top to bottom.

The four commonest and most characteristic Lias fossils may be traced from the very lowest of the beds into their junction with the ordinary Lias; and when I state that *Gryphæa incurva, Ostrea Liassica,* with *Lima gigantea* and *Ammonites* of large size, have been recognized in the rocks of this series, in place, I think that the Liassic age of these deposits may be regarded as fairly proved.

It is true that these fossils are somewhat sparingly distributed in the coast-section, and that the rocks are so hard that, even with the help of so experienced a collector as Mr. Gibbs, the number of specimens procured is scanty. Still they are sufficient to prove the case. In a conglomeratic deposit of this nature it is to be expected that fossils should be but sparingly present; and the Corals found in the Sutton Stone, especially between Sutton and West, partly consist of Palæozoic * species derived from the Carboniferous Limestone, which is there crowded with them, and out of which they have been washed during the denudation of the Carboniferous Limestone, which accompanied the deposition of the Sutton Stone.

Although aware that exceptions will be made to the statement of the occurrence of *Gryphæa incurva* and *Ostrea Liassica* in these beds, and that the fossils in question will be pronounced by some authorities, whom I hold in great respect, to be *Gryphæa irregularis* and *Ostrea irregularis,* it is nevertheless my belief that the *Gryphæa* of the beds in dispute, if not identical in form with *Gryphea incurva,* is yet the representative and only a variety of that shell, which occurs in such remarkable numbers in the Lias immediately above, the slight variation in their respective forms being a result of difference of conditions; and similarly as regards the *Ostrea.*

Probably, by means of a large collection of the shells in question, it might be possible to trace all the gradations between one form and the other. In fact it is stated by Dr. Duncan that "doubtful specimens of *Gryphæa incurva* are now and then met with in the Brocastle beds. * * * * One specimen from Brocastle has the

* Dr. P. M. Duncan, Quart. Journ. Geol. Soc. vol. xxii. p. 89, 1865; also vol. xxiii. p. 13, 1866.

laminate fossilization of the species, and a trace of the lateral groove which peculiarizes typical *Gryphæa*"*.

Dr. Duncan has already expressed his opinion that the Sutton series is above the Rhætic beds, although he does not class it with the Lower Lias, but with what he terms Infra-Lias†.

In his memoir, Mr. Tawney has given the figures and descriptions of twenty species of Mollusca, found by him in the Sutton Stone, all of which are stated to be new, and claimed as Rhætic species.

This is a discovery of much interest; but at the same time it is scarcely necessary to remark that the occurrence of so many new forms of shells affords no evidence, one way or the other, as to the real age of the beds in which they are found.

So far from proving the beds to be Rhætic, the argument that they are Liassic may be urged with greater force, because they come out of strata in which the most characteristic of Liassic shells occur, and are there associated with them.

One of the great difficulties felt by Mr. Tawney in fixing the precise position of the Sutton beds in the geological scale, was the want "of any section showing the position of the *Avicula-contorta* sandstones [or undoubted Rhætic beds] in relation to the Sutton and Southerndown Series" (p. 78).

This difficulty is overcome by means of the sections displayed at the Stormy Cement Works, north of Llangan, and at St. Mary Hill Common.

The section at the Stormy Cement Works, on the south side of the railway, rather less than two miles east of Pyle Station, shows about 20 feet of ordinary Lias limestone and shale, resting upon 2 feet of a hard, siliceous, and shelly blue conglomerate, under which occur from 12 to 15 inches of pale argillaceous limestones, breaking with a smooth conchoidal fracture, and which I believe to represent the "White Lias" or uppermost member of the Rhætic series.

The conglomerate of the Stormy Cement Works I take to be the attenuated representative of the conglomeratic Sutton Stone in its northerly extension, beyond which locality it probably extends beneath the ordinary Lias only a short distance before it altogether thins out.

Near Llangan, round which locality the Sutton Stone spreads over a large area, it undoubtedly is based upon the sands and shales of true Rhætic age, as may be seen in the section descending from the high ground, east of the cross road leading from the old lead-works, in an easterly direction. There the higher ground, over which the main road runs from Pentre Meirig northwards, is composed of the Sutton beds, beneath which the Rhætic sands and shales crop out in the descent of the road to Cwrt, north of which they are cut off by a fault bringing in the Carboniferous Limestone.

At St. Mary Hill Common the Sutton Stone has been worked at the south side of the Common, west of Termynydd. The beds are slightly conglomeratic, containing fragments of black chert, small pebbles of white quartz, and specks of galena, and dip at an angle

* *Ante*, p. 24. † *Ante*, pp. 23 and 27.

of 25° in a direction 25° west of south. The true position of these beds between the ordinary Lias and the Carboniferous Limestone is very clearly shown to the north; and fossils are plentiful, *Pinna, Modiola, Ostrea Liassica, Lima, and Pecten* (?*Suttonensis*) being the common shells.

The three sections I have briefly noticed prove the true position of the Sutton Stone relatively to the main mass of the Lias and the Rhætic series, and show that the conclusion "that the Sutton series was probably slightly anterior in age to the *Avicula-contorta* series" (Tawney, *loc. cit.* p. 78) is untenable.

It may not be out of place to remark here that the sandstones quarried for building and grindstones, 1½ mile north of Bridgend, on either side of the River Ogmore, are not situated at the base of the Keuper, as stated by Mr. Tawney, but are in the upper part of the Rhætic series, overlain by Lias crowded with the characteristic *Ostrea Liassica*. The sequence of the beds is clearly shown on the west side of the river at Angelton, where there is a large quarry by the roadside, whence the stone was procured for building the neighbouring County Asylum.

The replacement by sandstones of the ordinary calcareous and muddy sediments of which the Rhætic Series is generally composed indicates here a coast-line and shallow water. This is borne out by the fact that it is in their most westerly extension in South Wales (between Bridgend and Pyle) that this substitution of siliceous for calcareous and argillaceous sediment has taken place; and the Rhætic strata of the district now under notice represent the near-shore deposits of a formation which, on the continent of Europe (in the Rhætian Alps, in Lombardy, Germany, and France), assumes a far greater development than it does in this country.

At a later date the Magnesian Conglomerates at the base of the Lias indicate the shore- and shallow-water deposits of a country which is now part of South Wales, and which, in part, was being gradually submerged during the deposition of the Lias; so that the beds which rest on the irregular surface of the Carboniferous Limestone are not necessarily the oldest part of the Liassic series, but of different, though approximate, ages.

Sir Henry De la Beche, in his masterly Essay* "On the Formation of the Rocks of South Wales and South-western England," well describes the conditions under which these beds have been deposited, and speaks of them as "a deposit, partly chemical, partly mechanical, formed during depression†—occasionally perhaps including lowlands behind the shingle-beaches, the deposit of the time mingling with the older rocks previously broken up on the surface by atmospheric influences, and not sufficiently exposed to rounding by attrition before they were enveloped by the matter of the new deposit." He goes on to say that "in some localities we scarcely

* Memoirs of the Geological Survey of Great Britain, 1856, vol. i. p. 270.

† See also "On the Denudation of South Wales and the adjacent Counties of England," by Andrew C. Ramsay, F.G.S., in the Memoirs of the Geological Survey, vol. i. p. 297.

know where to draw the line between the Dolomitic and Lias Conglomerates. We can easily conceive that one part of a mass of shingle and fragments may have been formed at the end of one epoch, and another part at the commencement of another, the same general physical causes for the production, accumulation, and consolidation of the gravel and fragments continuing in particular localities."

The occurrence of an ore of lead in the Sutton Stone is an interesting fact. This ore, Galena (sulphide of lead), is met with in the stone, sometimes in sufficient quantity to offer inducements to mining-enterprise—more especially at Llangan, where Works have been erected and a considerable amount of ore is said to have been obtained.

The ore, in some instances, is associated with fossil plants, which it partly mineralizes; but its most common mode of occurrence is in strings or bunches, and sometimes disseminated through the stone. Lead-ore is noted by Sir Henry de la Beche as occurring in the Carboniferous Limestone of the district; and at St. Hilary the remains of old workings show that it was formerly worked to some extent in the Dolomitic Conglomerate. Hence the occurrence of Lead-ore in the Sutton Stone corroborates the theory of its derivation from the denudation of Carboniferous Limestone and Dolomitic Conglomerate in which it originally existed, being carried down with the calcareous mud and débris of which the Sutton beds consist, and re-deposited with them in the ancient Liassic sea-bottom.

Sir Henry De la Beche states that "at Candleston, a variety of Sutton Stone, with small cavities, often the casts of shells, is very plumbiferous, galena being distributed throughout it and even filling up the cavities left by the disappearance of the shells"*.

In surveying the country between the river Ogmore and Cowbridge, the area occupied by the Lias (including the so-called Sutton Stone) proved to be somewhat greater than was represented on the existing geological maps,—a discrepancy easily to be accounted for by the strong resemblance borne by the lower beds of that series to the Carboniferous Limestone upon which they there generally repose. This striking similarity had been noticed by Sir Henry De la Beche, who remarks that "at Merthyr-mawr, on the west bank of the Ogmore, the Lias so resembles the Carboniferous Limestone on which it rests, that when the curvatures of the latter bring portions of it into a nearly horizontal position, and this kind of Lias reposes upon it, it is only by a very strict search for organic remains that the difference can be found, especially as in some situations the Lias, from the presence of abundance of Pentacrinites, has the encrinal aspect of so much Carboniferous Limestone"†.

The object of this communication not being to describe the Sutton beds of South Wales in detail, but merely to define their true position in the geological scale, I will merely add, in conclusion, that in this district it will be found that, wherever the Lias rests upon

* Memoirs of the Geological Survey, vol. i. p. 272.
† *Ibid.* p. 272.

the Carboniferous Limestone or on the Dolomitic Conglomerate, the lowest beds of the first assume the abnormal conglomeratic structure characteristic of the Sutton Stone, indicating that the latter was deposited in a shallow sea the bordering land of which was formed of Carboniferous Limestone.

With regard to the assignment of any special name to these beds, I think the term "Infra-lias" which has been proposed by some authors, is both vague and misleading, and, to quote the words of Dr. Duncan, "it must be admitted that the terminology is somewhat objectionable"*. The term Lias Conglomerate, used by Sir Henry De la Beche, denoting structural character without reference to actual position in the geological scale, at the same time that it has the advantage of being precise and distinctive, is not open to any objection, and might therefore be adopted with propriety.

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5. *On* ABNORMAL CONDITIONS *of* SECONDARY DEPOSITS *when* CONNECTED *with the* SOMERSETSHIRE *and* SOUTH WALES COAL-BASINS; *and on the* AGE *of the* SUTTON *and* SOUTHERNDOWN SERIES. By CHARLES MOORE, Esq., F.G.S.

[The publication of this paper is unavoidably deferred.]

(Abstract.)

THE author first describes the geological constitution of the Mendip Hills, which, in his opinion, were upheaved by the intrusion of a basaltic dyke (now noticed for the first time) during the period of the Upper Trias. The Mendip chain proved an island barrier to the incursion of the deeper sea-deposits of the south, and on it lived the *Microlestes* and other terrestrial animals. Along the south side of this barrier shore-deposits were formed, the "Carboniferous Limestone" constituting the floor of the ocean at that time.

He then institutes a comparison between the Rhætic and Liassic formations within and those without the Somersetshire coal-basin. The thickness of the beds, from the Trias to the Inferior Oolite, is stated to be, outside the coal-field, 3320 feet, whilst inside it is only 169 feet. These results were obtained from an examination of numerous sections, which are described in detail by the author.

After considering the horizontal deposits beyond the Mendips, and the unconformable conditions within its coal-basin, the author discusses the abnormal conditions which are presented by deposits of the same age when they are intimately connected with the "Carboniferous Limestone." In the Charterhouse Lead-mine a deposit of clay 12 feet in thickness, and containing Liassic shells, is stated to occur at a depth of 260 feet in the Carboniferous Limestone.

Among the organic remains, three species of terrestrial shells, referable to the genera *Helix*, *Vertigo*, and *Proserpina*, and a Chara-seed, were discovered.

The author concludes by pointing out the peculiarities presented

* *Antè*, p. 24.

by the Liassic strata in Glamorganshire, with special reference to the stratigraphical position of the Sutton Stone and the Conglomerates of Brocastle &c.

April 3, 1867.

The Rev. John Edward Cross, M.A., F.R.A.S., Vicar of Appleby, Lincolnshire; Elias Dorming, Esq., Mem. Inst. C.E., 41 John Dalton Street, Manchester; R. Bruce Foote, Esq., of the Geological Survey of India, Calcutta; the Rev. Charles Fraser, M.A., Christchurch, New Zealand; Lieut. Luard, R.E., Windsor; John Noble, Esq., 51 Westbourne Terrace, Hyde Park, W.; George Spencer Perceval, Esq., Severn House, Henbury, Bristol; Thomas Richards, Esq., Mining Engineer, Bank House, Redruth, Cornwall; Charles Ricketts, M.D., 22 Argyle Street, Birkenhead; Wilfrid H. Hudleston, Esq., M.A., F.Z.S., J.P., Barrister-at-law, 21 Gloucester Place, Portman Square, W.; and Josiah Henry Trimellen, Esq., Mining Engineer, 2 Calvert Terrace, Swansea, were elected Fellows.

Professor Daubrée, of Paris, was elected a Foreign Member.

Professor Bernhard von Cotta, of Freiberg, was elected a Foreign Correspondent.

The following communications were read:—

1. *Remarks on the* Drift *in a part of* Warwickshire, *and on the evidence of* Glacial action *which it affords.* By the Rev. P. B. Brodie, M.A., F.G.S.

There are many points of great interest in the history of the Drift in Warwickshire, which it would be very desirable to have recorded, and which I hoped to have undertaken, but have not yet been able to accomplish; in the meantime, a few notes upon the subject, though confined to a very small area in the county, may be of service.

The later deposits of this kind are to be found along the valley of the Avon, and consist of the usual finer sands and gravels with mammalian remains; but I have not yet heard of any flint implements having been detected with them, though I do not think they have been so diligently searched after in the neighbourhood of Warwick, Stratford, and elsewhere in the county, as they have been in other places; and they may turn up at any time*. At Warwick and Leamington this gravel contains many rolled fragments of Liassic fossils, including the small corals (a species of *Montlivaltia*) immediately derived from the Hippopodium-bed at Fenny

* Since writing the above, I find that Dugdale mentions the occurrence of a flint implement in a field near Merivale, in Warwickshire; Mr. Bloxam, of Rugby, has shown me a large flint instrument (a Celt) which was picked up also in a field near Moreton in the Marsh; and Mr. Tomes informs me that another implement was discovered in the low-level Drift near Stratford-on-Avon, but was unfortunately lost. Mr. Cleminshaw, a student at Rugby, has lately detected some small flint implements in a fluviatile Drift of comparatively recent date on the banks of the river Avon, at Holbrook, associated with the bones of Deer, Ox, Bison, Water-Rat, Fox, &c., and remains of Anodon, a large collection of which may be seen in the School Museum at Rugby.

Compton, and pieces of Permian wood; and when the Jephson gardens were being made at the latter town, several fine remains of Elephant, Rhinoceros, and other mammalia were obtained, some of which are now deposited in the Warwick Museum. I believe some land- and freshwater shells were also procured; but I am not aware that any particular account has been given of them, or that any notice was taken of them at the time. Similar mammalian remains were found at Lawford, near Rugby, especially a fine jaw with teeth of *Rhinoceros tichorhinus*, now in the Museum at Warwick, and were described by Dr. Buckland; but the pits have been closed for some years.

Of older date than the above, belonging probably to the glacial period *, is a very extensive deposit of Drift, of which, however, I can now describe only a very small portion in a district occupying the higher tableland on which are situated the villages of Hazeley, Hatton, Edstone, Remington, and Temple Balsall, from six to twelve miles north, north-west, and west of Warwick †. Rounded pebbles and boulders of various sizes and diverse mineral composition are scattered in greater or less abundance over the whole of this tract. Occasionally large rounded boulders of sandstone and other rocks are met with, but in general the pebbles are of small size, consisting mostly of sandstones and quartz, large pieces of which sometimes occur; and here and there a few square blocks of hard stone may be observed. Granite is comparatively rare. Flints are nowhere absent from this Drift, though much more abundant in some places than others, as, for instance, at Hazeley, Hatton, and Edstone, where they largely predominate, some being of large size and little rounded; but the most remarkable quantity, both as to size and number, is at Hazeley and Hatton, where masses of large unrolled flints occur, looking as fresh as if they had lately come from a chalk-pit, and some fields yield flints in abundance. The only conceivable means of conveyance for these must be icebergs, unless it be conceded that the Cretaceous formation had a much further extension to the north, spreading over a considerable portion of the midland counties—an idea which the very remarkable and considerable mass of Chalk and Greensand which was observed in the Drift overlying the Lias at Campden, in Gloucestershire, might seem to favour. Small pieces of chalk are now and then, but more rarely, met with. One striking exception came under my notice in a small field at Rowington, where little bits of very hard chalk, rounded and scratched, are scattered over it so plentifully that they gave a white aspect to the land. Interspersed with them were flints, some Greensand with *Pectens*, a brown sandy stone with *Ostrea*, Great Oolite, Cornbrash, Forest Marble, and several square fragments of Lias, chert with shells from the Moun-

* It is possible that this Drift may be re-deposited glacial Drift, and, if so, would perhaps be "high-level Drift;" but I confess my impression, from the facts observed, is, that it is true glacial Drift, and therefore older.

† It certainly extends as far as Birmingham on the north-west; for I have noticed Lower Silurian pebbles at Saltley, close to the town. It caps the Lias at Wainlode Cliff near Gloucester, and is widely spread over other portions of Warwickshire (as at Grafton, &c., west of Stratford), Worcestershire, and Oxfordshire.

tain-limestone, ironstone, Carboniferous sandstone containing plants, grit, yellow magnesian limestone, rounded boulders of older rocks, including granite, and a large block of Syenite. This detritus was of all shapes, angular and rounded, the edges often being scratched and striated. The flints were little worn. The pieces of Oolite were flat and not rounded. I carefully searched the adjacent fields, but could detect no chalk in any of them, though there are flints; and the only way to account for this limited and local distribution of broken fragments of chalk and other materials seems to be that an ice-block discharged its load at this spot.

In no case, in the Drift hereabouts, have I seen so many traces of fossiliferous rocks, which are seldom met with in this district. In a contiguous field there was a deposit of brown clay, not usual in this neighbourhood, in which were many large and small boulders intermixed with slightly abraded chalk-flints. The gravel-pits in the district average from six to eight feet in thickness, or more, in different places, and consist of the same materials, but with fewer flints, which are intermingled with sand. At one spot, but of limited extent, there is a thick accumulation of fine sand with few pebbles of any kind. The gravel is finer and more sandy in some places than others. Where the Keuper comes close to the surface, as it often does, the superimposed Drift is of no great thickness. The gravel for the most part is made up of ancient metamorphic rocks, which probably were derived from the north, and is therefore usually termed "Northern Drift;" but although the fragments of the fossiliferous rocks are few, those which I have met with seem to have travelled from various points of the compass; for it is reasonable to suppose that icebergs were often borne in different directions by adverse currents. The larger flints in the greatest profusion in the tract referred to seem to occupy a line of no great breadth, running from the north for some miles, a little to the west of south, which would include the parishes of Hazeley, Hatton, and Wotton Wawen, with Edstone. The Lias outlier at Brown's Wood, near Wotton Wawen, is covered with Northern Drift; and a deep gravel-pit on the summit of the hill contains some very large boulders. For a long time I considered the abundant quartzose pebbles to be altogether unfossiliferous; but owing to the improvement in preparing the materials for the road under the new Act, they are now broken up, and occasionally, though very rarely, a few fossils are to be met with. Among these I was much struck with the resemblance of some of the shells to some lately discovered by Mr. Vicary in the Lower Silurian pebbles of the New Red Sandstone at Budleigh Salterton, and described by Messrs. Salter and Vicary in their interesting paper in the 20th vol. of the Journal of the Geological Society *. *Orthis redux*† is the most abundant fossil, usually occurring in groups as at Budleigh; *Lingula Lesueuri*, a few specimens, one full-grown, about the size of the largest from Devonshire; *Trachyderma serrata*

* Page 283.

† *Calymene Tristani* and *Orthis redux* are found in the Lower Silurian quartz-rock at Caerhayes, in Cornwall.

not unfrequent; there are also *Rhynchonella*, sp. ?, *Spirifer antiquissimus*, *Modiolopsis*, sp. ?, and a Bivalve undeterminable. Lithologically, the pebbles are exactly like those from Budleigh, and were at once recognized, with the fossils, by Messrs. Salter, Woodward, and Vicary. Although at present the fossils are so few, others may in time be discovered; but at all events the presence of the above species in this district is very interesting; and it may not be unreasonable to conclude that the upper red marl and sands with the pebbles once capped the Keuper in Warwickshire, and the marl having been denuded the heavier materials were scattered about as we now find them, and that many of these reddish, white, and brown quartzose pebbles were so derived, and had a similar origin with those in Devonshire.

Probably up to the Glacial epoch the Upper New Red marls existed here *in situ*, and were for the most part denuded by the various oscillations and great changes of level which then took place; and the Lower Silurian pebbles contained in it were again rolled and scattered about over a more or less limited area, and intermingled with the other materials brought from a distance by the agency of ice. These pebbles, of course, must have been deposited in the New Red Sandstone itself, at a much more ancient period, during the formation of the red marls, coeval with the equivalent Triassic bed in Devonshire; and the inference would seem to be that this great Lower Silurian formation, which is now so largely developed in Normandy, and which has left only a remnant in Cornwall, formerly occupied a much larger area in the south-west, and may also have had more extensive ramifications towards the north-east. This is only another of the numerous examples of the almost total destruction of an extensive formation—one of the broken links in the chain of geological evidence which we often look for in vain, but which, when found, is of much interest and importance.

Dr. Buckland long ago showed that many of the boulders so profusely scattered in the Northern Drift might be traced to their source in the higher beds of the Trias; but no doubt a great many, as I have suggested, came from other sources. In general the prevailing formations in a given district have mainly helped to form the matter of the local drifts; but hereabouts the Keuper sandstone, though having been much denuded, is by no means abundantly distributed in it; and the same remark applies to the Lias, which is very rarely met with: but this is less surprising, if most of the materials of which it is composed were brought by ice from a distance, which is now generally conceded. Here and there, in the tract under review, some large, rounded, erratic boulders, and square, almost tabular blocks, may always be found, though at wide intervals. In a heap of stones by the roadside, evidently Drift picked off the fields, two miles south of Shipston-on-Stour, at the extreme northern end of the county, I noticed the following rocks:—large and small boulders of granite and greenstone, several varieties of sandstone, chert with fossils from the Mountain-limestone, a large fragment of a *Lepidodendron* in carboniferous sandstone, very hard chalk, and many flints, mostly of small size, one of which was of special interest, as it bore the marks of glacial striæ, long since noticed by Professor Henslow in the Drift in Norfolk and Suffolk. Large pieces of Lias, the prevailing formation in the neighbourhood, belonging to the Cardinia-bed, were abundant.

These notes on the Drift over a very small area in the county of Warwick are very imperfect and incomplete; but it would be impossible to go into the subject thoroughly, as it deserves, without a long and careful survey, which I could not undertake; in the meantime, however, these few remarks may be of service.

The following list of some of the chief constituents of the drift above described, though by no means complete, will give some idea of its prevailing contents.

Crystalline limestone, veined, dark-coloured, often black.
Slaty dark limestone.
Breccia, some very coarse, forming the ordinary pudding-stone (not common).
Porphyry.
Porphyritic greenstone.
Greenstone and Trap.
Volcanic grit.
Hard black grit with much iron.
Syenite, large square block.
Hard siliceous grit, varying in colour and mineral composition (abundant).
Crystalline and schistose slate.
Pebbles of quartz, jasper and agate, numerous.
Pebbles of sandstone of various mineral character, rarely containing fossils.
Hard and soft chalk (the former predominates), containing *Ananchytes* much rolled, *Inoceramus*, *Terebratula*, and Sponges in flint.
Greensand with *Pecten*, &c.
Cornbrash with *Avicula echinata*.
Forest-Marble, fossiliferous.
Light-brown Oolitic limestone, like some of the Lincolnshire Oolites (Great Oolite?) with casts of shells—*Gervillia*, *Pinna*, *Cardium*, and *Nerinæa*.
Lias with *Ostrea* (*O. Liassica*) and *Gryphæa incurva*, much rolled.
Soft yellow Magnesian limestone containing *Arca striata*, impression of flat valve of *Strophalosia Morrisiana*, *Fenestella rotiformis*, casts of *Schizodus*?, fragments of *Pleurotomaria*, interior of a chambered shell like a *Nautilus*, and a trace of carbonized woody tissue. For the determination of the above I am indebted to Mr. Woodward.
Permian Wood, much rolled, frequent.
Mountain-limestone with characteristic fossils, large *Productus*, Corals, &c.
Chert with casts of Encrinital stems, *Productus*, *Orthoceras*, and other shells, &c., not uncommon.
Yellow shelly limestone (probably Carboniferous) containing univalves, bivalves, and fish-palate (*Deltodus*), part of a *Dithyrocaris*, Millstone grit with Coal-plants.

Lower Silurian fossils, in pebbles of siliceous sandstone:—

Orthis redux, *Lingula Lesueuri*.
Spirifer antiquissimus (MS., Salter).
Rhynchonella, sp.?
Modiolopsis, sp.? (Salter).
Bivalve undetermined.
Trachyderma serrata.
Trilobite, undetermined, in brown limestone, waterworn (*Trimerocephalus*?); may be Devonian.

Plants like Fucoids in siliceous sandstone pebbles, probably Lower Silurian.

Age uncertain:—
White siliceous grit with cast of a *Pecten*.
Fine yellow sandstone with casts of fossils.
Hard yellow crystalline limestone with shells.
Soft sandstone with *Leptæna* &c.

2. *On the* Dentition *of* Rhinoceros leptorhinus, *Owen*. By W. Boyd Dawkins, Esq., M.A. Oxon., F.R.S., F.G.S.

[Plate X.]

Contents.

I. Introduction.

1. *Rhinoceros tichorhinus*.—The remains of the British Pleistocene species of Rhinoceros merit a most careful examination, from their numbers and wide distribution, and the fact that they afford evidence of four species of the genus having roamed through the forests and perished in the floods of that portion of the ancient continent which now forms the British Isles. Of these, the most commonly known and the most widely spread is the *Rhinoceros tichorhinus* of Cuvier, or "*Rhinocéros à narines cloisonnées*;" it is characterized by the possession of an osseous septum, which completely insulates the one nostril from the other, and stands in direct relation to the development of a very large anterior horn, by the stoutness of its bones, and by certain dental and other peculiarities which it is unnecessary to mention in this place. The discovery of the carcass of this animal in 1771, preserved in the frozen sand of the Wilouji, a tributary of the Lena, proves that, unlike all the existing species of the genus, its hide was without folds, and that it was fitted to endure a climate of considerable severity by its clothing of hair. The remains swept down by the Pleistocene floods, and stored away in the dens of the Pleistocene carnivora, prove that the animals of this species ranged in considerable numbers throughout the Europeo-Asiatic continent (Scandinavia being excepted), north of a line passing through the Pyrenees, the Alps, the Caspian Sea, and the Altai Mountains. From the drawing of a lower jaw found near Bologna, and described by Professor Monti in 1719 as the head of a Morse, Baron Cuvier also would extend its range into Italy; but the spatulate expansion of the symphyses anterior to the molar series, upon which his determination is based, has since been proved to belong also to a species that occurs in vast abundance in Italy—the *Rhinoceros megarhinus* of M. de Christol*. With this equivocal exception, there is no

* A comparison of the megarhine jaw discovered in Hérault and figured by M. Gervais in the Paléontologie Française, pl. ii. fig. 8, with the figure of the jaw in question, Oss. Foss. tom. ii. pl. ix. fig. 10, shows the megarhine character of the latter. Since the above was written, M. Louis Caselli, the President of the Natural Science Section of the Society of the Immaculate Conception, at Rome,

instance on record of the occurrence of the tichorhine species in Southern Europe; and it seems to have been the hardiest member of the genus, fitted to inhabit the country of the Reindeer, Bison, and Musk Sheep rather than the warmer climates of Southern Europe and Asia.

The labours of Pallas*, Cuvier†, and Professors Brandt‡ and Owen§, have made the *tichorhine* the most familiar of the fossil Rhinoceroses; while the vast accumulation of organic remains in Wokey Hole Hyæna-den enabled me in 1863 || to define its dentition as compared with that of the three other species.

2. *R. megarhinus*.—Out of the confusion in which the non-tichorhine remains were involved throughout the Continent, M. de Christol in 1835 ¶ rescued the *Rhinoceros megarhinus*, or great slender-limbed Rhinoceros with largely developed nasals, which Baron Cuvier had considered identical with the *R. leptorhinus* of the Val d'Arno. The perfect skull found in a marine sand of Pliocene age near Montpellier, and figured by the founder of the species, proves that it was not furnished with any trace of a "cloison" or bony partition between the nostrils. The numerous bones and teeth in the British Museum from the river-deposits of Gray's Thurrock in Essex enabled me in 1865 ** to determine the occurrence of the species in the lower part of the Thames valley; while a fine upper premolar in the collection of the Rev. J. Gunn, F.G.S., obtained at Cromer, proves that it inhabited the Eastern Counties while the Preglacial forest-bed was being formed. On the Continent its remains have been found:—in the Italian peninsula in vast abundance in the Val d'Arno; in France, in the departments of Montpellier, Hérault, and Gard ††; and in Germany, near Würtemberg, where Professor Jäger‡‡ describes it under the name of *R. Kirchbergensis*. Thus the animal ranged through Germany and the east of England into France, and at least as far south as the Val d'Arno, its furthest northern range being the parallel of Norfolk. In the fact that it lived in the climate of Italy, while the Alps formed the southern limit of the tichorhine species, coupled with the range of the latter into the high northern latitudes, we may infer that it was specially adapted to the temperate zones of Europe. The megarhine species, indeed, probably bore the same geographical relation to the tichorhine as the Red deer does to the Reindeer. Of the two, the former was the older, and coexisted in Italy with the Pliocene *Mastodon Arvernensis*, in France with *Mastodon brevirostris* and

has found *R. tichorhinus* in the high-level fluviatile beds at Rome, associated with flint implements of the ordinary palæolithic types, and remains of *Megaceros*, *Cervus elaphus*, *Hyæna spelæa*, and *Ursus spelæus*, and many other species. (Correspondance de Rome, No. 455, 4 Mai, 1867.)

* Nov. Comment. Petrop. tom. xiii.

† Oss. Foss. tom. ii. pt. 1. 1825.

‡ Mém. Acad. St. Péters. 6e sér. tom. vii.

§ British Fossil Mammals, 1846.

|| Nat. Hist. Rev. 1863, xii. p. 525.

¶ Ann. de Sc. Nat. 1835.

** Nat. Hist. Rev. 1865, xix. p. 339.

†† Gervais, Paléont. Franç. second edit. p. 91.

‡‡ Ueber die fossilen Säugethiere welche in Würtemberg aufgefunden worden sind. Stuttgard, 1835. Folio, p. 179.

Halitherium Serresii, and in the Eastern Counties with *Elephas meridionalis* and *E. priscus*.

3. *R. Etruscus*.—The third British species of Rhinoceros is represented by comparatively numerous remains derived from the Forest-bed of Norfolk and Suffolk, for some of which the late Dr. Falconer proposed the name *Rhinoceros Etruscus*. The name of this unfigured and undescribed species rests upon MS. notes attached to specimens in the British and Norwich Museums, and in the collections of the Rev. S. W. King, F.G.S., and the Rev. J. Gunn, F.G.S., and is retained, out of respect for the memory of so much knowledge buried in Dr. Falconer's grave, for the assemblage of remains of Rhinoceros which belong to one and the same unpublished species.

An examination of the plaster cast of the skull of Rhinoceros found in the Val d'Arno, and exhibited in the Exhibition of 1861, proves that the Etruscan Rhinoceros, unlike the tichorhine and megarhine, had its nasals supported by a demi-cloison or osseous partition, which sundered in part the one nostril from the other, and strengthened the basement of the anterior horn. The head was smaller and more slender than that of the other species. The upper molars are characterized by the lowness of their crowns, which strongly resemble those of the milk-teeth of *R. megarhinus*; and the last true molar strongly resembles in general form that of the Miocene *Acerotherium incisivum* of Dr. Kaup, in the possession of Sir Philip Egerton, Bart., F.R.S. I have met with the remains of this species in the collections of Messrs. Gunn and King, and in the British and Norwich Museums. The teeth in the collection of Mr. Fitch, of Norwich, ascribed by Professor Owen to *R. leptorhinus*, belong to this animal. In Britain its remains have occurred only in the Forest-bed on the east coast. On the Continent they have been determined by Dr. Falconer from Malaga; and in the collection made by M. Bravard, from Perolles, and preserved in the British Museum, are two upper molars, labelled in the MS. Catalogue as tichorhine, which, beyond all doubt, belong to the Etruscan species, and correspond exactly in size, form, and sculpturing with specimens from the Cromer shore in the possession of the Rev. S. W. King, of Saxlingham. *Rhinoceros Etruscus*, therefore, in Preglacial times ranged from the Eastern Counties, southwards through France, on the one hand across the Pyrenees as far as the Straits of Gibraltar, on the other across the Alps, at least as far down in the Italian peninsula as the Vale of Florence. Its range over South-western Europe may perhaps prove that it was fitted for a warmer climate than the tichorhine species, which it preceded in point of time. In common with the other fossil members of the Genus Rhinoceros found in Britain, it was bicorn, and possessed a dental formula of three premolars and three true molars in both jaws. The description of the species, so far as my materials allow, I hope to complete in a few months.

II. Rhinoceros leptorhinus, Owen*.

1. *History of the name*.—The fourth British species of Rhinoceros

* *Op. cit.* p. 356.

is remarkable for the confusion in which it is involved from the fact of its being entirely distinct from the *R. leptorhinus* of Baron Cuvier *. The latter is founded upon a drawing of the head found near the Monte Pulgnasco in the upper Val d'Arno by M. Cortesi in 1805, and preserved in the Museum at Milan. The original, Baron Cuvier never saw; but from the drawing made by M. Adolphe Brongniart he inferred that it exhibited no trace of the osseous partition between the nares, so characteristic in the tichorhine species; and he therefore made it the type of the "Rhinocéros à narines non-cloisonnées," or *R. leptorhinus*. This determination was considered valid by the scientific men of Europe until, in 1835, M. de Christol, after having obtained very careful drawings of the same skull by MM. Gené and De la Marmora, came to the conclusion that the sketch published by Cuvier was incorrect, and accounted for the absence of the cloison by the hypothesis that it had been broken away. A comparison of his figure (Annales des Sciences, 2me série, t. iv. pl. ii. fig. 4) with that in the 'Ossemens Fossiles' (3rd edit. t. ii. part i. pl. ix. fig. 7) proves the truth of these inferences, which, moreover, were indorsed in the year 1846 by the authority of Prof. Owen. On the other hand, Dr. Falconer incidentally mentions, in his masterly treatise on the Mastodon and Elephant †, that the skull in question is exactly as Baron Cuvier described it—without the cloison. This conflicting evidence may perhaps be explained by the presence of more than one skull of Rhinoceros in the same Museum from the same deposit. As, however, M. de Christol's criticisms upon Baron Cuvier's species have remained unchallenged up to the present time, and, considering also that the remains of the species without the cloison are very abundant in the upper Val d'Arno, the probability seems to me that M. de Christol is right in disallowing the validity of Baron Cuvier's species, and that the skull which Dr. Falconer examined belongs to *Rhinoceros megarhinus*. To which of the fossil species the skull described by Cuvier may really belong, to the tichorhine, megarhine, Etruscan, or leptorhine of Professor Owen, is entirely a matter of conjecture. M. de Christol has succeeded only in demonstrating that it is not what it was supposed to be when it was constituted the type of the *R. leptorhinus* or "*R. à narines non cloisonnées.*" For it Desmarest proposed the name of *R. Cuvieri* ‡; and Dr. Fischer § defined it specifically as "capite bicorni, dentibus primoribus nullis, septo narium nullo; naribus multo gracilioribus, ossibusque nasalibus tenuioribus quam in *R. Africano*."

In this confusion the non-tichorhine species of Pliocene age were left up to the year 1846. In that year Professor Owen, in his great work the 'British Fossil Mammals' proposed the name of *R. leptorhinus* for portions of a skull, a lower jaw, and bones of *Rhinoceros* found in the freshwater deposits of Clacton, in Essex. A comparison of the lower jaw with those from the Val d'Arno described by

* *Op. cit.* p. 71. † Quart. Journ. Geol. Soc. 1865, p. 285.
‡ Mam. pp. 402, 632.
§ Synopsis Mammalium, 8vo, Stuttgardiæ (1829), p. 416.

Cuvier, led him to infer that the leptorhine of Essex was identical with that of Italy. The skull presenting a *partially ossified* cloison, or bony partition between the nostrils, enabled him to amend Cuvier's definition of "R. à narines non cloisonnées" into "R. à narines demi-cloisonnées," the name *leptorhinus* being retained because "the nasal bones, notwithstanding their partial osseous supporting wall, are actually more slender than those of *R. tichorhinus*" *. The specific identity of the lower jaws found in Italy with that found in Essex is, indeed, open to considerable doubt; but, since the species of *Rhinoceros* found at Clacton is one which I have traced widely in the bone-caverns and river-deposits, and since its definition by Professor Owen has been amply verified by recent discoveries, there is every reason for the *R. leptorhinus* of Professor Owen being retained as a specific name. Its identity with the *R. leptorhinus* of Cuvier, from the conflicting evidence as to the presence of the cloison in the skull which he constituted his type, is altogether a matter of conjecture.

2. *Synonyms.*—The *Rhinoceros leptorhinus* of Professor Owen is the equivalent of the species mentioned by Dr. Falconer in his account of the Caves of Gower as *R. hemitœchus* †, an undescribed and undefined species that owes its existence to the translation of Professor Owen's definition 'à narines demi-cloisonnées' into a Greek specific name. In central France it is probably identical with the *R. mesotropus* and *R. Velaunus* of M. Aymard ‡, the *R. Aymardi* of M. Pomel §, and the *R. leptorhinus* (Du Puy) described by M. Gervais in his 'Paléontologie Française' ‖.

The species is characterized by the possession of two horns, by the partial ossification of the septum, by the slenderness of the bones, and by certain peculiarities in the dentition, which I propose to describe in the following pages. In regard to the *partially ossified* septum, it is intermediate between the tichorhine Rhinoceros, in which the ossification is complete, and the megarhine, in which, according to M. de Christol, there is no trace of a cloison. The development of this bony support for the nasals stands, as Cuvier remarked of it in the tichorhine Rhinoceros ¶, in direct relation to the horn-development; and therefore we may infer that also in respect of the size of its anterior horn it was intermediate between the two above-named species.

The dentition of two out of the four British species of Pleistocene Rhinoceros, the tichorhine and megarhine, has already been described in the 'Natural History Review' **; that of the leptorhine of Professor Owen merits a more careful examination than the rest, because of its close resemblance to that of the megarhine, and the wider range of the species in Britain than of the latter. The terms and letters rendered necessary for its accurate description are those

* *Op. cit.* p. 368.
† Quart. Journ. Geol. Soc. xvi. p. 489.
‡ Pictêt, Pal. tom. i. p. 298, sec. ed. (1853).
§ Cat. Méth. 78, 1859.
‖ Sec. edit. (1859) p. 90.
¶ *Op. cit.* p. 68.
** No. XII. (1863). No. XIX. (1865).

used to denote homologous parts of the teeth of the tichorhine and megarhine species *.

3. *Milk Dentition.*—The Hyæna-den at Wokey Hole, which has afforded a vast quantity of the remains of the tichorhine Rhinoceros, has also yielded the best examples of the milk-teeth of the leptorhine species, in two fragments of an upper and lower molar. Those in the Museums of Oxford and the Geological Society of London, from Kirkdale, are so badly preserved as to be unworthy of a detailed notice. The fragment of the upper milk-molar, consisting of the *external lamina* (fig. 1) of the second of the series occupying the right upper jaw, is remarkable for the stoutness of the pyramidal *second costa* (*k* 2), which stands out boldly above the plane of the rest of the *lamina*, and is defined basally by two well-marked folds. The *third costa* (*k* 3), also pyramidal, but very faintly defined, occupies the *posterior area* (*n*); and between their apices is a small well-defined elevation on the exterior of the crown-summit, which is probably a mere individual variation, as it occurs also in some of the corresponding teeth of the tichorhine Rhinoceros. As compared with the homologous tooth of the latter species, the leptorhine is characterized by its smoothness, its small size, and the faint definition of its *third costa*; as compared with that of the megarhine, by the presence of the *third costa*, the stoutness of the *second* (*k* 2), but especially by its small size. The average basal measurement of the *lamina* of the second upper milk-molar is in the tichorhine 1·2 inch, in the megarhine 1·35 to 1·53, in the leptorhine 0·9 inch.

The second fragment (fig. 2), consisting of the unworn germ of the third lower milk-molar, probably (from its condition) belonged to the same individual as the preceding. Its *external lamina* (*l*) is divided by a deep oblique groove (*i*) into two areas, of which

* The following is the list of the terms and letters used to identify homologous parts in the most complex of the fossil Rhinoceros teeth (those of *R. tichorhinus*), and applicable to the teeth of all the species of the genus:—

a=Anterior valley="Vallis anterior," Brandt,="Vallon oblique" in upper molars, Cuvier.

b=Posterior valley="Vallis posterior," Brandt,="Ecorchure au bord postérieur," Cuvier,="Fossette postérieure," Blainville.

c=Accessory valley="Vallecula accessoria," Brandt.

d=Anterior collis="Collis anterior," Brandt,="Colline seconde," of upper molars, Cuvier.

e=Median collis="Collis medius," Brandt,="La troisième colline" of upper molars, Cuvier.

f=Posterior collis="Collis posterior," Brandt,="Le bord postérieur de la dent," Cuvier, Blainville.

g=Anterior combing-plate, a small process of enamel springing from the external lamina and peculiar to *R. tichorhinus* among the fossil species.

h=Posterior combing-plate, a small process of enamel thrown *forward* into the anterior valley. In the tichorhine species the union of *g* and *h* cuts off *c* from *b*.

i=Median groove on the external lamina.

k=Costæ="costæ," Brandt, on the external lamina.

l=External lamina="Collis externus," Brandt,="Colline première qui suit exactement le bord," Cuvier.

m=Anterior area.

n=Posterior area.

the anterior (*m*) bears two *costæ* (*k* 1 & *k* 2), faintly divided from each other by a broad shallow V-shaped depression, while the *posterior* (*n*), tumid basally, is sloped off abruptly from the base towards the crown-summit. The presence of the *costæ* defines the tooth from the megarhine homologue, the tumidity of the *posterior area* (*n*) from the tichorhine. On the crown-surface the *anterior valley* (*a*) is more shallow than the *posterior* (*b*); and of the three *colles*, as in all the homologous teeth of the genus, the *median* (*e*) is the largest. The summit of the latter is flattened antero-posteriorly at its inner side; and the transverse bridge of enamel that joins it from the *external lamina* is traversed by a notch ending in a cleft. The result of this arrangement would be, that in the slightly worn tooth the summit of the *median collis* (*e*) would exhibit a trefoil pattern, somewhat after the fashion of the teeth of the Pig and Hippopotamus. The low crown, the smoothness of the enamel, and the small size differentiate the tooth from the corresponding one of the tichorhine species, while the latter characteristic affords an easy means of defining it from the closely allied megarhine form.

4. *Permanent Upper Dentition.*—The entire permanent series of the teeth of this species was obtained by the late Mr. John Brown, of Stanway, from the brickfields of Lexden, near Colchester, in association with remains of *Hippopotamus major* and *Elephas antiquus*, and are preserved in the British Museum. The upper-jaw teeth very closely resemble those of the megarhine Rhinoceros, but are distinguished from them by the possession of the following characteristics:—by the rugosity of the enamel surface, by the development of a *third costa* (*k* 3) on the posterior area of premolars 3 and 4, by the concavity of the base of the *external lamina* (*l*), and by the inner side of the *collis* not being sloped off so abruptly as in the former species. As compared with the tichorhine Rhinoceros, the absence of the *anterior combing-plate* (*g*), so persistent in the teeth of that animal, the height of the entrance of the *anterior valley* in Premolars 3 and 4, the comparative smoothness and thinness of the enamel, the faintness of the *costæ* on the *external lamina*, the gradual slope of the *collis* on the inner side, and the great development of the *guard*, or stout ascending ridge of enamel on the anterior surface, are the salient points upon which a specific determination can be made. Besides these, also, the most noteworthy in the jaw under consideration are the stoutness of the guard in premolars 3 and 4, and the passage of a ridge across the entrance of their *anterior valley* (*a*). The posterior wall, also, or *third collis* bears a cusp, as in the tichorhine species; but it is faintly developed and is soon worn away.

Figures 3 and 4 (Pl. X.), which I owe to the kindness of my friend Professor Phillips, F.R.S., of a right upper premolar 4, from the Crawley Rocks, near Swansea, show all the salient points of the Upper premolar dentition of the species; while fig. 5, of a second upper true molar from Peckham, is typical of the leptorhine upper true molars. We are indebted to Professor Owen for a figure of the leptorhine first upper true molar from Clacton, in 'British Fossil

Mammals,' p. 141, which does away with the necessity of figuring that tooth.

The characters of the Lexden upper molars are found also in all those of the Rhinoceros of Kirkdale. In fig. 125 of the 'British Fossil Mammals' there is a tooth from this locality figured as the deciduous upper molar of the tichorhine species. Examined, however, by the light of other specimens discovered since that great work was written, the tooth in question, preserved in the British Museum, presents characters found only in the leptorhine species. The stoutness of the guard, the bevelling off of the inner surface of the anterior and middle colles, the absence of the *anterior combing-plate,* and, consequently, of the *accessory valley,* the large size of the *posterior valley* (A of Figure) differentiate it from the tichorhine, and prove it to belong to the leptorhine Rhinoceros. A comparison of the tooth with the figures given by Professor Brandt of the permanent teeth of *R. tichorhinus*, and with those of the deciduous dentition that I have published in the 'Natural History Review,' proves conclusively that it is non-tichorhine in character. It corresponds in every respect with a right upper premolar (4) in the Oxford Museum from the same cavern. The second right upper true molar, figured by Dr. Buckland in the 'Reliquiæ Diluvianæ' (pl. 7. fig. 3), also presents characters essentially leptorhine—namely, the excavation of the base of the *external lamina,* the stoutness of the ascending *guard,* and the suppression of the *anterior combing-plate.* The tooth is very much worn; and the guard obliterated to such a degree that in the figure the section of it visible on the crown-surface presents merely a deep fold at the inner and anterior angle. The germ of a first premolar (Pm. 2), also from Kirkdale, and in the Oxford Museum, presents the peculiarity of the entrance of the *anterior valley* being completely blocked up, of the *median collis* being represented by a thin bridge of enamel crossing the crown-surface obliquely backwards from the inner to the outer side and insulating the *anterior* from the *posterior valley.* The latter, also, is larger than the former. All the remains of Rhinoceros from the Kirkdale Hyæna-den that have passed through my hands belong, without exception, to the leptorhine species of Professor Owen.

A right upper premolar (4), from the Crawley Rock Cave near Swansea, in the Oxford Museum, presents the peculiarity of having the *posterior combing-plate* (*h*, fig. 4) divided into two, as in the corresponding tooth of the megarhine species from Hérault, figured by M. Gervais (Paléont. Fr. pl. 2. fig. 4). It is figured as illustrating all the salient points in the upper dentition of the species, and not merely as a fine specimen of the last premolars. Upper leptorhine molars have also been found in two other bone-caverns in this country—in Gower, quoted by Dr. Falconer as belonging to *R. hemitœchus,* and in the cave on Durdham Down near Bristol, whence they were obtained by Mr. Stutchbury and deposited in the Bristol Museum. To the courtesy of Mr. William Sanders, F.R.S., I am indebted for their examination. They consist of the upper teeth of the left side, with the exception of premolar 2. With the following exceptions they present all the characteristics of the series obtained from Lexden, above described. Premolar 3 presents a faint cusp at the entrance of the *anterior valley* (*a*) close to the cingulum. Premolar 4 has the *posterior combing-plate* (*h*) divided into three secondary folds, as in a corresponding tooth of the megarhine species, from the Forest-bed of Cromer, preserved in the collection of the Rev. J. Gunn, F.G.S. The first upper true molar also has a small cusp at the entrance of the *anterior valley*, and has the *third collis* divided from the *second* by a shallow notch, which, being worn away at an early period in the life of the adult, is not very often seen in the upper molars.

In the river-deposits of the Thames valley a leptorhine premolar 4 and molar 2 (fig. 5) were discovered in 1862, during the main-drainage works near Peckham, on the Surrey side of the Thames, and deposited in the British Museum. The matrix proves them to have been derived from a pale-grey clay, a point which is of considerable importance as marking the relative age of the leptorhine and tichorhine species in that particular locality. The premolar is remarkable for the development of two accessory *combing-plates* from the *median collis*, and their fusion, so that two accessory valleys are mapped off. The crown is uneven, and the *third costa* (*k* 3) strongly marked. The *third collis* is notched and cuspless. The true molar differs from the ordinary type of leptorhine upper molars, and approximates to the megarhine, in the external lamina not being hollowed basally; and were it not for the unequivocal evidence of the premolar 4 that belonged to the same jaw, it would be altogether a doubtful tooth. The Lower Brick-earths of Gray's Thurrock in Essex have furnished a second instance of leptorhine remains being found in the valley of the Thames, in a first upper true molar that agrees in all essential points with that from Clacton, figured by Professor Owen (Foss. Mam. fig. 141). The most remarkable discovery, however, is that made by Mr. Antonio Brady, F.G.S., of a leptorhine skull and lower jaw at Ilford. The former is very nearly perfect, and exhibits the demi-cloison or partially ossified septum between the nares, and the entire upper molar series. It also satisfactorily settles the question of the upper dental formula, as no trace of the premolar 1 is to be found on either side. With the exception of the last upper true molar, the description of the teeth from Lexden applies to these also, the *third collis* in the leptorhine (M 3) taking the form of a small cusp on the posterior border of the tooth, while in this it takes the form of a ridge. This variation is found also in the coresponding molars of *R. tichorhinus*. A fragment of the skull of the leptorhine species obtained from the same locality, in the cabinet of Dr. Cotton, F.G.S., exhibits also the entire upper molar dentition. With the exception of premolar 2, the first of the series, all the teeth bear the *third costa* (*k* 3) faintly developed. Leptorhine upper molars have been yielded also by the brick-earth on the south side of the Thames, at Crayford in Kent, and are in the collections of Dr. Spurrill and Mr. Grantham, to whose courtesy I am indebted for their examination. A last upper true molar, figured by Mr. Trimmer in the "Philosophical Transactions' for 1833, pl. ix., agrees exactly with the homologous leptorhine tooth from Lexden in the possession of the Rev. O. Fisher, F.G.S., and proves the occurrence of that species in the brick-fields of Brentford. It is quoted by Professor Morris*, on Professor Owen's authority, as tichorhine, from which, however, it differs in all the points already enumerated. In the Museum at York I also found evidence of the *R. leptorhinus* of Owen among the remains found at Bielbecks Farm, near Market Weighton, described in the 'Philosophical Magazine' for 1809. The suppression of the *anterior combing-plate*, the large development of the *guard*, the pyramidal shape of the *collis*, and the presence of the *third costa* present a combination of characters found in that species alone. From the same deposit were obtained the remains of the Cave-lion, Wolf, Horse, Mammoth, Bison, Urus, and Red Deer.

5. *Permanent Lower Dentition.*—The upper molar series in all the species of Rhinoceros, both recent and fossil, presents characteristics which enable us to detect the species from the examination of a single isolated tooth. The lower molars, on the other hand, are so remarkably alike in all the species that this is frequently impossible. In this respect, however, the tichorhine can be differentiated from the megarhine Rhinoceros, as I have already shown in my essays on their dentition. The leptorhine lower molars differ from the tichorhine in all those points by which the megarhine are characterized. In both, the obliquity of the wear of the enamel on the outer side of the crown-surface, caused by the overlapping of the upper teeth, contrasts with the even wear of the corresponding part of the tichorhine molars. In both, the first premolar (Pm. 2) is trenchant, and the *external lamina* presents a smooth, horizontally convex surface with a faint apical depression. The *anterior valley* is faintly impressed, the *posterior* is extremely shallow. In premolars 3 and 4 the *median groove* traverses the base of the *external lamina*. The leptorhine lower molars can, however, be differentiated from the megarhine by the coarser enamel-sculpture, and especially by the flattening of the *anterior area* (*m*) of the *external lamina*. These characteristics are found in all the lower teeth of *R. leptorhinus* which have been derived from the bone-caverns of Kirkdale or Durdham Down, and in all those which have been found in association with upper teeth in river-deposits, as in those figured by Professor Owen from Clacton and Walton, in Essex (Foss. Mam. figs. 12–136). Some non-tichorhine lower jaws, however, I am unable to assign with certainty to the leptorhine, megarhine, or Etruscan species.

The differences which Professor Owen notes between the lower teeth of the leptorhine and tichorhine species do not apply to their permanent dentition,—the lower rami of the latter species from Lawford and Thame, in the Oxford Museum, containing the milk-series, while the lower rami of the former, with which they are compared, present us with the permanent. While fig. 136 (*op. cit.*)

* Quart. Journ. Geol. Soc. vol. vi. p. 204.

is a most accurate figure of the leptorhine premolar 2, fig. 137 represents the first and second milk-molars, instead of the first and second premolars (Pm. 2 and 3) of the tichorhine Rhinoceros. In my essay on the latter species full evidence is given for this conclusion. In the lower jaw, figured by Professor Owen, from Clacton, the symphysis extends as far back as the middle of premolar 3.

A remarkably fine lower jaw from Lexden, containing the entire permanent set of teeth, with the exception of premolar 2, belongs to the same individual as the upper teeth from that locality described above.

The brickfields of Ilford, which have furnished the most perfect head of the leptorhine Rhinoceros, have yielded also numerous lower jaws belonging to the same species. One, in the possession of Mr. Antonio Brady, F.G.S., consisting of both rami, shows the spatulate termination of the jaw. On the rectangular area, anterior to the first premolars (premolars 2), formed by the horizontally flattened symphysial portions of the rami, are small depressions on the outer border, which probably are traces of embryonic incisors and canines. Several remarkably fine lower rami from the same locality are also in the collection of Dr. Cotton, F.G.S.

6. *Dental Formula.*—Although we have no absolute evidence as to the number of the milk-teeth of *R. leptorhinus*, the fact that in all the cases in which the milk-dentition of the genus *Rhinoceros* has been examined, it consists invariably of four teeth on either side of both jaws, leaves no room to doubt that this extinct species also possessed the same dental formula: $\frac{\text{Dm } 4}{\text{Dm } 4}$.

An examination of the entire dental series of the upper and lower jaws derived from the brick-earths of Lexden and Ilford prove that, like the tichorhine and Etruscan species, the permanent dental formula of the leptorhine was

$$\frac{\text{I. } 0 \quad \text{C. } 0 \quad \text{Pm. } 2.3.4 \quad \text{M. } 1.2.3}{\text{I. } 0 \quad \text{C. } 0 \quad \text{Pm. } 2.3.4 \quad \text{M. } 1.2.3}.$$

7. *Measurements.*—The measurements taken at the base of the crown, in inches and tenths, are uniform with those of the preceding essays on the tichorhine and megarhine dentition. They are:—

1. Antero-posterior, taken along the outside of the crown.
2. Antero-transverse, taken across the anterior lobe of the tooth.
3. Postero-transverse, taken across the posterior lobe of the tooth.

A comparison of the Tables of the leptorhine and megarhine measurements proves that the teeth of the former are, on the whole, smaller than those of the latter.

TABLE OF MEASUREMENTS.

Permanent Upper Dentition.

Locality.	Tooth.	1	2.	3.
Lexden (Brit. Mus.)	Pm. 2	1·15	1·4	1·4
	Pm. 3	1·4	1·75	1·7
	Pm. 4	1·51	2·1	1·92
	M. 2	1·93	2·33	2·05
	M. 3	2·51	2·12	0·0
Lexden (Rev. O. Fisher)..........	Pm. 2	1·15	1·19	1·28
	Pm. 3	1·26+	1·68	1·8
	Pm. 4	1·35+	2·0	1·81
	M. 3	2·2	2·1	....
Ilford (A. Brady, F.G.S.)	Pm. 2	1·25	0·0	0·0
	Pm. 3	1·51	2·05	2·05
	Pm. 4	1·7	2·4	2·35
	M. 1	1·88	2·55	2·4
	M. 2	2·25	2·73	2·5
	M. 3	2·63	2·55	1·7
Clacton (fig. 141 of Foss. Mam.) ..	M. 1	1·75	2·21	2·70
Grays Thurrock (Brit. Mus.)......	M. 1	1·6	2·01	1·98
Peckham (Brit. Mus.)............	Pm. 4	0·0	2·45	2·1
	M. 2	1·95	2·55	2·32
Durdham Down (Bristol Mus.).....	Pm. 3	1·4	1·98	1·83
	Pm. 4	1·6	2·28	2·15
	M. 1	1·73	0·0	2·32
	M. 2	2·1	2·7	2·3
Bielbecks Farm (York Mus.)	M. 2	2·24	2·62	2·22

Permanent Lower Dentition.

Locality.	Tooth.	1.	2.	3.
Lexden (Brit. Mus. 37405)........	Pm. 3	1·1	0·82	0·82
	Pm. 4	1·3	0·9	0·94
	M. 1	1·51	1·08	1·0
	M. 2	1·73	1·08	1·1
	M. 3	1·61	1·05	1·08
Ilford (A. Brady, F.G.S.)	Pm. 2	0·99	0·75	0·75
	Pm. 3	1·24	0·88	0·98
	Pm. 4	1·42	1·06	1·18
	M. 3	1·85	1·26	1·26
Clacton (Brit. Mus.)	Pm. 2	1·08	0·6	0·79
	Pm. 3	1·3	0·8	1·05
	Pm. 4	1·48	1·0	1·21

8. *Range in Britain.*—Of the four British species of Rhinoceros, the tichorhine is confined to the Postglacial deposits, and occurs in them throughout Britain, France, Germany, and Northern Russia. The megarhine, on the other hand, abundant in the Pliocene deposits of the Val d'Arno and of central France, has a limited range in this country, being confined to the brick-earths and gravels which occupy the lower part of the Thames valley, and which, from their position beyond the edge of the Boulder-clay, are of equivocal age,

and to the Preglacial Forest-bed on the Norfolk Coast. The fauna, indeed, of the former is more Preglacial than Postglacial in character, and differs from that of any other British river-deposit. The discussion of the Etruscan species we must reserve for a future essay. The range of the fourth, or *R. leptorhinus* of Professor Owen, is worthy of a most careful analysis, because of a current idea that it characterizes an epoch anterior to that of the Mammoth and tichorhine Rhinoceros. In the caverns of Gower*, ably described by Dr. Falconer, it is mentioned (under the name of *R. hemitœchus*) as being found in Minchin and Boscoe's Holes in association with *Elephas antiquus*, which latter species is particularly abundant in the Pliocene deposits of Italy, and in Preglacial British deposits. In Kirkdale Cavern, again, it occurred in association with *Elephas antiquus* and *Hippopotamus major*; and in the cave on Durdham Down the same three species were found associated by Mr. Stutchbury. Are we, then, to infer the Pleistocene deposits in which *Rhinoceros leptorhinus* occurs to be of higher antiquity than those from which it is absent? The evidence afforded *by the association* of organic remains in other localities seems to me incompatible with any such view. In the brick-earth at Ilford, for example, it is found in association with

Felis spelæa.	Elephas antiquus.
Canis lupus.	—— primigenius.
Ursus spelæus.	Equus fossilis.
Bos primigenius.	Rhinoceros megarhinus.
Bison priscus.	Castor Europæus.
Cervus elaphus.	Arvicola amphibia.

From the Hyæna-den of Wokey Hole I have also obtained the leptorhine Rhinoceros under circumstances that do not admit of doubt as to its being of the same relative age as the other animals found in the cave. It was associated with

Homo.	Canis lupus
Felis spelæa.	—— vulpes.
Hyæna spelæa.	Meles taxus.
Ursus spelæus.	Cervus elaphus.
—— arctos.	—— tarandus.
Bison priscus.	Elephas primigenius.
Bos —— ?	Equus fossilis.
Megaceros Hibernicus.	Rhinoceros tichorhinus.

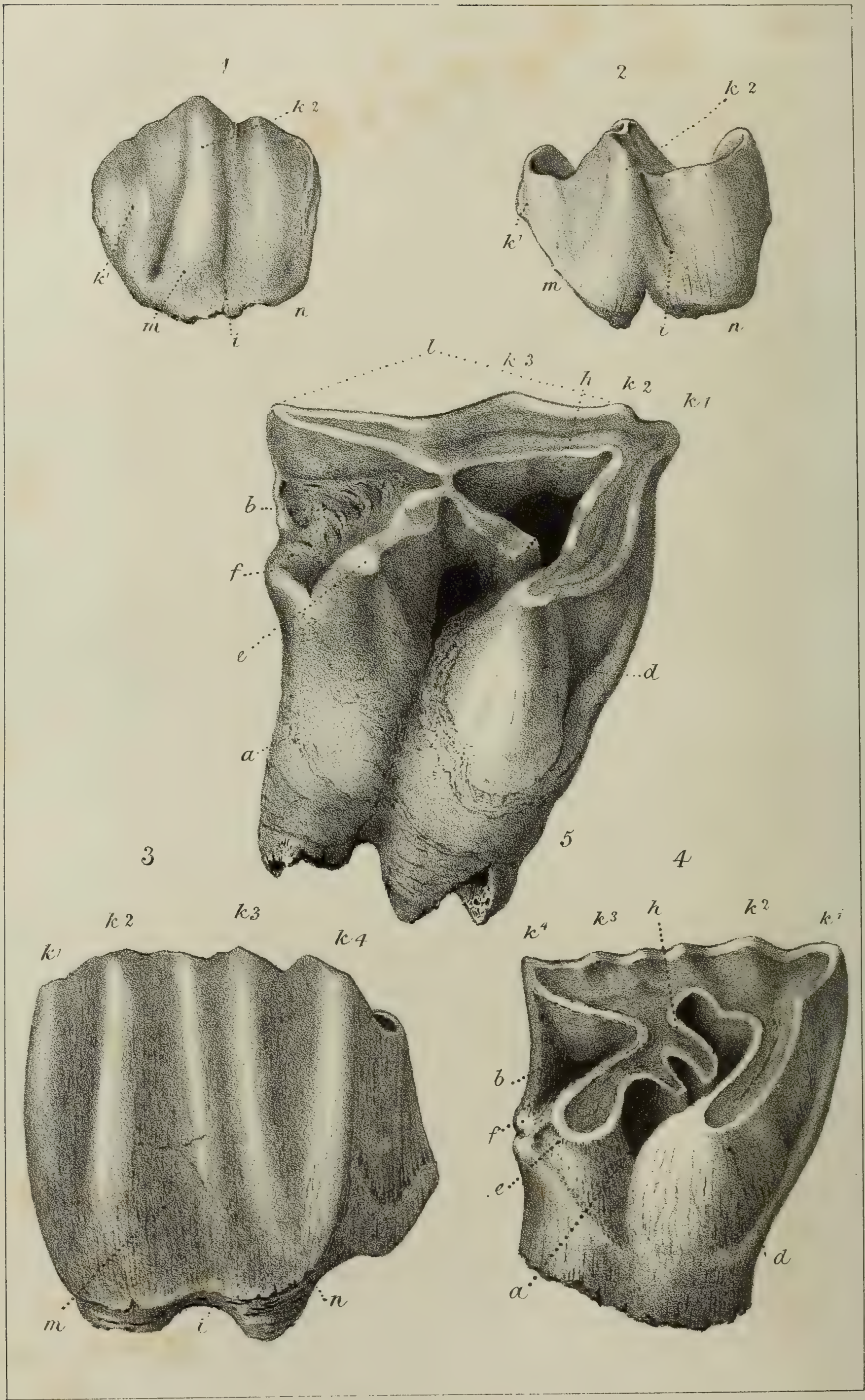
In both these cases it is found side by side with nearly the whole of the species which characterize the British Pleistocene period—*Elephas primigenius*, *Rhinoceros tichorhinus*, the spelæan Bear, Lion, and Hyæna. In the first, the leptorhine carcasses were borne down by the floods along with those of the other animals, and covered up by the silt or brick-earth which those floods deposited at Ilford. In the second, a young individual of the species happened to fall a prey to the Hyænas of Wokey Hole, and its remains have been preserved along with those of the other victims of different species that lived in the same Geological Epoch. A third instance of its occurrence,

* Quart. Journ. Geol. Soc. vol. xvi. p. 489.

at Peckham, places its relative age beyond all doubt. For the particulars of its "gisement" I am indebted to Mr. Davis, of the British Museum. In the construction of the sewer at Rye Lane, near Peckham, in 1862, the following strata were cut through:—

Vegetable soil.
3. Sandy gravel, 3 to 4 feet.
2. Light banded clay, 10 to 12 feet.
1. Peat, containing fragments of trees.

The remains obtained from the light clay, and preserved in the British Museum, comprise the incisor and canine of *Hippopotamus major*, the humeri of *Bos urus* and *Bison priscus*, the antler of a Deer, and two teeth and a tibia of *Rhinoceros leptorhinus*. The matrix still adherent to the specimens proves conclusively that they were derived from the pale-grey clay (2). From the peat which underlies, and which therefore is older than, the clay, was obtained the fine series of teeth of *Rhinoceros tichorhinus*. The deep-black colour of these, places the fact of their having been imbedded in the peat beyond all doubt. In this particular case, then, the remains of the tichorhine were deposited in the peat (1) before those of the leptorhine species in the clay (2). Had there been no other evidence of the date of the latter, this section might have been cited to prove that the leptorhine was of more modern date than the tichorhine Rhinoceros. Checked by other discoveries, it is a warning against too hasty generalizations. The sum, indeed, of the evidence of the range of the species, both in space and time, is simply this:—While it is perfectly true that in several instances the species has been found associated with the Pliocene *Elephas antiquus* and *Hippopotamus major*, as in the caves of Kirkdale, Durdham Down, and Gower, and in the Lexden Brickfields, the most common and characteristic Pleistocene mammals being absent, viz. the Mammoth and tichorhine Rhinoceros, its occurrence, in the Hyæna-den at Wokey and in the brick-earth of Crayford, with these latter two species forbids the hypothesis of its characterizing an epoch *anterior to the spread of these animals over Britain*. The "gisement" of the remains of Rhinoceros at Peckham would prove that, in some particular places, the leptorhine was imbedded in deposits of absolutely later date than the tichorhine species. At Brentford it is associated with Reindeer, and at Bielbecks with Cave-Lion and Mammoth. Whether or not, like the *Hippopotamus major* and *Elephas antiquus*, it lived in Pliocene times, and can be viewed as an animal that lingered on into the Pleistocene, is altogether an open question, as its correlation with the continental species is by no means satisfactorily decided. There is no proof of its having inhabited Preglacial Britain, as the remains from the Forest-bed on the Cromer shore in the collection of Mr. Fitch, of Norwich, ascribed by Professor Owen to *R. leptorhinus*, viewed by the light of other remains in the cabinets of the Rev. S. W. King and the Rev. J. Gunn, belong to the new and undescribed Pliocene species the *Rhinoceros Etruscus* of Dr. Falconer. In a word, the localities in Britain in which *Rhinoceros leptorhinus* has been found, and its association with other spe-



G. De Wilde, lith. M & N. Hanhart imp.

RHINOCEROS LEPTORHINUS, *Owen.*

and tichorhine Rhinoceros, that it had an extended range from Yorkshire, through the eastern counties, into South Wales and the south-west of England, that it was very much inferior to those species in point of numbers, and, lastly, that it lived in the valley of the Thames along with *R. megarhinus* and *Elephas priscus*, and throughout its British range with *Hippopotamus major*.

9. *Living Representative Species*.—The living species that most closely resembles the extinct leptorhine is the bicorn Rhinoceros of Sumatra (*R. Sumatranus*). They agree in the suppression of the *anterior combing-plate* (*g*), so persistent in the tichorhine species, in the excavation of the base of the *external lamina*, in the presence of a *third costa* (*k* 3) in the upper premolar series, in the presence of a cusp on the *third collis* (*f*), in the stoutness of the guard, and the pyramidal shape of the *colles* (*d*, *e*, *f*). They differ in that in the Sumatran species the *posterior combing-plate* (*h*) is suppressed, and the guard is feeble in the upper premolars. A reference to the analysis of the dental peculiarities of the other existing species of Rhinoceros in the article on the megarhine Rhinoceros obviates the necessity of its repetition in this place. The dentition of the tichorhine agrees with that of the leptorhine Rhinoceros remarkably in one point, that it is more specialized, or, in other words, more closely allied to that of living species than the megarhine,—a fact that seems to me to indicate that both came into being after the less specialized *R. megarhinus* had existed for some time upon the earth.

EXPLANATION OF PLATE X.

Fig. 1. Right upper milk-molar 2, nat. size. Wokey Hole.
2. Left lower milk-molar 3, nat. size. Wokey Hole.
3., 4. } Right upper premolar 4, nat. size. Crawley Rocks.
5. Upper true molar 2, nat. size. Peckham.

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3. *On the* Strata *which form the* Base *of the* Lincolnshire Wolds. By John W. Judd, Esq., F.G.S.

Contents.

I. Introduction.

That the geology of Lincolnshire has been generally neglected is perhaps easily accounted for when we consider the difficulties of observation in this district, arising from the absence of sea-cliffs, the paucity of good inland sections, either natural or artificial, and the enormous development of the superficial deposits. This neglect, however, is much to be regretted, as a careful study of the strata of this county, besides revealing many phenomena of great intrinsic interest, is calculated to afford much assistance in working out the mutual relations of the remarkably different sections of Yorkshire and the south of England. It is in the hope of contributing some materials towards the solution of this important geological problem that the present paper has been prepared.

The only previous notices of the district described in this essay, which I have been able to discover, are as follows:—

A paper* written by Mr. Bogg, in the year 1816, at the suggestion of Dr. Buckland, gives a tolerably correct account of the succession of beds lying to the west of Louth. Unfortunately, however, the author, relying on mineralogical characters only, was betrayed into the mistake of supposing the highly bituminous, slaty, and shaly beds of the Bain valley to be part of the Coal-measures, and, like many others before and since his time, spent considerable sums in boring for beds of coal in Lincolnshire.

In 1820 the district was examined by Professor Phillips †, who was then assisting William Smith to complete the Geological Map of England; and a few passing allusions to it occur in the 'Geology of Yorkshire' (1829) ‡.

In 1837 Messrs. W. H. Dikes and J. E. Lee published a short but very accurate account of the Geology of Nettleton Hill §. In this paper some of the extremely interesting features in the physical geology of this district are clearly described, and lists of the fossils from each of the beds are given. Mr. Lee also constructed a very excellent model of the country round the hill (including a space 4 miles in length by 3 in width), founded on a great number of barometrical observations made by himself ||.

Lastly, the second edition of Phillips's Manual of Geology (1855) contains a short *résumé* of all that was then known on the subject ¶.

The very few statements, referring to this district, which are scattered through various other geological papers are vague, and often contradictory, from the want of recognition of an important fact (to cies, oblige me to conclude that it was coeval with the Mammoth

* "Outlines of the Geology of the Lincolnshire Wolds," Trans. Geol. Soc. 1st series, vol. iii. p. 392.

† Memoirs of William Smith.

‡ Pages 44 &c.

§ Mag. Nat. Hist. 2nd ser. vol. i. (1837) p. 561. I am indebted to Prof. Phillips for calling my attention to this very valuable paper, which I had unfortunately overlooked.

|| This model is in the Museum of the Literary and Philosophical Society of Hull.

¶ *Vide op. cit.* p. 352.

which special attention will be directed in the present communication), namely, that there are several beds of red chalk in this county, in some localities of very similar lithological character, and only distinguishable by a careful examination of their fossil contents. Still further confusion has arisen, in other instances, from mistaking a series of limestones, ironstones, and clays which present in places a very marked oolitic structure, but which are of undoubted Neocomian age, for part of the Jurassic formation.

In the attempt to unravel the somewhat complicated geology of this district, the best clue is afforded by the remarkable beds for which Mr. Seeley has proposed the name of the "Hunstanton Limestone"*; and my first systematic efforts were directed to a careful mapping of the outcrop of this stratum across the county. Throughout the district now under consideration it serves as an excellent datum line, the relations of the other beds to which can usually be determined. Owing also to a combination of very pronounced lithological characters with a most distinct and characteristic assemblage of fossils, it can be traced with comparative ease wherever the country is not too thickly covered with drift; and although it is of no great thickness, its position between the Chalk and the Neocomian formations invests it with much interest. The following pages will be devoted to a description of the Hunstanton series as developed in Lincolnshire, with a more general account of the strata which lie respectively above and below that series.

II. The Hunstanton Limestone.

a. *Outcrop of the series in Lincolnshire.*—The only localities of these beds in this county, hitherto recorded, are South Ferriby†, Louth‡, and Brinkhill§. It will be seen in the sequel that the red beds at the second of these places do not belong to the Hunstanton series, no outcrop of which occurs within five miles of that town.

The section at Hunstanton is so well known, and has been so frequently described, that it will not be necessary for my present purpose to do more than call attention to one or two facts concerning it. The bed of red limestone is at this place 4 feet in thickness, and is divided by very distinct planes of stratification into three nearly equal courses. The lowest of these courses graduates into the "Carstone" beneath, while the upper one is separated by a variable seam of red clay from the "Sponge-bed," a layer of hard white chalk, 15 to 18 inches thick, and full of the so-called "*Spongia paradoxica*;" there is never any appearance of gradation in colour between the red and the white beds.

The most south-easterly point in Lincolnshire at which I have succeeded in detecting this series of beds, is a pit in a field on the right-hand side of the road leading from Gunby to Welton-

* Ann. & Mag. Nat. Hist. 3rd ser. vol. vii. p. 233.

† Wiltshire, "On the Red Chalk of England," Geologist, 1859, p. 267.

‡ *Ibid.* p. 268. Seeley, "On the Red Limestone of Hunstanton," Ann. & Mag. Nat. Hist. April 1861.

§ Wiltshire, "On the Red Chalk," where the name is misprinted "Brickhill."

le-Marsh. This spot is distant, in a direct line, exactly 20 miles from the cliff-section at Hunstanton; and near it the Chalk strata sink under the great mass of Boulder-clay and other Drift which form the substratum of the Lincolnshire marsh.

The succession of beds in this pit is as follows:—

1. Chalk-rubble.	
2. Grey, somewhat arenaceous chalk, containing innumerable fragments of *Inocerami* .... (This bed exactly resembles that at Hunstanton, which Mr. Rose has identified with the *Chalk-marl**.)	2 to 3 ft.
3. Sponge-bed .... Resembling in every respect the corresponding bed at Hunstanton, except that here it shades into a yellow colour at its lower half.	1 ft. 6 in.
4. Red clay..	less than 1 inch.
5. A course of light-coloured yellow and pink chalk, containing a very few specimens of *Belemnites minimus*, Mill.	1 ft. 6 in.
6. Dark-red chalk, like that of Hunstanton, in courses, with red-clay bands between them. *Belemnites minimus*, Mill., very abundant.. The bottom of this bed is not seen in this pit. The dip of the beds is about 5° E., but increases near a fault which, running E. and W., throws down the beds on the S. about 3 feet.	3 ft. to bottom of pit.

Less than half a mile west of this point, in a large chalk-pit on the road from Burgh-le-Marsh to Skendleby, occurs a second exposure of these beds. Here we have a considerable thickness of the white chalk exposed, containing fossils, among the most abundant of which are *Discoidea cylindrica*, Lam., *Holaster subglobosa*, Leske, sp., *Terebratula biplicata*, Sow., var., *T. obesa*, Sow., *Rhynchonella Cuvieri*, D'Orb., *Inoceramus Cuvieri*, Sow., *Ammonites Mantelli*, Sow., and teeth of *Lamna*. The lower part of the white chalk consists of dark-coloured sandy courses with innumerable fragments of *Inoceramus*. In these I found a specimen of *Ammonites peramplus*, Sow., 1 ft. 9 in. in diameter. They are succeeded by the sponge-bed, white in its upper part and yellow below, which is separated by a parting of red clay from two beds called by the workmen the "yellow course" and the "pink course." These last are underlain by the "blood-red courses" full of the characteristic Hunstanton fossils,—*Belemnites minimus*, Mill., *Terebratula biplicata*, Sow., and fragments of large *Inocerami* being especially numerous. This pit does not pass through the red chalk.

Above the village of Candlesby there are several pits in which the red chalk is seen, containing the characteristic Hunstanton fossils. The succession of beds in these pits agrees in every respect with that described in the last two sections. In making some lime-kilns here the red chalk was passed through, and the brown sands below exposed. At Welton mill, too, a well sunk to the depth of 120 feet, through white and red chalk, also reached the sands. From information which I received concerning both these works, I con-

* "On the Cretaceous Group in Norfolk," Proc. Geol. Ass. 1862.

clude that the thickness of the red beds at this place is from 12 to 14 feet.

A precisely similar succession of beds is seen in several chalk-pits near Grebby Mill. In the largest of these pits, the supposed representative of the "chalk-marl" may be well studied; for under the hard chalk ("blue courses" of the workmen) we have 5 feet of "grey courses" almost made up of fragments of *Inocerami* and other shells. *Echini* are very numerous, and *Terebratula obesa*, Sow., and *Rhynchonella Cuvieri*, D'Orb., tolerably abundant. The Hunstanton beds here present no new feature. There are also at this place several pits in the sand below the red chalk, which is seen to be coarse, and of a greenish or yellowish-brown colour, or ash-grey, with brown seams running horizontally through it.

The red chalk is seen in a road-cutting by Grebby Hall, and can be easily traced to Skendleby, running round the sides of a valley formed by a tributary of the river Steeping. A well at Skendleby furnished the following section:—

1. Rubble and white chalk	6 ft.
2. Red chalk	14 ft.
3. Brown sands in which the springs arise.	

Along the hillsides north-westward from this place the outcrop of the red chalk can be easily traced, as it forms a ridge above the steep slopes of sand.

Between Dalby and Langton there are two pits, which together furnish a most useful section of the beds of this district: in the one is seen the white and grey chalk, followed by the sponge-bed, the yellow and pink courses, and the upper beds of the dark-red chalk; in the other we have the lower beds of the red chalk, with about 30 feet of the sands below. The lowest course of the red chalk is here seen to be very argillaceous, and contains small shining black and brown pebbles, thus graduating into the sands below, exactly as at Hunstanton.

Above Sutterby is a small pit of white chalk, in which the red beds are thrown up for a breadth of 9 feet by a double fault.

On the slope of Harrington-hill, and in several openings above Brinkhill and Driby, the Hunstanton beds may be again seen and their fossils collected. North of these places, the Wolds are cut through by a stream flowing to the north-east and called the Withern Eau. The sides of the valley thus formed are so covered with superficial deposits that the position of the red chalk can be given only approximately; indications of it, however, are seen near the hamlet of Ruckland, and all round the sides of the deep longitudinal and tributary valley which runs up to Oxcomb. Near South Ormsby we again recognize the Hunstanton beds by their marked lithological features and characteristic fossils, and can trace them thence round Holster Dale to Tetford Hill, where they are well seen in a road-section, with the sands below them. Aided by numerous openings, of greater or less extent, combined with the very marked surface-contour of the district, the extremely irregular line of the red chalk outcrop may be traced above Belchford and Scamblesby, and along the whole eastern side of the Bain valley as far as the village of Biscathorpe. Along this line, and indeed wherever the sands are soft, the red chalk forms a steep escarpment; and the position of the various beds is very distinctly indicated: the white chalk forms sheep-walks or arable land; the red chalk is frequently covered with plantations; and the sands below form rabbit-warrens. The pits on this line, where the succession of the beds of this series may be best studied and their fossils collected, are those at Red Hill Kiln, Pan Holes Lane, Nob Hill, and one on the slope of the hill above Donnington. At the second-mentioned of these localities the whole series is seen at once, and its thickness can be measured; inclusive of the sponge-bed, it is 14 feet, the dip of the beds being 3° E. Along the whole of this line the Hunstanton beds maintain a great uniformity of lithological character, as well as of thickness. Everywhere we find the top of the series formed by the sponge-bed, which graduates in colour into the yellow and pink courses; and these are followed by a number of courses, each 12 to 15 inches thick, of the nodular dark-red chalk, the lowest course graduating into the sand. The upper beds of the series contain *Spongia paradoxica*, Woodward, *Terebratula biplicata*, Sow., and large *Inocerami* in great abundance, while *Belemnites* are comparatively scarce. The lower portion of the series, on the contrary, abounds with the different varieties of *Belemnites minimus*, Mill., while the first-mentioned fossils are of comparatively rare occurrence.

The red chalk is seen running along both sides of the deep and narrow valley called Welsdale Bottom, which is cut through the Lower Chalk into the sands below, and opens into the valley of the Bain at Gayton-le-Wold.

The river Bain is formed by the junction of two small streams, one rising at Ludford, and the other near Kelstern; and in the sides of the narrow and tortuous valleys formed by these streams, the red chalk can at short intervals be traced.

The line of outcrop of the red chalk on the west of the Bain valley is hidden by enormous masses of Drift, consisting principally of white chalk-rubble with flints; pits from 20 to 30 feet deep occur in this rubble, which is extensively dug for lime-burning. At the top of the valley, which runs by South Willingham, however, we again find the Hunstanton limestone, as also in a pit at the Heneage Arms Inn. In this district the red chalk is used for "marling" the land, and the pits dug in it for that purpose enable us to trace its outcrop along the brow of the Wolds, above North Willingham, Tealby, and Walesby, beyond which last place it makes a circuit round a valley formed by a tributary of the Ancholme, and runs in a very irregular line northwards, forming the boundary between the smooth chalk hills and the rugged cliffs of clay, limestone, and ironstone. Thus it is seen above Nettleton (near which place it apparently attains its highest elevation in this county), and again in the lower part of the town of Caistor, beyond which it has been traced and mapped as far as Grasby. At this place the escarpment, of which the red chalk forms the summit, has declined very greatly in height; and proceeding northward we find it so covered by a talus of chalk rubble that the outcrop of the Hunstanton series is for the most part hidden. Its presence, however, is sufficiently proved by the occurrence, in the lower part of the talus, of fragments of red chalk, sometimes in considerable quantities; these not unfrequently contain the characteristic fossils. A well dug near the church, at Barnetby-le-Wold, reached a bed of red chalk, which I have little doubt is part of the Hunstanton series, although in the very few fragments visible at the time of my visit I failed in my search for fossils. Where the talus is cut through by streams, the red chalk is brought to light; thus, in the sides of the valley in which Elsham is situated, there are several exposures of the beds, which are seen to have the usual characters. Between Elsham and Worlaby also the outcrop can be traced; and at the last-mentioned place we have a very good section. It cannot be ascertained if the sponge-bed be present here; but the yellow and pink chalk is seen with the dark-red beds below, full of the usual fossils. This is the most northern point in Lincolnshire at which I have succeeded in detecting the Hunstanton series, the slopes of the Wolds to the north of this place being covered with thick masses of chalk-rubble. At South Ferriby I did not succeed in finding the Hunstanton beds; but in the Museum of this Society is the following note attached to some rock-specimens:—"Section at South Ferriby, near the Humber, Lincolnshire, W. L." (William Lonsdale?).

"1. White chalk."
"2. Gritty chalk (specimen *a*)."
"3. Red chalk (specimen *b*)."
"4. Blue clay."

2. has the appearance of belonging to the "sponge-bed."

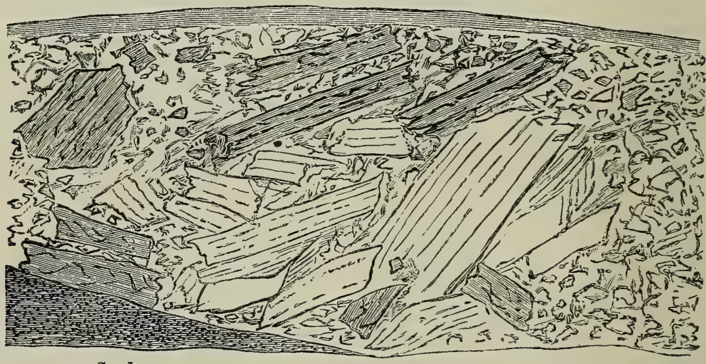
3. contains several specimens of *Belemnites minimus*; it is not of a very deep colour, and probably came from one of the upper courses of the red Hunstanton limestone.

Besides the main line of outcrop which has been thus minutely described, the same beds are seen in several outliers and inliers on either side of it.

b. *Outliers.*—On Cloven Hill and the hill to the west of Ormsby Wood, as also on Gaumer Hill, occur outliers of considerable size, composed of white chalk, with the Hunstanton limestone lying below it. On Cawkwell Hill, and perhaps also on the hill behind Tetford Parsonage, smaller ones, consisting only of the red beds, are seen. Many other hills in the neighbourhood of these might be thought from their forms to be capped by beds of solid chalk; but on close examination their summits are seen to be composed of a very remarkable drift, consisting of chalk-rubble with flints and sand, and enclosing great masses of white chalk, with large slabs from the sponge-bed and the different red layers of the Hunstanton limestone. A sketch of a pit in this drift is given in fig. 1.

c. *Inliers.*—To the north of the narrow valleys described as being formed by the sources of the Bain, a number of small streams take their rise on the *eastern* side of the ridge of hard chalk which forms the watershed of this district, and flow in a north-easterly direction into the North Sea and the Humber. These streams have cut themselves deep and narrow valleys quite through the chalk into the sands and stone below, forming a very peculiar and interesting feature in the physical geography of this part of the county. The flat bottoms of these valleys are composed of the limestone-beds, usually thickly covered with alluvium: somewhat steep but low escarpments, composed of the Hunstanton series and the sands below it, run round the sides; while rounded chalk-hills rise, often to a great height, above. This interesting phenomenon of the occurrence of inliers of the Lower Cretaceous rocks in the midst of the chalk wolds, which has not, I believe, been described as occurring in any other part of this country, may be well seen in the deep valleys in which are situated the villages of Stainton-le-Vale, Thoresway, Rothwell, and Caborn.

Fig. 1.—*Section of Drift in a pit between Belchford and Scamblesby.*



d. *General Remarks on the Hunstanton series in Lincolnshire.*—From the above descriptions it will be seen that the Hunstanton series, as displayed in this county, presents a most remarkable similarity in lithological characters to those of the typical section of these beds at Hunstanton cliff. The chief points of difference are as follows:—

1. The thickness of the series, which, including the sponge-bed, is in Norfolk little more than 5 feet, in Lincolnshire appears to be 14 feet and upwards.

2. While in Norfolk the white sponge-bed always forms a marked contrast in colour to the red beds below, in Lincolnshire there is always an almost perfect gradation in colour, the sponge-bed being yellow in its lower part, and the yellow and pink courses being interposed between it and the deep-red courses below.

Thus it would appear that this series of rocks, which about twelve miles south of Hunstanton altogether thins out and disappears*, has already at that place become much contracted in thickness. The

* Rose, "On the Cretaceous Group in Norfolk," Proc. Geol. Assoc. 1862.

thickness of that portion of the Speeton section which I regard as belonging to the Hunstanton series is about 30 feet; and we have thus indications of a regular attenuation of these beds southwards, until they finally disappear near Lynn.

e. *Fossils of the Hunstanton series in Lincolnshire.*—While these beds do not afford a great number of *species*, that of *individuals* is remarkably large. In the following list are the names of all the species I have observed during my survey of the line of outcrop. It will be seen to be smaller than the corresponding list from Hunstanton; but it must be recollected how thoroughly the latter locality has been explored. With the exception of an *Avicula*? an *Ostrea*, and some specimens too obscure for description, the whole of the fossils in this list have been already recorded from Hunstanton.

List of Fossils from the Hunstanton Series of Lincolnshire.

Spongia paradoxica, *Woodw.*
Apiocrinites rugosus, *D'Orb.*
Cardiaster suborbicularis, *Defr.*, sp.
Serpula irregularis.
Vermicularia elongata, *Bean, MS.*
Terebratula biplicata, *Sow.*
—— biplicata, var. Dutempleana, *Dav.*
—— semiglobosa, *Sow.*
—— capillata, *D'Arch.*
Ostrea, sp.
Exogyra, sp.
Inoceramus Coquandianus, *D'Orb.*
—— Crispii, *Goldf.*
—— tenuis, *Mant.*
Avicula or Lima (spec. nov.?).
Belemnites minimus, *Mill.*
—— Listeri, *Mant.*
—— attenuatus, *Sow.*
—— ultimus, *D'Orb.*
Nautilus simplex, *Sow.*
Jaws of Ichthyosaurus campylodon, *Carter.*

The locality of this last fossil is somewhat doubtful; but it was certainly from either the sponge-bed or the lowest portion of the Chalk-marl.

The presence of perforated shells in this as well as the Louth red chalk would appear to indicate the existence of Carnivorous Gasteropods, though no shells of them have been found. The guards of *Belemnites minimus* are not unfrequently found bored by mistake.

III. The Beds above the Hunstanton Limestone.

a. *General Remarks on the Chalk of Lincolnshire.*—The time has not yet come for separating the great mass of the chalk-formation in this county into zones characterized by their peculiar assemblages of organic life. Indeed such a task has not been accomplished in the case of the best-explored districts of the chalk, except in a very imperfect manner. On the other hand, every geologist who has examined this formation over any considerable area, must be convinced of the futility of basing any classification on mere lithological characters, such as the occurrence of layers of flint, or the modifications of the chemical and mineralogical characters of certain beds by the admixture of varying quantities of argillaceous, siliceous, or ferruginous matter with the always predominating calcareous basis in these rocks. Illustrations of this statement occur plentifully in the district at present under consideration: thus it is certain that the first appearance of layers of flint in ascending the chalk series in this county cannot be correlated with any particular palæontological zone; and in fact they descend to a much lower level in the series in the north than they do in the south of the county. Nor do these facts differ from what might be our previous anticipations, when we reflect that many of the chemical and mineralogical characters of these beds must have been acquired, not at their original deposition, but during their subsequent "metamorphism." It may, however, be safely asserted that distinct zones of life are to be traced in the Lincolnshire chalk, and that, during the enormous period occupied by its deposition, the fauna of the district underwent numerous and important changes—changes which cannot, as in some cases, be accounted for on the ground of variation in physical conditions, as the remarkable uniformity of lithological characters in the whole series indicates a corresponding permanence in the conditions under which the beds were deposited. The work of identifying and accurately defining these zones, however, can only be attempted when extensive and carefully formed collections of the chalk fossils shall have been formed, which in Lincolnshire has been scarcely commenced. Under these circumstances, the remarks which I can offer upon these strata must necessarily be of a somewhat general and superficial nature; and I shall in a great measure confine my attention on the present occasion to a description of the various beds of red chalk which occur in the series and which have been mistaken for the Hunstanton limestone, and to a determination of their true position on palæontological and stratigraphical evidence.

Attention has already been called in the first part of this paper to the fact that in the southern part of this district we have, lying directly upon the Hunstanton series, beds of arenaceous chalk full of fragments of *Inocerami*, and of precisely similar character and appearance with the beds at Hunstanton and other places in Norfolk, in which Mr. Rose has detected *Turrilites tuberculatus*, Sow., *Pecten Beaveri*, Sow., and *Ostrea carinata*, Lam., and which he has consequently described as Chalk-marl *. The same fossils occur in the equivalent bed in Lincolnshire.

Above this stratum we have, as in west Norfolk, a great thickness of hard chalk, destitute of flints, the different beds of which present considerable variation in chemical and physical characters. This stone, as in Norfolk, has been extensively employed as a building-material, and even for the purpose of sculpture. Thus a great part of Louth Abbey, erected in the twelfth century, is constructed of this material; and it is a noteworthy fact that, while some of the stones have decayed and fallen almost to powder, others have as sharp edges, and exhibit the tool-marks as perfectly, as if but yesterday brought from the quarry. Probably by exercising care in the selection of particular beds, and in laying the blocks in their natural positions, this rock might still be made to furnish a very serviceable building-stone.

These beds of hard chalk have suffered less from denudation than the superior and softer beds, and they rise into an almost continuous

* "On the Cretaceous Group in Norfolk," Proc. Geol. Assoc. 1862.

ridge along the western side of the Wolds, constituting some of the highest points in the county. This ridge is the watershed for the greater part of East Lincolnshire, as its continuations are for Norfolk and the East Riding of Yorkshire. It is cut through, however, by the stream called the Withern Eau, and by the numerous large rivers which now unite to form the Wash. From this main ridge proceed a number of spurs, running in a north-easterly direction, with transverse valleys between, in which flow a number of streams that eventually empty themselves into the North Sea. These spurs or secondary ridges are divided by longitudinal valleys which are generally dry. The Wolds of Lincolnshire are much more covered with superficial deposits, sometimes of considerable depth, than the downs of the south of England, or even of Norfolk; hence the district of the chalk in this county does not present that uniformly bare and arid appearance so characteristic of it in most parts; in fact, nearly the whole of it has now been brought under the plough, and with the most satisfactory results.

Above the hard chalk which constitutes the primary ridge of the Lincolnshire Wolds, we have a great mass of chalk-beds, containing layers of nodules and large tabular masses of flint, as also scattered flints of peculiar forms, which occur in considerable abundance, while *Paramoudra* are rare. The whole of these beds probably correspond to Woodward's "medial chalk"*; for the peculiar fossils of the division, called by the same author "Upper Chalk"†, have not been found in this county; and if such beds really exist here, they are probably entirely hidden by the extensive Pleistocene deposits which overlie the chalk in the eastern part of the county, in depths varying from a few feet only to upwards of 200, and which, being themselves covered with beds of peat and warp, constitute the very fertile district known as the Lincolnshire marsh.

b. *The Louth Red Chalk.*—Mr. Seeley has described‡ a thin bed of red chalk as occurring in the midst of the hard white chalk of the Hunstanton cliff, but running only a very short distance. This bed is of a pale-pink colour, its upper and under surfaces being ill-defined; and it appears to graduate vertically as well as horizontally into the white chalk which encloses it. Similar appearances, but often on a much larger scale, occur in different portions of the Lower Chalk of Lincolnshire, as I shall now proceed to show; and I have already suggested that probably part of the Speeton section should be considered a similar instance.

In the extensive chalk-pits about the town of Louth, as well as in several road-sections in the neighbourhood, is seen a thick and very conspicuous bed of red chalk, which is doubtless the one referred to by Mr. Wiltshire§ and Mr. Seeley || as belonging to the Hunstanton series. Neither of these gentlemen, however, appears to have had

* Geology of Norfolk, p. 27. † *Ibid.* p. 25.

‡ "On the Hunstanton Red Rock," Quart. Journ. Geol. Soc. vol. xx. p. 329.

§ "On the Red chalk of England," 'Geologist,' 1859, p. 268.

|| "On the Red Limestone of Hunstanton," Ann. & Mag. Nat. Hist., 3rd ser. vol. vii. p. 241.

any opportunity of examining the stratigraphical relations of the bed, or of collecting its fossils; and the following facts will suffice to prove that such an identification is erroneous.

1. The bed is always underlain by a great mass of the ordinary hard white chalk, the exact thickness of which cannot be exactly ascertained; but it is certainly 40 feet, and probably much more.

2. The sponge-bed does not occur at its upper surface, though at the outcrop of the true Hunstanton beds due west of Louth it is well seen and presents all the usual characters.

3. By far the most important fact in connexion with this subject, however, is that, although I collected, with the greatest care, the fossils of the Louth bed, not one specimen of *Belemnites minimus* was found; and out of a list of twenty fossils occurring in the bed, only two, *Terebratula biplicata*, Sow., and *Terebratulina gracilis*, Schl., are common to it and the Hunstanton series; and both of these fossils have a very extended range in Lincolnshire.

As this bed, unlike most of the other red beds in the chalk, can be traced over a considerable area, I shall distinguish it in the remainder of this paper by the name of the Louth Red Chalk.

By the side of the deep valley formed by the river Lud, is to be seen a good section showing the hard white chalk with the red bed in its midst. The whole appears to lie in irregular courses, with thin clay partings; and in the coloured portion of the section, these are of the same pink tint as the chalk itself. This colour would be described in hand-specimens as a very pale pink; but viewed in the mass and at a distance, the rock appears to be of a much more intense colour, and is very conspicuous. The thickness of the bed is about 5 feet; and it passes into the white chalk, both above and below, by insensible gradations. The red rock has the earthy fracture and the other physical characters of the adjoining white chalk, and displays no signs of a nodular character, except towards the middle, where there is a band of intensely hard nodules, breaking with a conchoidal fracture, and exhibiting a perfectly white interior; among these occur abundantly the remains of *Echini*. The whole series of beds is much broken up by a number of small faults; and the same phenomenon is exhibited in a greater or less degree in all the sections where this bed is seen,

Rather more than a mile south-west of this place, in a large chalk-pit at Hallington, the same beds are seen; and the red one can be traced at intervals between these two sections. Although the colour of the rock here is a little paler than at the last section, the bed forms a very conspicuous object in the chalk-pit, which is on a hillside, and it may be seen at the distance of several miles. The section differs in no essential particulars from that on the banks of the Lud; and the red bed contains the same fossils.

In the large chalk-pit near the Louth Union the bed is very variable in colour, in some parts of a decided red. It is here underlain by a grey sandy chalk containing nodules, and a branching form like *Spongia paradoxica*, as also *Pecten orbicularis*, Sow., and a large *Terebratula*. At a depth of about 30 feet under the above-described red bed in this pit, a second coloured stratum was reached; but strong springs of water arising at this point, the attempt to go down further was abandoned. From the pieces taken out at this place, it appeared to be of a mottled pink and white colour (like Castile soap), but I could detect no fossils in it. There were no signs of the sponge-bed; and I have but little doubt that this lower red bed is only a local one lying in the midst of the white chalk.

In the very deep cuttings and chalk-pits on the London-road, we have a number of extensive sections afforded us. The succession of beds in these is as follows. (See diagram, fig. 3.)

1. Soil.
2. Rubbly chalk.
3. Chalk with a few flints (very large sandpipes occur in it).
4. White chalk without flints, upwards of 20 feet.
5. Variegated band of Fuller's earth ....12 to 15 in.
6. First "white course" .... 2 feet.
   (A bed of very hard chalk, white above and tinted pink below.)
7. Second "white course" .... 2 feet.
   (Similar to the bed above.)
8. Red chalk .... 5 to 6 feet.
   (Soft pink and red chalk with clay bands of the same colour.)
9. "Soft white courses" .... 8 to 10 feet.
10. Hard "grey stone" ....10 feet.
11. Hard white "Brackly Chalk"............................ to bottom.

5. is a water-bearing bed; it is striped horizontally of various colours, green, pink, and purplish red, and is seen at the same level in all the pits at this part of the town. In its lower portion it becomes nodular, and graduates into the chalk. At the pit near the Union, it is only seen in one corner, and rapidly thins out.

8. presents the usual characters. *Terebratulæ* and *Echini* occur in it; a very large *Micraster* among the latter.

9. contains several veins of pink clay, each about one inch thick.

One of the pits in this neighbourhood was once dug to a much greater depth than at present; and the workmen state that at something over 30 feet below the red bed (8) another bed of a dark red colour, 5 to 6 feet thick, was met with. In this springs of water arose; and it would doubtless be the same bed as is seen in the bottom of the pit by the Union. This bed is stated by the workmen to have been underlain by 6 or 7 feet of white chalk, and that again by another dark-red nodular bed, also from 5 to 6 feet thick, under which the chalk was again white.

There are other places in the neighbourhood at which the Louth Red Chalk occurs, but they present no fresh features of interest; the most northern point to which I have yet succeeded in tracing it is a chalk-pit near South Elkington.

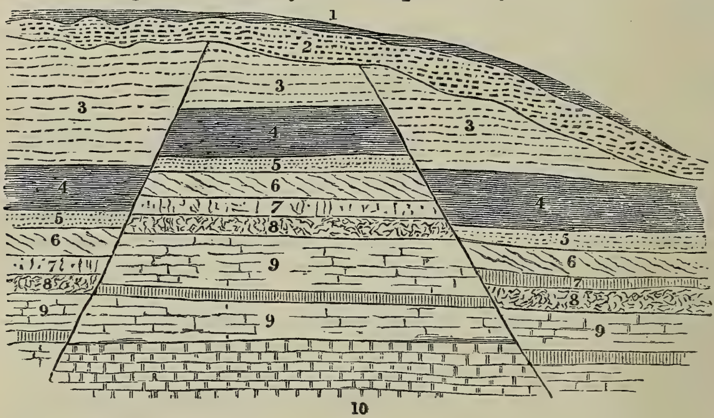
c. *Fossils of the Louth Red Chalk.*—The following is a complete list of the fossils that I have found in this bed. Some of the shells are perforated.

Holaster subglobosa, *Leske*, sp.
Micraster.
Ananchytes.
Discoidea cylindrica, *Lam.*
Discoidea subuculus, *Bronn.*
Cidaris sceptrifera? (spines).
Spines of several other species of *Cidaris.*
Serpula *or* Vermicularia.
Terebratula biplicata, *Sow.*
—— obesa, *Sow.*
Terebratulina gracilis, *Schl.*
Rhynchonella Mantelliana, *Sow.*
Exogyra.
Ostrea.
Plicatula inflata, *Sow.* (?)
Casts of several other bivalves.

d. *Other Beds of Red Chalk.*—Besides the beds already described, there are a number of chalk-pits in Lincolnshire where layers of a more or less decided red colour are seen. These for the most part do not present any special points of interest.

In the deep chalk-pit at Tetford Hill, however, we have a pink bed which extends over a considerable area, like the Louth red chalk, of which bed it may possibly be a continuation. The sketch (fig. 2) shows the succession of beds in this pit.

S.E. Fig. 2.—*Section of a Chalk-pit at Tetford Hill.* N.W.



1. Soil.
2. Chalk rubble.
3. Soft white chalk in small pieces.
4. Pale pink chalk similarly "shattered," graduating into the white above and below.................... Thickness = 5 to 6 feet.
5. Soft white chalk .... 2 feet.
6. Very hard white bed... 2 „
7. "Drab bed" (arenaceous chalk) .... 1 foot 6 in.
8. "Knobbly white bed" .... 2 feet.
9. Very white chalk .... 12 „
   In the midst of this occurs a course of hard undivided chalk, called by the workmen "Pot chalk," or "Ringing chalk," from its ringing under the hammer.
10. Nodular chalk, in which the workmen have bored more than 30 feet.

The only fossil I could find in the red bed was *Terebratula obesa*, Sow. The white beds contained many fossils. In the bed 7. a new and puzzling fossil (possibly a *Hippurite*) occurs.

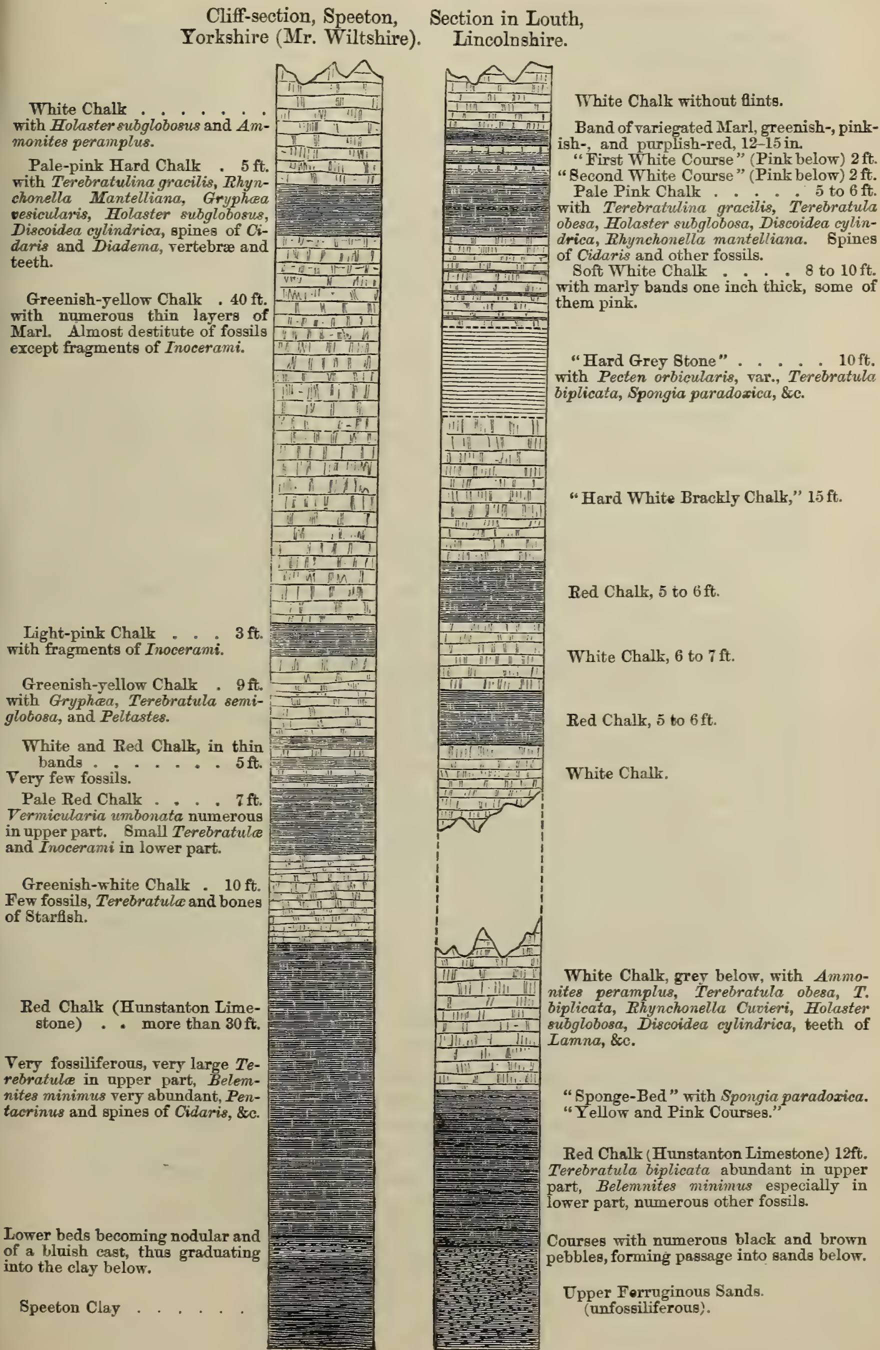


Fig. 3.—*Comparative Sections of the Lower Chalk &c. of Yorkshire and Lincolnshire.*

The same pink bed is seen in several other chalk-pits in the neighbourhood, *e. g.* one near Ruckland, and two others on the main road known as the High-street, between Tetford Hill and South Ormsby.

Since my observations were made in Lincolnshire, I find that the Rev. Mr. Wiltshire has published* a very clear and detailed account of the magnificent section at Speeton; this section I have placed for comparison alongside of that from Louth. In both cases I regard the lowest only of the red beds as the Hunstanton limestone, and the others to be more or less local red beds intercalated in the lowest portion of the chalk. The remarkable agreement, however, in thickness, lithology, and fossils, of the uppermost of these beds in each series suggests (in spite of the distance of the sections) the possibility of their being parts of one widely spread stratum (see fig. 3).

IV. The Beds below the Hunstanton Limestone.

a. *Unconformity at the base of the Hunstanton Limestone.*—The great physical break in the succession of strata, which has been so well described by Prof. Phillips as occurring between the Chalk and Speeton Clay of Yorkshire, is quite as strongly marked in Lincolnshire. This want of conformity of the Hunstanton Limestone with the beds below is manifested in several ways.

1. The strike of the Upper Cretaceous beds is not parallel with that of the Neocomian and Jurassic beds, the result of which is that in going northwards we find the latter overlapped and covered up by the former. Thus the sands which form the upper member of the Neocomian series, and which are probably 70 to 80 feet thick at their most southern exposures in this county, appear to thin out gradually northwards, and finally disappear altogether near Caistor. The limestones and clays, which form the second member of the series, are in their turn similarly overlapped, no trace of them being seen north of Clixby, while the sands and sandstones forming the third member disappear in like manner near Elsham. North of this place the Hunstanton limestone is found lying successively on the different zones of the Kimmeridge Clay. On crossing the Humber, it is well known that the "Red Chalk" is found lying in succession on each of the members of the Jurassic formation, but that near Grimstone, its strike becoming greatly altered, and running nearly at right angles to its former course, the various Oolites and Speeton beds reappear from underneath it in reverse order.

2. The thickness of the upper member of the Neocomian series increases in going eastwards as well as southwards. This I am enabled to prove by means of the curious inliers which have been already described as occurring in the midst of the Chalk Wolds. Thus in the valley of Thoresway the upper sands are more than 12 feet thick, while at the main line of outcrop in Nettleton Valley, a mile to the west, they have almost entirely disappeared†. Similarly,

* See Wright's Mon. Brit. Cret. Echin. p. 8, Mon. Pal. Soc. vol. xv.

† I find that this fact was noticed, but without any explanation of it being given, by Mr. Lee in 1837.

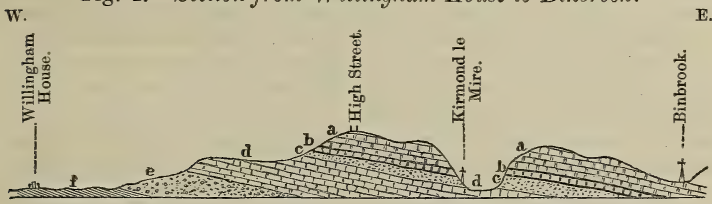
above Tealby these sands are much thinner than in the valley of Stainton, which lies directly to the east.

3. In places where the junction of the two series can be seen, the dip of the Hunstanton Limestone and other Upper Cretaceous beds is found to be different from that of the beds below. The most striking example of this, with which I am acquainted, is in the section above Langton-by-Spilsby, where the dip of the chalk and Hunstanton Limestone is 3° E., while that of the sands below it is 15° E.

b. *Succession of Beds.*—The extensive series of rocks (sands, sandstones, grits, limestones, clays, and ironstones) which are seen on the western side, and in the inliers of the Lincolnshire Wolds, fall naturally into the three main divisions, which, however, in different parts of the county are of very varying thickness and importance. There is perhaps no place where the whole of these members can be so well seen and studied as at the village of Tealby and the country immediately surrounding it; I have therefore ventured to suggest as a provisional name for the middle and most highly fossiliferous portion of the formation that of "the Tealby series." The divisions, as seen in this district, are as follows:—

(1) *The Upper Ferruginous Sands*, non-fossiliferous, about 20 feet thick.
(2) *The Tealby Series,* consisting here of alternate beds of sandy clay and limestone, with an extensive and interesting suite of fossils, from 40 to 50 feet thick.
(3) *The Lower Sand and Sandstone,* with few fossils, from 30 to 40 feet thick (see section, fig. 4).

Fig. 4.—*Section from Willingham House to Binbrook.*



a. White Chalk.
b. Hunstanton series.
c. Upper Ferruginous Sands.
d. Tealby series.
e. Lower Sand and Sandstone.
f. Blue Clay and Slaty beds.

c. *The Upper Ferruginous Sands.*—This is a bed of tolerably persistent character, consisting of coarse yellowish or greenish-brown, sometimes pebbly sand. Brown oxide of iron occurs, forming concentric concretions and thin laminæ lying between or cutting across the beds. As seen at the surface, it is frequently of a bright-red colour, which, however, is due to the washings from the red beds above, and is never observed in deep sections. At Thorpe-le-Vale, and several other places situated on the inliers of the Wolds, this bed may be well studied; but the best exposure with which I am acquainted is that in the pits above Langton Hall, already alluded to. The section as seen here is as follows:—

(1)	Chalk-marl and Hunstanton Limestone.	
(2)	Mass of greenish brown, unstratified sands	10 feet.
(3)	Bright-yellow sand, with irregular laminæ of peroxide of iron in the planes of stratification	20 „

The Tealby series is found about 30 feet below the bottom of this pit; hence the total thickness of these sands is here about 60 feet.

Between Belchford and Tetford these sands yield an iron-ore of the kind known to workmen as "cinder," which may hereafter be found to be of commercial value. The manner in which these sands appear to thin out towards the north and west, owing to the unconformity between the Upper and Lower Cretaceous rocks, has been already explained. I have as yet altogether failed in my search for fossils in these beds.

d. *The Tealby Series.*—This includes a great variety of rocks, the most persistent and characteristic being the sandy limestone provincially known as "greystone." In a large pit above North Willingham, we have the following section of these beds:—

1.	Soil	2 feet.
2.	Sandy clay of a bluish-grey colour, containing an irregular bed of sandy limestone	4 „
3.	Three courses of sandy limestone with clay partings ...	3 „
4.	Sandy clay	3 „
5.	Hard blue limestone	$2\frac{1}{2}$ „
6.	Sandy clay (to bottom of pit)	3 „

The workmen bored 9 feet below the bottom of the pit without finding another bed of hard limestone. In the midst of the clay-bed (2) occurs a remarkable layer of fossils, consisting of numerous specimens of *Pecten cinctus*, Sow., mingled with *Exogyra sinuata*, Sow., and numerous other fossils, among which *Belemnites semicanaliculatus*, Blain., *Ostrea frons*, Park., *Pecten orbicularis*, Sow., and *Rhynchonella parvirostris*, Sow., are perhaps the most abundant. The specimens of *Pecten cinctus*, which are from 9 to 12 inches in diameter, are always found lying on their lowest or most convex side; and their upper valves, as well as the edges of their lower ones, are not unfrequently covered, to the thickness of 2 inches or even more, with a tangled mass composed of *Serpulæ* of several species. Other shells, as *Exogyræ*, are frequently attached to these gigantic Pectens. The *Exogyræ* also frequently occur of very large size, and with valves of great thickness; they are also often found growing together in great masses, just as the same species frequently occur at Shanklin, Isle of Wight. All these circumstances serve to indicate the extremely slow and tranquil conditions under which the beds in question were deposited.

Above the village of Tealby, in the valley formed by the upper course of the River Rase*, are several pits, in which the gigantic

* Near the upper waterfall in the gorge above Tealby occurs an interesting deposit of travertine; the course of the stream has been changed at this place, and in the old river-bed the deposit in question is seen; it is about 8 feet thick in its deepest part, but is of no great length. The lower part of this deposit is white and crumbling, the upper light-brown and hard; it contains very numerous plant-remains, and also shells of terrestrial mollusca, among which I recognized *Helicella nitida*, Müll., and *Succinea putris*, Linn.

Pecten-bed and the several beds of limestone are well seen; large specimens of *Ammonites* and *Ancyloceras* occur here. Northward, at Walesby and Normanby-le-Wold, the limestones appear of great thickness, and predominate over the clays. Here too a still further modification is effected by the impregnation of some of the beds with oxide of iron, which renders them extremely valuable ironstones. The iron in these beds occurs in two states—namely, chemically combined with the rock, or as nodules of almost pure hydrated brown oxide of iron mechanically diffused through it. This brown oxide of iron sometimes forms minute spherical oolitic grains, exactly resembling those in the ironshot beds of the Inferior Oolite, at others irregular concretionary nodules up to the size of a hen's egg. Many hundreds of tons of ironstone have already been sent from pits at Claxby, Acre House, and Hundon to the furnaces of Yorkshire; and a great part of the land in this district has, I believe, been secured by ironmasters, with a view to the full development of these mineral treasures. At present the face of the cliff in which these iron-yielding beds are exposed, is in a great measure concealed by superficial deposits, while still greater confusion has been caused by landslips; but when mining operations shall have been commenced we may hope to gain much valuable information, both on the stratigraphical position and the fossil contents of the various beds.

Perhaps the best place for examining these beds is on the cliff below Acre House. The rocks here, consisting of alternations of limestones and clays (some of the latter being of a pinkish colour), all impregnated with oxide of iron, are very full of fossils. Besides the species mentioned as occurring at North Willingham, which are almost equally abundant here, we find *Terebratula depressa*, Lam. (several varieties), *T. hippopus*, Röm., *T. obtusa*, Sow. *T. sella*, Sow., with *Belemnites lateralis*, Phil., and *B. jaculum*, Phil. The brow of Nettleton Hill is evidently formed of the beds of the Tealby series; and numerous fossils may often be picked up on the surface of the ploughed fields. Further to the north, as we have already seen, these beds disappear under the Wolds.

South of Tealby these beds are seen to great advantage in the pits about Sixhills, Hainton, and South Willingham, but they show indications of diminishing in thickness as we go southwards. The country south of the last-mentioned village is much covered with masses of chalk-rubble, as before described. On the east of the river Bain, however, we again find these beds at several places, as above Scamblesby and Brinkhill. In a bed of clay at the latter place, which contains the characteristic Tealby fossils, large quantities of iron-pyrites have been found at different times; this has long been locally celebrated as "Brinkhill gold." In digging the foundations and well for the new hall at Langton, the Tealby series was passed through. It appears here to be only 10 or 12 feet thick, and to consist of yellow very sandy limestone and clay; many of the characteristic fossils of the series were found here. In Norfolk no trace of the Tealby series has yet been found, the Carstone formation of that county (appearing to represent the Upper Ferruginous Sand of Lincolnshire) lying directly on the Lower Sand and Sandstone.

The limestones of the Tealby series are very variable in composition, some being exceedingly arenaceous, and may indeed be described as sands cemented by calcareous matter, while others are extremely hard, crystalline, and blue-hearted. Large veins of calcspar, and nodules of pyrites are in some places very abundant; at Bully Hill the fissures of the limestone contain considerable quantities of black oxide of manganese. The softer limestones are largely used for building-purposes, the harder as road-metal.

The rocks of the Tealby series give rise to very marked features in the physical geography of this district; for, being cut through by the numerous streams flowing westward from the watershed, they form a number of prominent spurs standing at right angles to the chalk Wolds, the terraced appearance of which is in striking contrast with the smoothly rounded undulations of the latter.

e. *Fossils of the Tealby Series.*—The following list includes the most characteristic species; but, as there are a considerable number of forms awaiting description, it is by no means exhaustive.

List of Fossils from the Tealby Series.

Wood (rather abundant).
Spongia paradoxica, *Woodw.*, and allied forms.
Scyphia clavellata, *Röm.*
Spines of *Cidaris.*
Serpula filiformis, *Sow.*
—— antiquata, *Sow.*
——, sp.
Vermicularia Sowerbii, *Mant.* (rare).
Terebratula faba, *D'Orb.*, not *Sow.*
—— hippopus, *Röm.*
—— depressa, *Lam.* (many varieties).
—— biplicata, var. obtusa, *Sow.*
—— sella, *Sow.*
Rhynchonella parvirostris, *Sow.*, sp.
—— Gibbsiana, *Sow.*, sp.
Ostrea frons, *Park.*
——, sp.
Exogyra sinuata, *Sow.*
Anomia, sp.
Perna Ricordeana ?, *D'Orb.*
Pecten cinctus, *Sow.*
—— orbicularis, *Sow.*
—— elongatus, *Lam.*
—— (several other species).
Lima (large species).
Astarte substriata, *Leym.*
Lucina crassa, *Sow.*
Pleuromya, sp.
Panopæa plicata, *Sow.*, sp.
Thetis Sowerbii, *Röm.*
Trigonia alæformis, *Park.*
Numerous casts of large *Trigoniæ* and other bivalves.
Pleurotomaria, sp.
Solarium ornatum, *Sow.* ?
Ammonites clypeiformis, *D'Orb.*
—— plicomphalus, *Sow.*
(Several other species of *Ammonites*, probably new).
Ancyloceras Duvalii, *Leveille*, sp.
—— Puzosianus, *D'Orb.*, sp.
Crioceras ? Bowerbankii, *Sow.*
Belemnites lateralis, *Phil.*
—— jaculum, *Phil.*
—— semicanaliculatus, *Blain.*
—— minimus ?, *Mill.*
Vertebræ and teeth of *Ichthyosaurus.*
Vertebræ of *Plesiosaurus.*

f. *The Lower Sand and Sandstone.*—This division consists of a very variable mass of sands, in some places indurated into loose sandstones. In numerous localities along the lower slopes of the limestone hills every variety of these sands may be seen, from the finest white sand, fit for glass-house purposes, to coarse dark-brown conglomerates. In a large sand-pit some distance below the stone-pit (already described) at North Willingham, we have a section 20

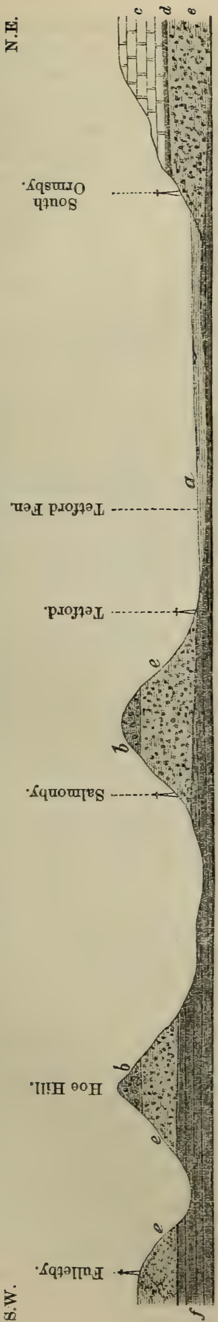


Fig. 5.—*Section from Fulletby to near South Ormsby.*

a. Alluvium.
b. Drift.
c. White Chalk.
d. Hunstanton Limestone.
e. Neocomian beds (Sand and Sandstone).
f. Blue Clay and Slaty beds.

or 30 feet deep, entirely in these sands. In the upper part we find white, ash-grey, and mottled sands; in the lower part coarse brown sands, in places indurated into a stone like the "Carstone" of Norfolk. The only fossil which occurs in any abundance is a species of *Pecten* (*P. elongatus*?, Lam.), which, however, is very seldom found, except in fragments.

North of the typical section, this series of beds appears to become much thinner; it can, however, be traced at various places, as at Searby, the Gallows Plantation, near Barnetby-le-Wold, and the sides of the valley in which Elsham is situated. The most conspicuous parts of the stratum at these places are the masses of hard greenish sandstone and grit (often full of casts of *Pectens*), which are used for building.

On going southwards, however, we find that as the limestones and clays of the Tealby series thin out, the sands and sandstones below become of greater thickness and importance, and spread over a much more considerable area. The formation here constitutes the mass of numerous ridges and isolated hills which are capped by the peculiar drift already described, and are characterized by their fantastic and often picturesque outlines. The bottoms of the valleys between these ridges and hills are formed by the blue clays, which lie below the beds I am describing, usually much covered with alluvium. See section, fig. 5.

With the exception of the species of *Pecten* already mentioned, fragments of which occur in great numbers scattered through the sandstone, fossils are rare, and usually confined to particular bands of nodules. Such bands are seen in the pits at Holbeck and Winceby, whence I obtained the following fossils:—*Ammonites*, several species in the form of casts, *Belemnites lateralis*, Phil., *B. minimus*?, *Lucina crassa*, Sow., and several other bivalves. The most extensive suite of fossils from this part of the formation is from near Bolingbroke, immediately south of which place the beds in question are covered up by the alluvium of the fens. At this place, in addition to the whole of the fossils above mentioned, *Ammonites plicomphalus*, Sow., *Trochus*? (large species), *Pholadomya Martini*?, Forbes, *Thracia*, sp., *Pinna* (large species), and some other forms, but all in the condition of casts, were found. This is the locality whence were obtained several of the species figured and described by Sowerby in the 'Mineral Conchology.'

The coarse sandstone of this series is the material of which nearly all the churches in this part of Lincolnshire are built; and its want of durability imparts to many of them, of no great antiquity, a very ruinous and dilapidated appearance. In the railway-cutting at Spilsby large irregular masses of intensely hard greenish-white grit are found, which show no trace of concretionary structure when first dug out, but which, on exposure to the air, soon become soft and of a dark-brown colour, and on being broken exhibit a great number of concentric layers disposed around a central nucleus.

In many parts of the county, especially about Market Rasen, the district occupied by the Lower Sand and Sandstone formed at one time only extensive rabbit-warrens and fir-plantations, some of which still remain; but in many cases, by the judicious application to this sandy soil of blue clay dug from the beds below, it has been brought into a fit state for cultivation.

The Lower Sand and Sandstone are throughout Lincolnshire underlain by hard slaty and shaly beds with numerous compressed *Ammonites* and other fossils. These are highly bituminous and inflammable, and have hence been frequently supposed to form a part of the Coal-measures; they constitute the upper member of that great mass of blue clays which, in this county, represents the whole of the Upper and Middle Jurassic formations.

V. Faults, &c.

In the district described in the preceding pages faults, though small, are very numerous. The fault at Welton-le-Marsh and the double one at Sutterby have been already mentioned. The small outlier at Gaumer Hill is cut across by several small faults ranging N. and S., and in that above Ormsby Wood, the beds are inclined at a high angle. In Tetford Hill chalk-pit two faults are seen (fig. 2), each of about 7 feet throw; and here the workmen have found at different times open fissures of considerable size: one of these is said to have been "large enough to admit a waggon and horses;" and it was explored for some distance by the workmen, until fear drove them back, without their having found its termination. In the pit at Nob Hill the beds of the Hunstanton series are seen to be broken up by several small faults; while in that north of Donnington-on-Bain they dip 8° E. In nearly all the pits about Louth small faults occur. In the pit above

South Willingham the Lower Chalk and Hunstanton beds dip 25° N., while in that at the Heneage Arms Inn they show great signs of disturbance, being in one part level, and in another dipping 28° N. Above the village of Searby the beds of Lower Chalk are actually contorted; and at Worlaby the Hunstanton series is cut across by a fault ranging N. and S., by which the red chalk is brought into juxtaposition with the white. At this place, as also at Gaumer Hill, veins of crystallized calcspar occur near the base of the white chalk.

VI. Conclusion.

Believing that a full discussion of the exact age of the several series of beds described in the foregoing paper would at the present time be premature, I propose to offer a few very general remarks only by way of recapitulation.

With regard to the Hunstanton limestone, the observations of Mr. Seeley in a recent paper*, if not altogether conclusive, are at least exhaustive of the subject as far as the data at present go. We can scarcely be wrong in assigning this series, which is conformable with the Upper Cretaceous beds, but unconformable with the Neocomian, and which has a fauna so distinct from those of the beds above and below it, to the age of the Upper Greensand or Gault—or in supposing, as is perhaps more probable, that it represents both of these formations.

That the Tealby series represents a part of the great Neocomian formation cannot be doubted; but the analogies of its fauna, like that of the Speeton clay, are to be sought for in the Neocomian of North-western Germany and South-eastern France, rather than in the Lower Greensand of the south of England. We have already shown that the stratigraphical relations of this formation are identical with those of the Speeton clay of Yorkshire; and a large proportion of the fossils of the Tealby series are also found in the Speeton clay. Thus the whole of the *Belemnites*, including at least two forms (*B. lateralis* and *B. jaculum*) found in no other British deposit, are common to the two formations. Similarly the very characteristic gigantic form of *Pecten cinctus* is found in a particular zone of the Speeton clay. It is a noteworthy fact that *Ammonites* are rare or absent in this particular zone of the Yorkshire deposit, but the species of *Ancyloceras* found agree with those of the Tealby series. On the other hand, a few species peculiar to the Tealby series and new to this country, as *Ammonites clypeiformis* and *Terebratula hippopus*, appear to characterize the Middle Neocomian of the Continent, to which stage in the geological scale I venture to anticipate the Tealby series and the equivalent portion of the Speeton clay will be finally assigned. To these beds, therefore, the highest interest is attached, as the possible marine representative of the Wealden of the south of England, and as possessing a fauna now for the first time recognized in this country.

The fossils of the Lower Sand and Sandstone, at present known, are so few and imperfect as to preclude us from offering even an opinion

* Ann. & Mag. Nat. Hist. 3rd ser. vol. vii. p. 233 *et seq.*

as to whether these beds are palæontologically separable from the Tealby series.

Lastly, I have shown that, in Lincolnshire at least, the occurrence of beds of a red colour in the Cretaceous series is by no means a unique phenomenon. The explanation of the reactions by which the colouring-matter in these cases, *anhydrous* peroxide of iron, has been produced, offers an interesting problem to the chemical geologist—one which he can only hope to solve by combining extensive observation in the field with minute research in the laboratory. The explanation, when found, will probably embrace other cases of the occurrence of red limestone, such as those of Inferior Oolite age at Bredon Hill*, and those of Devonian age in Devonshire, with others which will doubtless occur to geologists†. Regretting that I am at present unable to carry out my design of supplementing the present paper by a series of careful analyses of the various red beds described in it, I add the following general observations, which may be of use to any one investigating the subject:—The ordinary white chalk of Lincolnshire, when exposed to a moderate degree of heat, as in the sides of lime-kilns, becomes pink or red; while the red chalk of Louth, as well as that of the Hunstanton series, makes a perfectly white lime; indeed the red beds are preferred by the lime-burners to the white ones. The explanation of these facts is probably as follows:—in the first case the small quantity of hydrous or brown peroxide of iron is dehydrated, and converted into the intensely colouring red oxide; perhaps also by a slow oxidizing process the minute grains of silicate of iron are decomposed: in the latter case an exactly opposite action takes place, the peroxide of iron is reduced (probably by carbonic oxide) to the state of protoxide, and, uniting with the silica, forms silicate of the protoxide of iron, which is pale-green, and of extremely feeble colouring-power. The existence of large quantities of silica in the Lower Chalk and Hunstanton beds is shown by the fact that, when used for lime-burning, great care is required to prevent the heat from rising to too high a degree, in which case the whole contents of the kiln would run together in consequence of the formation of fusible silicates.

VII. Notes on some of the Fossils.

1. Pecten cinctus, Sow. = *P. circularis*, Goldf. = *P. crassitesta*, Röm.

This species was originally described by Sowerby from two specimens, one of which was obtained from Lincolnshire, and the other from the drift of Suffolk; by him they were erroneously referred to the inferior Oolite, on account of the resemblance of their matrix to the "ironshot oolite" of that formation. Although both Mr. Lee and Prof. Phillips correctly quote this species, and Römer himself, in 1841‡, cancelled his own name in favour of that of Sowerby, other palæontologists have constantly applied the latter to two other quite

* Strickland's Collected Works, p. 81.

† It may be of interest to mention that beds of red limestone occur in the Oolite near Lincoln.

‡ Verst. Nord. Kreid. Geb. p. 70.

distinct species, one from the Inferior Oolite, and the other from the Marlstone. It is, however, a very characteristic Neocomian shell; and some of the Lincolnshire specimens are of extraordinary size. Dwarf specimens occur in the Lower Greensand of the south of England, and full-sized ones in a particular zone of the Speeton clay. The species is interesting as being the largest known *Pecten*, either recent or fossil.

2. Lucina crassa, Sow.

The original specimen of this shell was obtained from the sandstone at Bolingbroke. That figured from the Great Oolite, by Lycett and Morris, as a variety of this species is probably a distinct form; in accordance with a well-established precedent, I would suggest that it should be called *L. Morrisii*.

3. Ammonites plicomphalus, Sow.

This is another of the Bolingbroke shells sent to Sowerby by Mr. Weir, the historian, of Horncastle. The figured specimens are both somewhat obscure casts, but seem to agree with a species found in the Speeton clay. A number of Oolitic forms have at different times been erroneously referred to this species.

4. Belemnites minimus, List., *B. Listeri*, Mant. et Phil., *B. attenuatus*, Sow., and *B. ultimus*, D'Orb.

The whole of these forms occur together in great numbers in the lower beds of the Hunstanton limestone. From a careful examination of a great number of forms, I feel convinced that they can only be regarded as varieties of one species.

Before concluding this paper, I am desirous of expressing my obligations to Mr. Etheridge for much advice and assistance kindly afforded to me in drawing up the lists of fossils. To Prof. Huxley, also, I am indebted for the examination of the specimen of *Ichthyosaurus*.

April 17, 1867.

John Francis Walker, Esq., B.A., F.C.S., of Sidney-Sussex College, Cambridge, was elected a Fellow.

The following communication was read:—

On the Physical Structure *of* North Devon, *and on the* Palæontological Value *of the* Devonian Fossils. By Robert Etheridge, Esq., F.R.S., F.G.S., Palæontologist to the Geological Survey of Great Britain.

[The publication of this paper is unavoidably deferred.]

(Abstract.)

The Lower, Middle, and Upper groups of sandstones and shales of West Somerset and North Devon are described in this paper as occurring in a regular and unbroken succession from north to south—

namely, from the sandstones comprising the promontory of the Foreland, at the base, to the grits and slates &c. overlying the Upper Old Red Sandstone of Pickwell Down to the south. The author has been unable to see any trace of a fault of sufficient magnitude to invert the order of succession, or that would cause the rocks of the Foreland at Lynton to be upon the same horizon as those south of a line of high ground that passes across the county from Morte Bay on the west to Wiveliscombe on the east.

The Foreland grits and sandstones are overlain by the Lower or Lynton slates, and form a group equal in time to the Lower Old Red Sandstone of other districts, but deposited under purely marine conditions.

The author then shows that above the Lower or Lynton slates there is an extensively developed series of red, claret-coloured, and grey grits, from 1530 to 1800 feet thick; these form a natural and conformable base to the Middle Devonian or Ilfracombe group. The highest beds, containing *Myalina* and *Natica*, insensibly pass into the gritty and calcareous slates of Combe Martin, Ilfracombe, &c.; this Middle group Mr. Etheridge unhesitatingly regards as the equivalent of the Torquay and Newton Bushel series of South Devon.

Mr. Etheridge gives detailed Tables of the organic remains of the two groups (the Lower, or Lynton, and the Middle or Ilfracombe), and collates with them those species found in equivalent strata in Rhenish Prussia, Belgium, and France. He is inclined to believe that these two marine fossiliferous groups represent in time the unfossiliferous Old Red Sandstone (Dingle beds) of Kerry, and the Glengariff and Killarney Grits of the south-west of Ireland.

The author then endeavours to prove that the Pickwell Down beds are the true *Upper* Old Red Sandstone only, not the whole of the formation, as was lately proposed.

Arguments are also brought forward to show the probability of the Carboniferons slate (in part) and Coomhola grits being the equiqualent of the English Upper Old Red Sandstone, or Upper Devonian, and that the North Devon beds only are to be regarded as the true type, to which the Irish must be compared, and not *vice versâ*.

Physical and palæontological evidence distinctly proves, the author states, that the whole of the slates and limestones of Lee, Ilfracombe, and Combe Martin underlie the Morte Bay Red Sandstones.

The author compares the whole of the Devonian fauna of Britain with that of the Rhine, Belgium, and France, by means of a series of Tables based upon the British types. These marine Devonian species are compared with those of the Old Red Sandstone proper, the Silurian, and the Carboniferous; and analyses are made of all the classes, orders, genera, and species, in relation to the groups of rocks in which they occur,—the result being the conclusion that the marine Devonian series, as a whole, constitutes an important and definite system.

May 8, 1867.

H. Cooper Rose, M.D., F.L.S., Hampstead, N.W., was elected a Fellow.

The following communications were read:—

1. *On New* Specimens *of* Eozoon. By Sir W. E. Logan, F.R.S., F.G.S.

Since the subject of Laurentian fossils was placed before this Society in the papers of Dr. Dawson, Dr. Carpenter, Dr. T. Sterry Hunt, and myself in 1865, additional specimens of *Eozoon* have been obtained during the explorations of the Geological Survey of Canada. These, as in the case of the specimens first discovered, have been submitted to the examination of Dr. Dawson; and it will be observed, from his remarks contained in the paper which is to follow, that one of them has afforded further, and what appears to him conclusive, evidence of their organic character. The specimens and remarks have been submitted to Dr. Carpenter, who coincides with Dr. Dawson; and the object of what I have to say in connexion with these new specimens is merely to point out the localities in which they have been procured.

The most important of these specimens was met with last summer by Mr. G. H. Vennor, one of the assistants on the Canadian Geological Survey, in the township of Tudor and county of Hastings, Canada West, about forty-five miles inland from the north shore of Lake Ontario, west of Kingston. It occurred on the surface of a layer, inches thick, of dark-grey micaceous limestone or calc-schist, near the middle of a great zone of similar rock, which is interstratified with beds of yellowish-brown sandstone, grey close-grained siliceous limestone, white coarsely granular limestone, and bands of dark-bluish compact limestone and black pyritiferous slates, to the whole of which Mr. Vennor gives a thickness of 2000 feet. Above this zone are reddish granitic gneiss, and a great thickness of green diorite-slates; while beneath it are grey and pink dolomites, bluish and greyish mica-slates, grey siliceous whetstone-slate, with whitish brown-weathering dolomites, which often pass into coarse conglomerates, enclosing a multitude of large well-rounded masses of gneiss, syenite, and quartzite; to which succeed whitish highly crystalline limestone, dark-green chlorite-slates, with workable beds of magnetic iron-ore, and at the base red orthoclase felspathic rocks. This series, according to Mr. Vennor's section (which is appended), has a thickness of 2000 feet; but the possible occurrence of more numerous folds than have yet been detected may hereafter require a considerable reduction.

These measures appear to be arranged in the form of a trough, to the eastward of which, and probably beneath them, there are rocks resembling those of Grenville, from which the former differ considerably in lithological character; and it is therefore supposed that the Hastings series may be somewhat higher in horizon than that of

Grenville. From the village of Madoc, the zone of limestone which has been particularly alluded to runs to the eastward on one side of the trough, in a nearly vertical position into Elzivir, and on the other side to the northward, through the township of Madoc into that of Tudor, partially and unconformably overlain in several places by horizontal beds of Lower Silurian limestone, but gradually spreading, from a diminution of the dip, from a breadth of half a mile to one of four miles. Where it thus spreads out in Tudor it becomes suddenly interrupted for a considerable part of its breadth by an isolated mass of anorthosite rock, rising about 150 feet above the general plain, and supposed to belong to the unconformable Upper Laurentian, thus showing that the specimens of *Eozoon* of this neighbourhood, like those previously discovered and described, belong to the Lower Laurentian series.

The Tudor limestone is comparatively unaltered; and, in the specimen obtained from it, the general form or skeleton of the fossil (consisting of white carbonate of lime) is imbedded in the limestone without the presence of serpentine or other silicate, the colour of the skeleton contrasting strongly with that of the rock. It does not sink deep into the rock, the form having probably been loose and much abraded on what is now the under part, before being entombed. On what was the surface of the bed, the form presents a well-defined outline on one side; and in this and the arrangement of the septal layers it has a marked resemblance to the specimen first brought from the Calumet, eighty miles to the north-east, and figured in the 'Geology of Canada,' p. 49; while all the forms from the Calumet, like that from Tudor, are isolated, imbedded specimens, unconnected apparently with any continuous reef, such as exists at Grenville and the Petite Nation. It will be seen, from Dr. Dawson's paper, that the minute structure is present in the Tudor specimen, though somewhat obscure; but in respect to this, strong subsidiary evidence is derived from fragments of *Eozoon* detected by Dr. Dawson in a specimen collected by myself from the same zone of limestone near the village of Madoc, in which the canal-system, much more distinctly displayed, is filled with carbonate of lime, as quoted from Dr. Dawson by Dr. Carpenter in the Journal of this Society for August 1866.

In Dr. Dawson's paper mention is made of specimens from Wentworth, and others from Long Lake. In both of these localities the rock yielding them belongs to the Grenville seam, or uppermost of the three great bands of limestone heretofore described as interstratified in the Lower Laurentian series. That at Long Lake, situated about twenty-five miles north of Côte St. Pierre in the Petite-Nation Signiory, where the best of the previous specimens were obtained, is in the direct run of the limestone there; and like it the Long-Lake rock is of a serpentinous character. The locality in Wentworth occurs on Lake Louisa, about sixteen miles north of east from that of the first Grenville specimens, from which Côte St. Pierre is about the same distance north of west, the lines measuring these distances running across several important undulations in the Grenville band in both directions. The Wentworth specimens are imbedded in a portion of the Grenville band, which appears to have escaped any great alteration, and is free from serpentine, though a mixture of serpentine with white crystalline limestone occurs in the band within a mile of the spot. From this grey limestone, which has somewhat the aspect of a conglomerate, specimens have been obtained resembling some of the figures given by Gümbel in his 'Illustrations' of the forms met with by him in the Laurentian rocks of Bavaria.

In decalcifying by means of a dilute acid some of the specimens from Côte St. Pierre, placed in his hands in 1864–1865, Dr. Carpenter found that the action of the acid was arrested at certain portions of the skeleton, presenting a yellowish-brown surface; and he showed me, two or three weeks ago, that in a specimen recently given him, from the same locality, considerable portions of the general form remained undissolved by such an acid. On partially reducing some of these portions to a powder, however, we immediately observed effervescence by the dilute acid; and strong acid produced it without bruising. There is little doubt that these portions of the skeleton are partially replaced by dolomite, as more recent fossils are often known to be, of which there is a noted instance in the Trenton limestone of Ottawa. But the circumstance is alluded to for the purpose of comparing these dolomitized portions of the skeleton with the specimens from Burgess, in which the replacement of the septal layers by dolomite appears to be the general condition. In such of these specimens as have been examined the minute structure seems to be wholly, or almost wholly, destroyed; but it is probable that upon a further investigation of the locality some spots will be found to yield specimens in which the calcareous skeleton still exists unreplaced by dolomite; and I may safely venture to predict that in such specimens the minute structure, in respect both to canals and tubuli, will be found as well preserved as in any of the specimens from Côte St. Pierre.

It was the general form on weathered surfaces, and its strong resemblance to *Stromatopora*, which first attracted my attention to *Eozoon*; and the persistence of it in two distinct minerals, pyroxene and loganite, emboldened me, in 1857, to place before the Meeting of the American Association for the Advancement of Science specimens of it as probably a Laurentian fossil. After that, the form was found preserved in a third mineral, serpentine; and in one of the previous specimens it was then observed to pass continuously through two of the minerals, pyroxene and serpentine. Now we have it imbedded in limestone, just as most fossils are. In every case, with the exception of the Burgess specimens, the general form is composed of carbonate of lime; and we have good grounds for supposing it was originally so in the Burgess specimens also. If, therefore, with such evidence, and without the minute structure, I was, upon a calculation of chances, disposed to look upon the form as organic in 1857, much more must I so regard it when the chances have been so much augmented by the subsequent accumulation of evidence of the same kind, and the addition of the minute structure, as described by Dr. Dawson, whose observations have been confirmed and added to by the highest British authority upon the class of animals to which the form has been referred, leaves on my mind no room whatever for doubt of its organic character. Objections to it as an organism have been made by Professors King and Rowney; but these appear to me to be based upon the supposition that because some parts simulating organic structure are undoubtedly mere mineral arrangement, therefore all parts are mineral. Dr. Dawson has not proceeded upon the opposite supposition, that because some parts are, in his opinion, undoubtedly organic, therefore all parts simulating organic structure are organic; but he has carefully distinguished between the mineral and organic arrangements. I am aware, from having supplied him with a vast number of specimens prepared for the microscope by the lapidary of the Canadian Survey, from a series of rocks of Silurian and Huronian, as well as Laurentian age, and from having followed the course of his investigation as it proceeded, that nearly all the points of objection of Messrs. King and Rowney passed in review before him prior to his coming to the conclusions which he has published; and his reply to these objections forms a part of the succeeding paper.

APPENDIX.

Ascending Section of Laurentian Rocks in the County of Hastings, Canada West. By H. G. Vennor, Esq.

	feet.
1. Red felspathic strata, composed chiefly of red orthoclase, colourless quartz, and grey or greenish-grey hornblende, running in streaks in some places. The greater part of the mass is coarse-grained; but there occur in it occasional interstratified bands of a pale flesh-red, which are finer in grain; red hæmatite in streaks, and iron pyrites in crystals, are more or less scattered through the mass, which has a probable thickness considerably over	5000
2. Dark-green chlorite slates, associated with masses of greenstone and actinolite-rock, probably in lenticular patches, and interstratified with occasional beds of magnetic iron-ore, of which the Seymour bed, thirty feet thick, is one. Bands of pale flesh-red felsite, or petrosilex, are of occasional occurrence in the mass; and garnets characterize some parts of the chlorite slates........	200
3. Whitish highly crystalline limestone, interstratified with three bands of tremolite, and with grey and pinkish dolomites, weathering drab or some shade of yellowish-grey, presenting beds of from fifteen to forty feet in thickness. Where the limestone adjoins the greenstone of No. 2, the limestone becomes charged with grains of quartz, and more or less interstratified with bands of quartz and siliceous or micaceous slates. When the dolomite and greenstone adjoin, the dolomite presents thin layers or segregated veins, composed of calcspar, bitter spar, and small crystals of hornblende, which are characterized occasionally by the occurrence of copper-pyrites, and, on the eighteenth lot of the fifth concession of Madoc, by the presence of gold in considerable quantity, the three-inch belt in which it is enclosed being flanked on each side by soapstone, of which there are occasional beds in the upper part of the mass, some of them four feet thick........	2200
4. Grey siliceous or fine micaceous slates, fit for whetstones, with an interstratified mass of yellowish white dolomite, weathering yellowish	

brown, having a thickness of sixty feet, and separated into beds by thin layers of the mica-slates. The dolomite beds often pass into conglomerates, enclosing a multitude of well-rounded masses of gneiss, syenite, and quartzite, ranging in diameter from one to twelve inches .... feet. 400

5. Bluish and greyish mica-slates, studded in some places with crystals of magnetic oxide of iron, and interstratified with an occasional band of quartzite 500

6. Grey and pinkish dolomite, weathering brown 100

7. Grey micaceous limestone or calc-schist, interstratified with beds of yellowish-brown sandstone, grey impure limestone, white coarsely granular limestone, and bands of dark-bluish compact limestone and black pyritiferous slates. The calc-schist greatly predominates, and in Tudor it is cut by several N.W. & S.E. lodes, containing galena in considerable quantity, in a matrix of calc-spar and barytes. Near the middle of the mass, on the surface of a three-inch band of the calc-schist in Tudor, on the fifteenth lot of the Hastings road-range, east side, was obtained a fossil which Dr. Dawson, after careful examination, pronounces to be *Eozoon Canadense* 2000

8. Green diorite-slates, interstratified with beds of fibrous diorite holding iron-pyrites, and with bands of mica-schist; somewhat below the middle of the mass there occurs a six-feet band of white, highly crystalline limestone, in which is interstratified a bed of earthy graphite, with a thickness of a foot; and a three-feet bed of finely granular white iron-pyrites underlies the limestone. These diorite-slates graduate downwards into mica-slates, which are interstratified with frequent bands resembling serpentine, and some of green and reddish coarse soapstone, which has been used for furnace-hearths. These mica-slates graduate into green massive hornblende-rock or amphibolite, the weathered surface of which in some places shows subradiating forms of hornblende. The amphibolite finally passes into diorite-slates, composed of the same green hornblende, with a large admixture of albite. These four groups of rock occupy a breadth of 15,000 feet, standing in a vertical attitude on the east side of Elzivir; and as there is reason to suppose that they fold over sharply on themselves, their volume is estimated at 7500

9. Reddish granitic gneiss, the total thickness of which has not been ascertained, but is for the present estimated at 2100

20,000

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2. *Notes on* Fossils *recently obtained from the* Laurentian Rocks *of* Canada, *and on* objections *to the* Organic nature *of* Eozoon. By J. W. Dawson, LL.D., F.R.S., F.G.S. *With* Notes *by* W. B. Carpenter, M.D., F.R.S.

[Plates XI. & XII.]

Contents.

I. Specimen of Eozoon from Tudor, C. W.

This very interesting specimen, submitted to me for examination by Sir W. E. Logan, is, in my opinion, of great importance, as furnishing a conclusive answer to all those objections to the organic nature of *Eozoon* which have been founded on comparisons of its structures with the forms of fibrous, dendritic, or concretionary minerals,—objections which, however plausible in the case of highly crystalline rocks, in which organic remains may be simulated by merely mineral appearances readily confounded with them, are wholly inapplicable to the present specimen.

1. *General Appearance.*—The fossil is of a clavate form, six and a half inches in length, and about four inches broad. It is contained in a slab of dark-coloured, coarse, laminated limestone, holding sand, scales of mica, and minute grains and fibres of carbonaceous matter. The surface of the slab shows a weathered section of the fossil (Pl. XI.); and the thickness remaining in the matrix is scarcely two lines, at least in the part exposed. The septa, or plates of the fossil, are in the state of white carbonate of lime, which shows their form and arrangement very distinctly, in contrast to the dark stone filling the chambers. The specimen lies flat in the plane of stratification, and has probably suffered some compression. Its septa are convex toward the broad end, and somewhat undulating. In some places they are continuous halfway across the specimen; in other places they divide and reunite at short distances. A few transverse plates, or connecting columns, are visible; and there are also a number of small veins or cracks passing nearly at right angles to the septa, and filled with carbonate of lime, similar in general appearance to the septa themselves.

On one side, the outline of the fossil is well preserved. The narrow end, which I regard as the basal portion, is rounded. The outline of the side first bends inward, and then outward, forming a graceful double curve, which extends along the greater part of the length. Above this is an abrupt projection, and then a sudden narrowing; and in the middle of the narrow portion, a part has the chambers obliterated by a white patch of carbonate of lime, below which some of the septa are bent downward in the middle. This is probably an effect of mechanical injury, or of the interference of a calc-spar vein.

With the exception of the upper part above referred to, the septa are seen to curve downward rapidly toward the margin, and to coalesce into a lateral wall, which forms the defined edge or limit of the fossil, and in which there are some indications of lateral orifices opening into the chambers. It is worthy of remark that, in this respect, the present specimen corresponds exactly with that which was originally figured by Sir W. Logan in the 'Geology of Canada,' p. 49, and which is the only other specimen that exhibited the lateral limit of the form.

On the side next the matrix, the septa terminate in blunt edges, and do not coalesce; as if the organism had been attached by that surface, or had been broken before being imbedded.

2. *Microscopic Characters.*—Under the microscope, with a low power, the margins of the septa appear uneven, as if eroded or tending to an acervuline mode of growth; but occasionally the septa show a distinct and regular margin. For the most part merely traces of structure are presented, consisting of small parts of canals, filled with the dark colouring-matter of the limestone. In a few

places (Pl. XII. fig. 1), however, these appear as distinct bundles, similar to those in the Grenville specimens, but of fine texture.

[In fig. 2 is represented a portion of the canal-system in a Grenville specimen, in which the canals, which are transparent in one side (being infiltrated with carbonate of lime only) are seen on the other to be partially filled with black matter, probably a carbonaceous residuum of the sarcode which they originally contained.—W.B.C.]

In a few rare instances only, can I detect, with a higher power, in the margin of some of the septa, traces of the fine tubulation characteristic of the proper chamber-wall of *Eozoon*. For the most part this seems to have been obliterated by the infiltration of the tubuli with colourless carbonate of lime, similar to that of the skeleton.

In comparing the structure of this specimen with that of those found elsewhere, it would appear that the chambers are more continuous, and wider in proportion to the thickness of the septa, and that the canal-system is more delicate and indistinct than usual. In the two former respects the specimens from the Calumet and from Burgess approach that now under consideration more nearly than do those from Grenville and Petite Nation; but it would be easy, even in the latter, to find occasional instances of a proportion of parts similar to that in the present example. General form is of little value as a character in such organisms; and, so far as can be ascertained, this may have been the same in the present specimen and in that originally obtained from the Calumet, while in the specimens from Grenville a massive and aggregative mode of growth seems to have obliterated all distinctness of individual shape. Without additional specimens, and in the case of creatures so variable as the Foraminifera, it would be rash to decide whether the differences above noticed are of specific value, or depend on age, variability, or state of preservation. For this reason I refer the specimen for the present to *Eozoon Canadense*, merely distinguishing it as the Tudor variety.

From the state of preservation of the fossil, there are no crystalline structures present which can mislead any ordinarily skilful microscopist, except the minute veins of calcareous spar traversing the septa, and the cleavage-planes which have been developed in some portions of the latter.

I would remark that, as it seemed desirable not to injure any more than was absolutely necessary a unique and very valuable specimen, my observations of the microscopic structure have been made on a few slices of small size,—and that, as the microscopic structures are nearly the same in kind with those of specimens figured in former papers, I have not thought it necessary to prepare numerous drawings of them; while the admirable photograph executed for Sir W. E. Logan by Mr. Norman illustrates sufficiently the general form and arrangement of parts (see Pl. XI.).

3. *Concluding Remarks.*—In a letter to Dr. Carpenter, quoted by him in the 'Quarterly Journal of the Geological Society' for August 1866, p. 228, I referred to the occurrence of *Eozoon* preserved simply

in carbonate of lime. The specimens which enabled me to make that statement were obtained at Madoc, near Tudor, this region being one in which the Laurentian rocks of Canada appear to be less highly metamorphosed than is usual. The specimens from Madoc, however, were mere fragments, imbedded in the limestone, and incapable of showing the general form. I may explain, in reference to this, that long practice in the examination of these limestones has enabled me to detect the smallest fragments of *Eozoon* when present, and that in this way I had ascertained the existence of this fossil in one of the limestones of Madoc before the discovery of the fine specimen now under consideration.

I am disposed to regard the present specimen as a young individual, broken from its attachment and imbedded in a sandy calcareous mud. Its discovery affords the hope that the comparatively unaltered sediments in which it has been preserved, and which also contain the worm-burrows described by me in the 'Quarterly Journal of the Geological Society' for November *, will hereafter still more largely illustrate the Laurentian fauna.

II. Specimens from Long Lake and Wentworth.

Specimens from Long Lake, in the collection of the Geological Survey of Canada, exhibit white crystalline limestone with light-green compact or septariiform † serpentine, and much resemble some of the serpentine-limestones of Grenville. Under the microscope the calcareous matter presents a delicate areolated appearance, without lamination; but it is not an example of acervuline *Eozoon*, but rather of fragments of such a structure, confusedly aggregated together, and having the interstices and cell-cavities filled with serpentine. I have not found in any of these fragments a canal-system similar to that of *Eozoon Canadense*, though there are casts of large stolons, and, under a high power, the calcareous matter shows in many places the peculiar granular or cellular appearance which is one of the characters of the supplemental skeleton of that species. In a few places a tubulated cell-wall is preserved, with structure similar to that of *Eozoon Canadense*.

Specimens of Laurentian limestone from Wentworth, in the collection of the Geological Survey, exhibit many rounded siliceous bodies, some of which are apparently grains of sand, or small pebbles; but others, especially when freed from the calcareous matter by a dilute acid, appear as rounded bodies, with rough surfaces, either separate or aggregated in lines or groups, and having minute vermicular processes projecting from their surfaces (Pl. XII. fig. 3). At first sight these suggest the idea of spicules; but I think it on the whole more likely that they are casts of cavities and tubes belonging to some calcareous Foraminiferal organism which has disappeared. Similar bodies, found in the limestone of Bavaria, have been described by

* Vol. xxii. p. 608.

† I use the term "septariiform" to denote the *curved* appearance so often presented by the Laurentian serpentine.

Gümbel, who interprets them in the same way*. They may also be compared with the siliceous bodies mentioned in a former paper as occurring in the Loganite filling the chambers of specimens of *Eozoon* from Burgess.

III. Specimens from Madoc.

I have already referred to fragments of *Eozoon* occurring in the limestone at Madoc, one of which, found several years ago, I did not then venture to describe as a fossil. It projected from the surface of the limestone, being composed of a yellowish dolomite, and looking like a fragment of a thick shell. When sliced, it presents interiorly a crystalline dolomite, limited and separated from the enclosing rock by a thin wall having a granular or porous structure and excavated into rounded recesses in the manner of *Eozoon*. It lies obliquely to the bedding, and evidently represents a hollow flattened calcareous wall filled by infiltration. The limestone which afforded this form was near the beds holding the apparently worm-burrows described in the Society's Journal for November, 1866.

[A thin section of this body, carefully examined microscopically, presents numerous and very characteristic examples of the canal-system of *Eozoon*, exhibiting both the large widely branching systems of canals and the smaller and more penicillate tufts (Pl. XII. figs. 4, 5) shown in the most perfect of the serpentinous specimens—but with this difference, that the canals, being filled with a material either identical with or very similar to that of the substance in which they are excavated, are so transparent as only to be brought into view by careful management of the light.—W. B. C.]

IV. Objections to the Organic Nature of Eozoon.

The discovery of the specimen from Tudor, above described, may appear to render unnecessary any reference to the elaborate attempt made by Profs. King and Rowney to explain the structures of *Eozoon* by a comparison with the forms of fibrous and dendritic minerals †, more especially as Dr. Carpenter has already shown their inaccuracy in many important points. I think, however, that it may serve a useful purpose shortly to point out the more essential respects in which this comparison fails with regard to the Canadian specimens—with the view of relieving the discussion from matters irrelevant to it, and of fixing more exactly the limits of crystalline and organic forms in the serpentine-limestones and similar rocks.

The fundamental error of Messrs. King and Rowney arises from defective observation—in failing to distinguish, in the Canadian limestones themselves, between organic and crystalline forms. This is naturally followed by the identification of all these forms, whether mineral or organic, with a variety of purely crystalline arrangements occurring in other rocks, leading to their attaching the term

* Proceedings of Royal Academy of Munich, 1866; Q. J. G. S. vol. xxii. pt. i. p. 185 *et seq.*

† Quart. Journ. Geol. Soc. vol. xxii. pt. ii. p. 23.

"Eozoonal" to any rock which shows any of the characters, whether mineral or organic, thus arbitrarily attached to the Canadian *Eozoon*. This is obviously a process by which the structure of any fossil might be proved to be a mere *lusus naturæ*.

A notable illustration of this is afforded by their regarding the veins of fibrous serpentine, or chrysotile, which occur in the Canadian specimens, as identical with the tubulated cell-wall of *Eozoon* —although they admit that these veins traverse all the structures indifferently and do not conform to the walls of the chambers. But any microscopist who possesses specimens of *Eozoon* containing these chrysotile veins may readily satisfy himself that, under a high power, they resolve themselves into *prismatic crystals in immediate contact with each other*; whereas, under a similar power, the true cell-wall is seen to consist of *slender, undulating, rounded threads of serpentine, penetrating a matrix of carbonate of lime.* Under polarized light more especially, the difference is conspicuously apparent. It is true that, in many specimens and parts of specimens, the cell-wall of *Eozoon* is badly preserved and fails to show its structure; but in no instance does it present the appearance of chrysotile, or of any other fibrous mineral, when examined with care under sufficiently high powers. In my original examination of Sir William Logan's specimens from Grenville and the Calumet, I did not detect the finely tubulated cell-wall, which is very imperfectly preserved in those specimens; but the veins of fibrous serpentine were well known to me; and when Dr. Carpenter discovered the tubulation of the cell-wall in the specimens from Petite Nation, I compared this structure with that of these veins, and satisfied myself of its distinctness before acceding to his conclusions on this point.

It would also appear that the radiating and sheaf-like bundles of crystals of tremolite, or similar prismatic minerals, which occur in the Canadian serpentines, and also abound in those of Connemara, have been confounded with the tubulation of *Eozoon*; but these crystals have no definite relation to the forms of that fossil, and often occur where these are entirely absent; and in any case they are distinguishable by their straight prismatic shape and their angular divergence from each other. Much use has also been made of the amorphous masses of opaque serpentinous matter which appear in some parts of the structure of *Eozoon*. These I regard as, in most cases, simply results of alteration or defective preservation, though they might also arise from the presence of foreign matters in the chambers, or from an incrustation of mineral matter before the final filling up of the cells. Generally their forms are purely inorganic; but in some cases they retain indications of the structures of *Eozoon*.

With reference to the canal-system of *Eozoon*, no value can be attached to loose comparisons of a structure so definite with the forms of dendritic silver and the filaments of moss-agates; still less can any resemblance be established between the canal-system and vermicular crystals of mica. These occur abundantly in some serpentines from the Calumet, and might readily be mistaken for organic forms; but their rhombic or hexagonal outline when seen in cross section, their transverse cleavage-planes, and their want of any definite arrangement or relation to any general organic form are sufficient to undeceive any practised observer. I have not seen specimens of the metaxite from Reichenstein referred to by Messrs. King and Rowney; but it is evident, from the description and figure given of it, that, whether organic or otherwise, it is not similar to the canals of *Eozoon Canadense*. But all these and similar comparisons are evidently worthless when it is considered that they have to account for definite, ramifying, cylindrical forms, penetrating a skeleton or matrix of limestone, which has itself a definite arrangement and structure, and, further, when we find that these forms are represented by substances so diverse as serpentine, pyroxene, limestone, and carbonaceous matter. This is intelligible on the supposition of tubes filled with foreign matters, but not on that of dendritic crystallization.

If all specimens of *Eozoon* were of the acervuline character, the comparisons of the chamber-casts with concretionary granules might have some plausibility. But it is to be observed that the laminated arrangement is the typical one; and the study of the larger specimens, cut under the direction of Sir W. E. Logan, shows that these laminated forms must have grown on certain strata-planes before the deposition of the overlying beds, and that the beds are, in part, composed of the broken fragments of similar laminated structures. Further, much of the apparently acervuline *Eozoon* rock is composed of such broken fragments, the interstices between which should not be confounded with the chambers; while the fact that the serpentine fills such interstices as well as the chambers shows that its arrangement is not concretionary*. Again, these chambers are filled in different specimens with serpentine, pyroxene, loganite, calcareous spar, chondrodite, or even with arenaceous limestone. It is also to be observed that the examination of a number of limestones, other than Canadian, by Messrs. King and Rowney, has obliged them to admit that the laminated forms in combination with the canal-system are "essentially Canadian," and that the only instances of structures clearly resembling the Canadian specimens are afforded by limestones Laurentian in age and in some of which (as, for instance, in those of Bavaria and Scandinavia) Carpenter and Gümbel have actually found the structure of *Eozoon*. The other serpentine-limestones examined (for example, that of Skye) are admitted to fail in essential points of structure; and the only serpentine believed to be of eruptive origin examined by them is confessedly destitute of all semblance of *Eozoon*. Similar results have been attained by the more careful researches of Prof. Gümbel, whose paper is well deserving of study by all who have any doubts on this subject.

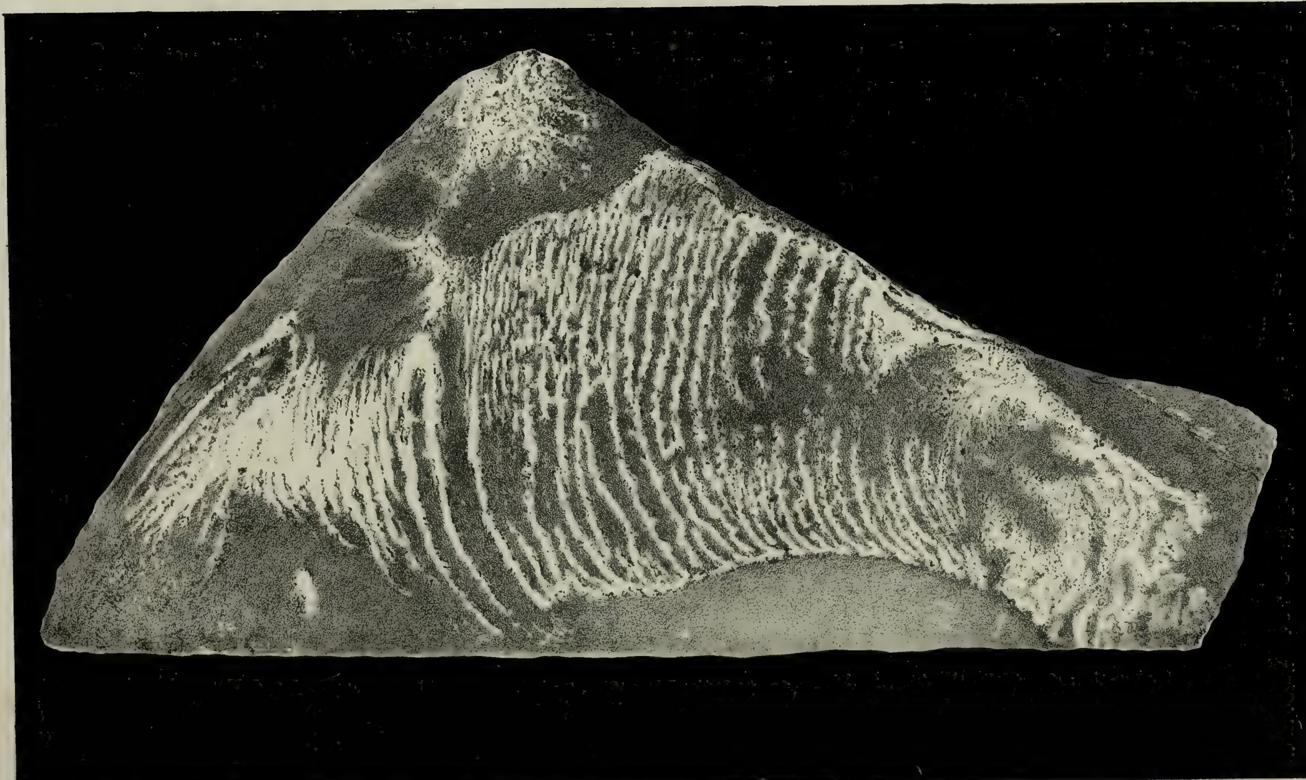
In the above remarks I have not referred to the disputed case of the Connemara limestones; but I may state that I have not been able

* I do not include here the "septariiform" structure referred to above, which is common in the Canadian serpentine and has no connexion with the forms of the chambers.

to satisfy myself of the occurrence of the structures of *Eozoon* in such specimens as I have had the opportunity to examine *. It is perhaps necessary to add that there exists in Canada abundance of Laurentian limestone which shows no indication of the structures of *Eozoon*. In some cases it is evident that such structures have not been present. In other cases they may have been obliterated by processes of crystallization. As in the case of other fossils, it is only in certain beds, and in certain parts of those beds, that well-characterized specimens can be found. I may also repeat here that in the original examination of *Eozoon*, in the spring of 1864, I was furnished by Sir W. E. Logan with specimens of all these limestones, and also with serpentine-limestones of Silurian age, and that, while all possible care was taken to compare these with the specimens of *Eozoon*, it was not thought necessary to publish notices of the crystalline and concretionary forms observed, many of which were very curious and might afford materials for other papers of the nature of that criticised in the above remarks.

[The examination of a large number of sections of a specimen of *Eozoon* recently placed in my hands by Sir William Logan, in which the canal-system is extraordinarily well preserved, enables me to supply a most unexpected confirmation of Dr. Dawson's statements in regard to the occurrence of dendritic and other forms of this system, which cannot be accounted for by the intrusion of any foreign mineral; for many parts of the calcareous lamellæ in these sections, which, when viewed by ordinary transmitted light, appear quite homogeneous and structureless, are found, when the light is reduced by Collins's "graduating diaphragm," to exhibit a most beautiful development of various forms of canal-system (often resembling those of Dr. Dawson's Madoc specimen represented in Pl. XII. figs. 4, 5), which cross the cleavage-planes of the shell-substance in every direction. Now these parts, when subjected to decalcification, show no trace of canal-system; so that it is obvious, both from their optical and from their chemical reactions, that the substance filling the canals must have been *carbonate of lime*, which has thus completely solidified the shell layer, having been deposited in the canals previously excavated in its interior, just as crystalline carbonate of lime fills up the reticular spaces of the skeleton of Echinodermata fossilized in a calcareous matrix. This fact affords conclusive evidence of *organic structure*, since no conceivable process of crystallization could give origin to dendritic extensions of carbonate of lime disposed on exactly the same crystalline system with the calcite which includes it, the two substances being mineralogically homogeneous, and only structurally distinguishable by the effect of their junction-surfaces on the course of faint rays of light transmitted through them.—W. B. C.]

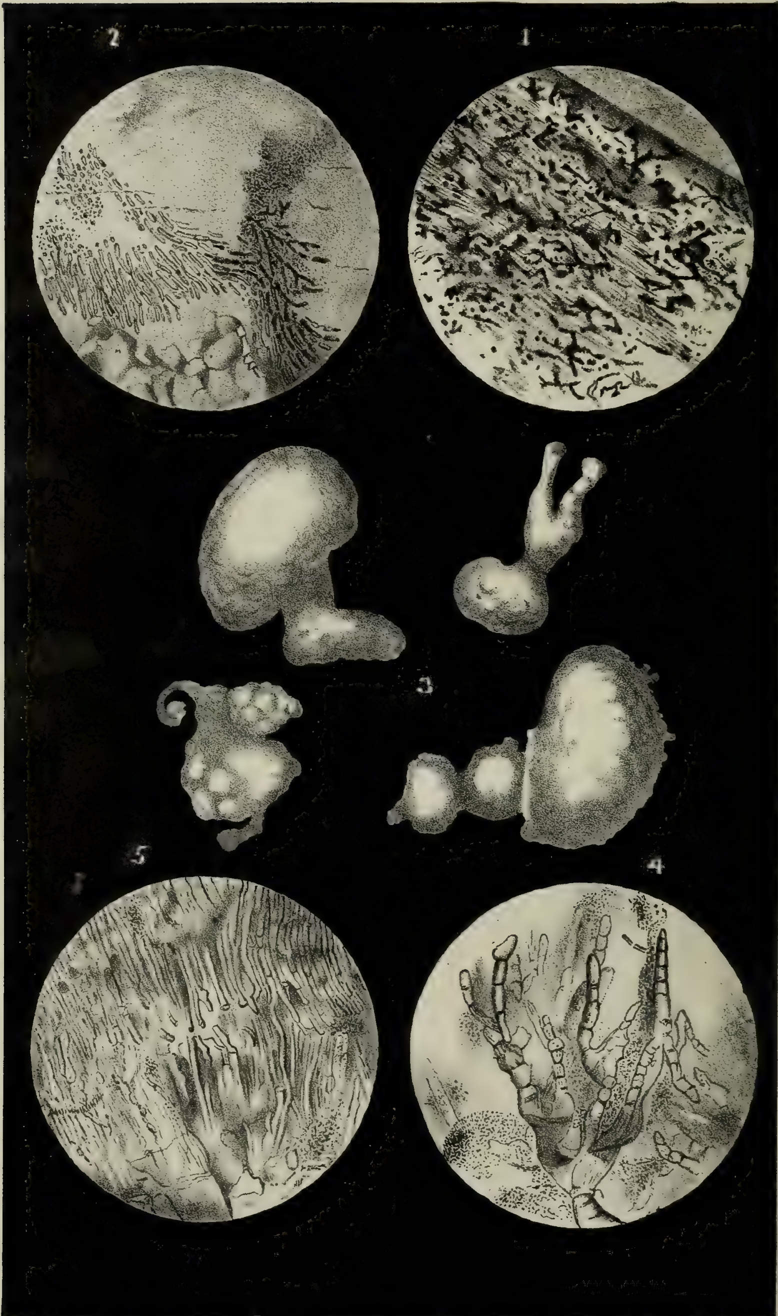
* Such Irish specimens of serpentine limestone as I have seen, appear much more highly crystalline than the beds in Canada which contain *Eozoon*.



De Wilde lith.

M. & N. Hanhart imp.

EOZOON CANADENSE FROM TUDOR.



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EOZOON CANADENSE.

EXPLANATION OF PLATES XI. and XII.

Plate XI.

Specimen of *Eozoon Canadense*, imbedded in a dark-coloured homogeneous limestone occurring in the Lower Laurentian series, at Tudor, Canada West; two-thirds the natural size.

Plate XII.

Fig. 1. Section of one of the calcareous layers of the Tudor specimen (Plate XI.), showing canal-system imperfectly infiltrated with black (carbonaceous?) matter; magnified 120 diameters.

2. Section of the shelly layer of a specimen of *Eozoon* from Grenville, showing a minute form of canal-system partly injected with black matter, and partly with serpentine; magnified 120 diameters.

3. Siliceous bodies (internal casts?) from a specimen of *Eozoon* from Wentworth; magnified 50 diameters.

4, 5. Sections of a fragment of *Eozoon* from the Madoc limestone, showing various forms of canal-system filled with carbonate of lime; magfied 120 diameters.

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3. *On* Subaerial Denudation, *and on* Cliffs *and* Escarpments *of the* Tertiary Strata. By W. Whitaker, Esq., B.A., F.G.S.

[This paper was withdrawn by permission of the President.]

(Abstract.)

From the fact that escarpments differ from cliffs in all their chief features, the author infers that the two could hardly result from the same action, but that, whilst the latter were made by the sea, the former seem to have been cut out by subaerial agents.

The chief contrasts between the two kinds of ridges are:—

(1) Escarpments always run along the strike. Cliffs rarely do so.

(2) The bottom of an escarpment is not at one level throughout. That of a sea-cliff is.

(3) At the foot of an escarpment one does not find a beach or other trace of the action of the sea, but often such débris as would be left by a slow and quiet denuding agent.

(4) Two escarpments facing the same way often run near and parallel to one another for many miles. Not so with cliffs.

(5) The ridge of an escarpment is a nearly even line, and forms the highest ground of the neighbourhood. The top of a cliff is often very uneven and bordered by higher ground.

From an examination of escarpments of the Chalk and of the Tertiary beds, it was shown that though at first sight they might seem like old lines of cliff, yet a little study would destroy the fancied likeness, and it would be found that they are quite unlike cliffs *in the same beds*; for though, from their winding outline, these ranges of hills might remind one of some irregular coast, caused by rocks of different hardness wearing away at different

rates, they have little in common with the far more even coast that is formed where there is but one kind of rock.

It was then pointed out that along the present coast the sea is not the only force engaged in the work of destruction, but that it is largely helped by atmospheric agents (the latter acting from above downwards, to detach and hurl down masses of rock, which the former, acting horizontally below, pounds down and sweeps away); and it was inferred that the joint action of the two kinds of force had a far greater effect than either alone.

In conclusion it was argued that as deposits of great thickness (such as the Wealden beds) had been made by rivers, it must be granted that (allowing for waste) still greater masses of rock had been destroyed by streams and by subaerial actions generally. The denuding power of the sea, however, was by no means denied; but it was allowed that as marine deposits much exceed in quantity those of freshwater origin, so the great denudations, the planings-down of vast tracts of which examples are given by unconformities, have been worked out by the action of the sea, but that, on the other hand, the far smaller denudations and *comparatively* trifling irregularities of the surface (our hills and valleys) have been worn out by the long-continued action of rain, rivers, and ice.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

May 22, 1867.

Elias J. Beor, Esq., Mining Engineer, Swansea; Harmer Edward Moore, Esq., C.E., 66 St. George's-road, Belgravia, S.W.; Henry Alleyne Nicholson, Esq., B.Sc., 18 Nicolson-street, Edinburgh; Henry Waugh, Esq., C.E., Gainsborough, Lincolnshire; and the Rev. Francis Le Grix White, M.A., Croxton Parsonage, Eccleshall, Staffordshire, were elected Fellows.

The following papers were read:—

1. *On the* Bone-Caves *near* Crendi, Zebbug, *and* Melliha, *in the* Island *of* Malta. By Captain T. A. B. Spratt, R.N., C.B., F.R.S., F.G.S.

Contents.

I. Introduction.

This paper was, for the most part, written several years ago, but its publication has been delayed with a view to its accompanying the description of the remains of the extinct animals found within the several caverns, and more particularly the detailed description of the *Elephas Melitensis* (the Pigmy Elephant) by the late Dr. Hugh Falconer. His lamented and premature death causing a still further delay, it is now presented to the Society in anticipation of the immediate publication of Dr. Falconer's prepared drawings and final notes upon the Little Elephant, with other posthumous papers, under the editorship of his friend Dr. Murchison, F.R.S.,—and also in anticipation of an elaborate paper upon the same subject, which is being prepared by Mr. G. Busk, F.R.S., to whom the bones were transferred at Dr. Falconer's decease. The bones of birds have been described by Mr. W. K. Parker, F.R.S. &c.*

II. The Maghlak Bone-cave.

The first of these bone-caves was discovered in the summer of 1858, on the south coast of Malta, near the town of Crendi. That part of the coast, for a distance of about six miles on either side of the cavern, presents a line of almost precipitous cliffs or bold scarps, extending from Marsa Scirrocco Bay, at the south-eastern extremity of Malta, to the small bay Foum el Rieh, at the north-western extremity and the base of the Bengemma heights or plateau.

These bold features terminate above in two distinct plateaux of nearly equal extent—the eastern plateau averaging a height of from 300 to 350 feet above the sea, and the western averaging about 800 feet and forming the summits of the before-named Bengemma heights.

The strata constituting these two plateaux lie nearly horizontal, there being a slight dip to the eastward throughout; and the origin of the plateaux is plainly due to the upper series of rather soft strata that rise up into the upper or western plateau having been entirely swept off from the lower and harder strata of calcareous sandstones and compact limestone by an encroachment of the sea, when it must have long remained about that level.

It was therefore the exposure of the harder stratum of limestone constituting the lowest of the series on the coast, near the village and well-known Phœnician ruin of Crendi, that led to the opening of a quarry there in 1858 for a durable stone suitable for the construction of the new naval dock, and, in the autumn of the same year, to the unexpected discovery of a bone-cave containing remains of the Hippopotamus and other animals. I therefore adopted the name of Crendi to distinguish the locality of the bone-cave and quarry, in my brief notice of the discovery laid before the Geological Society in 1859.

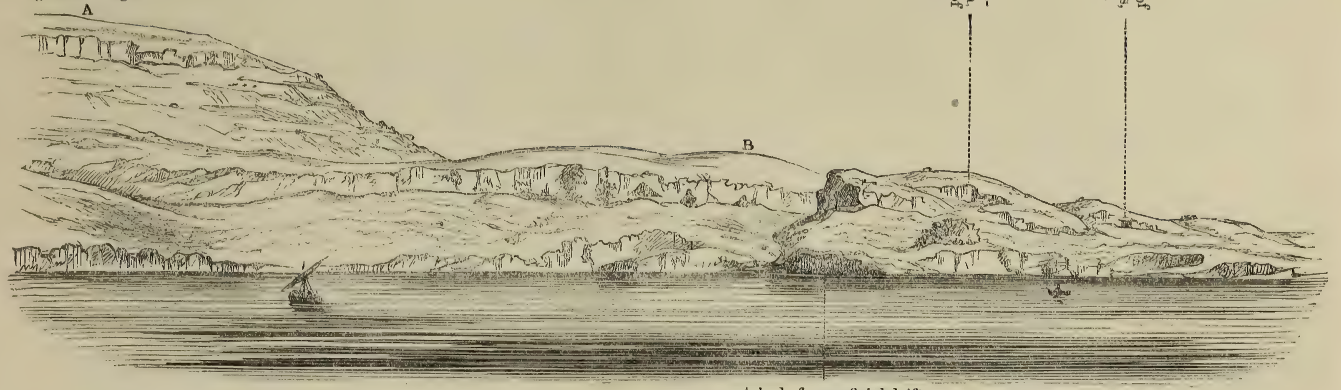
The late Mr. Horner, in his Presidential Address to the Society in 1861, consequently adopted the name of Crendi also for this quarry and cavern in his notice of the interesting discovery.

As Dr. Leith Adams, F.G.S., who arrived in Malta about two years subsequent to the first discovery of the cave, and whose more recent labours amongst its débris enabled him to procure similar remains, and to learn the history of the cavern both from the quarrymen and myself, adopted the local name of Maghlak, in a notice which he published respecting the cavern and its relics, in the Royal Dublin Society's Journal † and in his Report to the British Association ‡, geologists have in consequence a somewhat confused familiarity with both names; it is therefore necessary for me to point out that they both apply to the same quarry and cavern.

At about the same level as the Crendi or Maghlak cavern, the crest cliffs overlooking the sea on both sides have indications of the

* Trans. Zool. Soc. vol. vi. p. 119.
† Vol. iv. p. 11.
‡ British Association Report, 1865, p. 259.

Fig. 1.—*Sketch of some of the Cliffs and Caves of Malta.*



A. Upper Plateau, consisting of upper series of strata.
B. Lower Plateau, denuded of upper series of strata

former existence of several other caverns more or less shallow and open, more particularly on the west side, as shown in the sketch (fig. 1). None, however, contain any stalagmitic floor, or present any indication of bone breccia; and although generally wider and higher than the Maghlak Cavern, none of them penetrated so far inwards, except one, of very great interest, lying about 100 yards on the east side, between the Maghlak quarry and the lowest of the Phœnician temples of Crendi above alluded to, which has been very recently opened by Dr. Adams (see sketch), and found by him to be of such importance, from the special character of the larger mammalian remains, being those of Elephants* and not of Hippopotamus, as to have induced the British Association to grant to him the sum of £30 for its exploration; the results, as far as obtained, will therefore, I believe, form the subject of a Report by Dr. Adams.

Having proceeded to the Maghlak Quarry soon after the discovery of the bone-cavern within it, in company with my friend, W. Medlycott, Esq., we were shown numerous large blocks of its stalagmitic flooring, mingled with the talus of débris that had recently been ejected from the quarry, down the sea face of the scarp lying under it, and also upon a narrow natural terrace existing about halfway down. After some labour with our hammers amongst the blocks of bone-breccia found lying upon the talus, and upon this lower terrace, we were enabled to procure from them a few perfect teeth, and some nearly perfect tusks of the Hippopotamus; but from the extreme hardness of the stalagmitic bone-breccia, and the friable nature of the teeth, they in general crumble to chips under the heavy blow of the hammer necessary to fracture the hard matrix in which they are imbedded. The bones and teeth, however, were very numerous throughout these detached and fragmentary blocks, and showed that the remains of a large number of these animals were originally accumulated in the cavern, but indiscriminately, and that they consisted chiefly of the smaller bones of this mammal.

From close examination of the numerous fragments of bone-breccia, we were enabled to perceive that the flooring of the cavern consisted of two distinct layers of fossil bones. The lower, which must have been in some parts fully 3 and 4 feet thick, and composed of an indurated, brownish, stalagmitic clay, almost as hard as flint or jasper, contained in abundance well-rounded pebbles of the native rock, intermixed with the bones and teeth of the Hippopotamus; but these bones and teeth were not in general waterworn, as were the pebbles and shingle found with them; and consequently they were introduced into the cavern *after* its shingle floor had been raised above the surf-action of a surrounding sea, which no doubt produced both the caverns, and also rounded the pebbles, since there is no evidence or good reason to infer that either this cavern or the neighbouring caves on nearly the same level require any local river to account for their origin and position.

On comparing these teeth and tusks, immediately afterwards, with figures in Pictet's 'Paléontologie,' I was led to refer them to the

* Geological Magazine, vol. ii. p. 490.

Hippopotamus, which conjecture was confirmed by Prof. Owen on the exhibition of the teeth in the Geological Society's rooms in 1859; and moreover they were then identified by him as the same species as that found so abundantly in the bone-caves near Palermo and in other parts of Sicily, viz. *H. Pentlandi*. These large mammalian remains were overlain by a bed of similar stalagmite of one foot or more in thickness, but without fossils, showing a period during which the Hippopotamus had become extinct; and this was succeeded by another stalagmitic bone-bed containing abundantly the bones and teeth of a Rodent, named *Myoxus Melitensis* by Dr. Falconer. Besides the Rodent bones, there were also the bones of Birds. From the fragments of the flooring scattered with the débris under the quarry, this upper stalagmitic crust enclosing the Rodent and Bird remains was seen to have varied in thickness from 6 or 8 inches to a foot or more in some parts of the cavern.

On ascending to the quarry to learn from the quarrymen more of the nature of the cavern when first discovered, we were informed that it did not extend inwards more than about 40 or 50 feet from the face of the cliff; and at about that distance from it, within the quarry, we were shown a portion of its stalagmitic flooring *still in situ*, forming what appeared to have been the termination of a narrow recess at the inner end of the cavern. This fragment of bone-breccia *in situ* exhibited the same arrangement as above described from the débris of fragments ejected from the quarry; that is, the Hippopotamus-remains were entirely confined to the lower stratum, and the Rodent and Bird-bones, with land shells of living species, to the upper; but it was composed at this part *in situ* of about a foot of thinly stratified stalagmitic layers, with red earth or clay between them, whence I swept up several handfuls of the fragments of Bird-bones, and of the teeth and bones of the Rodent *Myoxus Melitensis*, so named by Dr. Falconer, and described in a letter to me soon afterwards as a Dormouse of twice or thrice the size of the existing species.

III. The Zebbug Ossiferous Cavern.

Two years subsequent to the discovery of the bone-cave near Crendi, another of more startling interest was discoverd, in the centre of the island, near the large town of Zebbug. It was accidentally struck upon in sinking an excavation for a tank, upon the upper of the two terraces forming the garden of Signor Buttegieg, on the north side of the rocky valley separating the towns of Zebbug and Seggieni. The excavation for the tank had reached a depth of 10 or 12 feet in the native rock, when the roof of the cavern was suddenly broken into, and it was found filled to the top with clay; and as it was much narrower than the intended diameter of the tank, the excavation of the rock was continued down to the floor of the cavern, viz. about 5 feet lower, thus separating the outer portion of the cavern from its inner, as shown in the following ground-plan (fig. 2).

The openings leading off from the tank on each side into the extension of the cavern inwards and outwards were then walled up to complete the cementing of its sides, so as to enable it to retain water.

In removing the loose soil and clay from the part of the cavern thus broken into (for it was full to the roof with yellow and grey sandy clay, without any stalactites, or stalagmitic floor, such as existed in the Hippopotamus-cavern of Maghlak), a quantity of fragments of bones and teeth of at least two species of *Elephas* (one of ordinary size, but the more abundant being of a remarkable pigmy species), and other bones of extinct animals were found mingled with subangular and not waterworn fragments of the parent calcareous sandstone rock in which this fissure-like cavern ran, the bones and fragments being generally found lying upon the natural floor of the cavern. These had been thrown out confusedly together into an accumulated heap of soil and fragments near the mouth of the tank, and remained undisturbed at my visit.

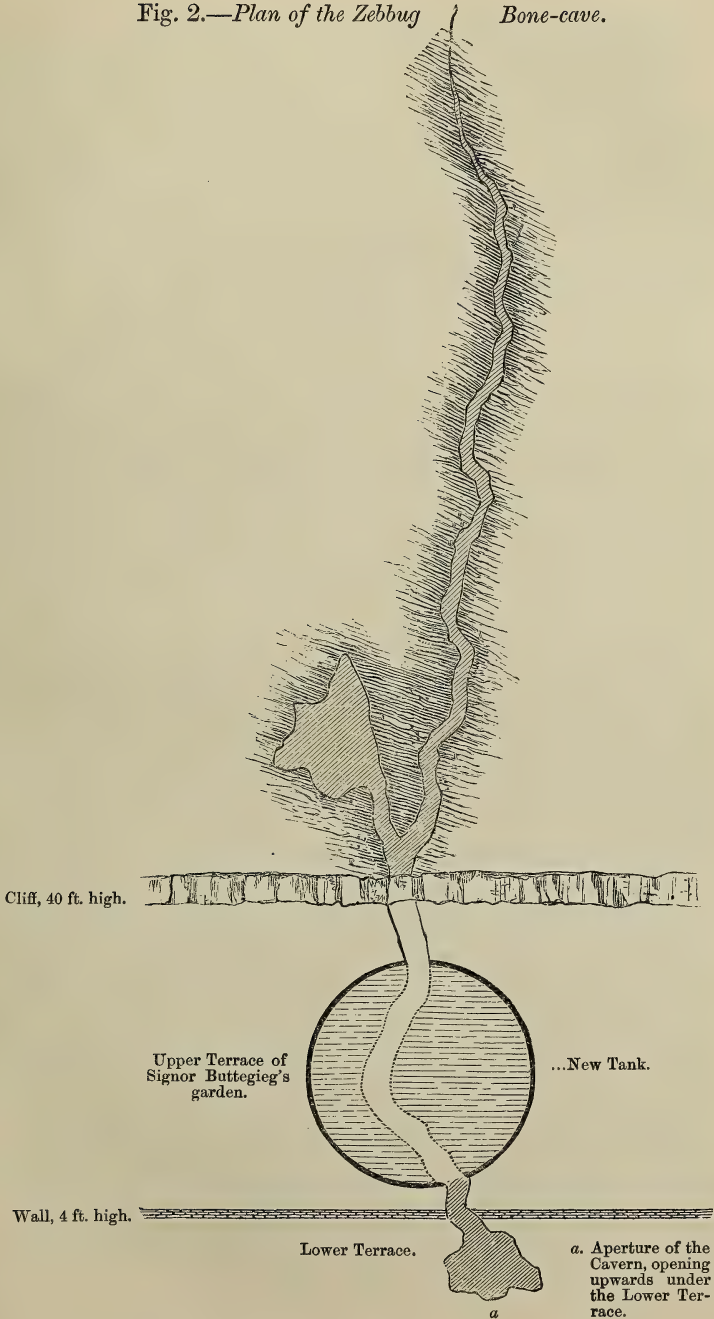
As on examining this heap of cave soil I procured a considerable number of fragments of the same Pigmy Elephant as I had seen in the Library Museum, and which had been presented a short time previously by Signor Buttegieg, the proprietor of the garden, I was anxious to complete the exploration of the parts of the cavern that had been walled up; and by the kind permission of the proprietor, and the assistance of his son, Padre Pietro, I had the cavern reopened on each side of the tank, and finally traced it inwards to a distance of about 75 feet. It was then traced for about 15 feet on the other side of the tank, to its original mouth opening out into the side of the valley, but which now lies completely under the soil and roots of the fruit-trees growing upon the lower terrace of the garden at about five or six feet only above the level of the rocky torrent-bed that meanders through the valley. The cavern, I found, ran nearly horizontally from the ravine, having one short branch, terminating in a small chamber as seen in the plan, and varied in height from $4\frac{1}{2}$ to $5\frac{1}{2}$ feet, with a breadth varying from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet, until it became contracted to a few inches only.

The results of this exploration, and a subsequent resifting of the heap of soil when dry, some months after, by the express desire of the late Dr. Falconer, yielded not only many bones of the Pigmy Elephant, but also a complete set of the tusks and teeth of this singular extinct species, in every stage of growth, mingled with which were fragments of ivory, that had evidently formed part of the tusk of a much larger but ordinary-sized elephant; yet none of the teeth of the latter were found.

All these fragments bore evidence, more or less marked, of fierce gnawing by some carnivorous animal, apparently not larger than a jackal. But it became apparent to me during the examination of these fragments that they differed entirely from the large mammalian remains from Crendi cavern, and that it in fact contained no remains of Hippopotamus.

The necessity of keeping this point in view, and the importance of identifying its relics, as being distinct from those of the Crendi

Fig. 2.—*Plan of the Zebbug Bone-cave.*



[The shaded parts of the cavern are those which were excavated by the author.]

cavern, became more and more evident as the exploration progressed, since they had now become confused together in all local collections and in the local notices of these caverns, none of the writers having visited either cavern; and thus all idea of their special characters, as being probably indicative of two distinct geological periods or conditions of the island, was lost sight of.

Besides these relics of the Elephants, there were fragments of the large and small bones of aquatic birds, namely two gigantic Swans *, and of a Turtle, or Tortoise,—as also some few bones and jaws of the *Myoxus Melitensis* found in the Crendi cavern, and another species of *Myoxus*, figured by Dr. Carte in the 'Transactions' of the Royal Dublin Society.

IV. The Melliha Cavern.

In the Spring of 1862 I was again so fortunate as to find the vestiges of another bone-cave in Malta (namely, near the village of Melliha, at the north end of the island), a report of the existence of which had, however, been communicated to Lord Ducie and myself, five or six years previously, by Mr. St. John, then Deputy Inspector of Police; but our efforts to find it at the time did not result successfully, as the discovery was made more than 20 years previously, and but a few fragments of it had been seen by any one but the peasant who found it and utilized its débris in the walls and terraces he was constructing near the spot. But having in the early part of 1862 accidentally seen in the collection of local fossils made by Signor Pace, of the Protestant College, a fragment of the tooth of a Hippopotamus, which he had himself recently found in a wall under the village of Melliha, I was induced to make further research and inquiry at the locality for the above-mentioned ossiferous breccia. Its position was at length shown to me, at about 200 yards to the north of the church or chapel of Melliha, and in front of a cavernous cliff that fringes the north crest of the hill there, at an elevation of about 300 feet above the sea, the old chapel itself being partly formed within one of these shallow caverns, which are all at about the same level as the Crendi caverns, and were, no doubt, originated by the same cause and at the same time, the present sea-shore under the Melliha caverns being only from 200 to 300 yards distant from them. Some of the caverns have been enlarged and utilized as stables; and others were converted into rock habitations, or tombs, by the ancient inhabitants of this part of Malta.

The bone-breccia when originally discovered at Melliha was found lying at a distance of from 15 to 20 feet and more in front of one of these shallow caverns, thus showing that the roof of the cavern must have extended beyond its present limits at the time when the bones of the extinct Hippopotamus it contained were carried into it; also the breccia lying between two projecting angles of the cliff is likewise an indication of the fact of the former extension of the cavern beyond its present area, and of the great antiquity of the cavern breccia in a geological point of view.

* Described by Mr. W. K. Parker, F.R.S., Trans. Zool. Soc. vol. vi. p. 111.

The previously disturbed parts of this bone-breccia I found mingled with the walls of the adjacent terraces, and procured from them two bushels of bone-fragments, amongst which were several perfect teeth, as well as many fragments of teeth and tusks of *Hippopotamus*, as at the Crendi Cavern, but of a smaller species.

As a narrow space of about ten or twelve feet in length, and six or eight in breadth, existed between a terraced road recently made, leading to a cemetery, and the front of the part of the cavern that now remains, I dug down there to verify the information regarding the spot at which the ossiferous breccia was discovered, and was fortunate in finding a portion of the bone-breccia still *in situ*, which I broke up (more of it lies under the road), and found it also to contain fragments of bones and teeth of the same *Hippopotamus* as did the scattered fragments of the débris gathered from the adjacent terraces and walls. No remains of the *Elephant* were found here. Neither were any small bones, such as those of Rodents and Birds, found in it, or in any of the scattered fragments, as in the upper stalagmitic stratum of the Crendi cavern, and as was found also in the Zebbug cavern, commingled with the Elephant-bones; but the bones of the Birds and small *Myoxus* may have existed in the original condition of the floor of the Melliha cavern nevertheless, although not contemporary with the Hippopotamus, since we have now but a fragmentary exhibition of it.

V. General Conclusions.

The Melliha cavern, like the Crendi cavern, seemed, therefore, to have exclusively contained remains of *Hippopotamus* only; for not a single fragment of the tusk or tooth of either species of Elephant was found amongst the fragments of bone-breccia to indicate their contemporary existence with the Hippopotamus, although there were the remains of many individuals of the latter; and thus the time of the Melliha cavern seemed to have been associated exclusively with the remains of *Hippopotamus* of the lower stalagmitic stratum of the Crendi cavern, rather than with the Zebbug cavern, the remains in which were exclusively those of the Elephant; and therefore also the relics in the latter cavern are more probably linked with the *Myoxus* and Bird bones, and existing land shells, forming the upper stalagmitic stratum of the Crendi cavern.

It is remarkable that the lower part of the Crendi cavern, and the entire bone breccia (at present found) of the Melliha cavern, are characterized by the bones and teeth of the Hippopotamus only, and the Zebbug Cavern débris by only Elephant-teeth, tusks, and bones, to the exclusion of any remains of Hippopotamus.

Therefore the upper stalagmitic layer of the Crendi cavern, containing existing land shells imbedded with the Rodent and Bird bones, seems to bring the latter, and the associated Pigmy Elephant of the Zebbug cavern, down to a period more recent than the Hippopotamus—in fact, to a distinct and later geological epoch; for had these animals existed at the same time with the Hippopotamus, their relics would have been found in some degree commingled in these caverns.

This was a point I felt it especially necessary to notice when the remains of this remarkable little species of extinct Elephant were exhibited by the late Dr. Falconer and myself, in 1862, at the Cambridge Meeting of the British Association.

It therefore opens out the following questions:—What were the times, and what were the special conditions of the locality favouring the existence of each large species of Mammalia? one being so distinctly an amphibious animal, and moreover an animal peculiar to a freshwater condition not now in any way indicated by the existing climate and region; and the other an animal exclusively of the forest and land, and thus indicating the existence, at one time, of a very proximate, if not entire connexion of Malta with Europe and Africa, by land that must have existed to serve as a highway of migration between them, but which has since subsided beneath the Mediterranean.

These submerged lands are really now indicated by the bank called the "Adventure Bank," discovered by Admiral Smyth, between Tunis and the north-west part of Sicily, as one, and no doubt the most important, highway of migration of these extinct animals, and also by another bank, which we found soon after the discovery of the Elephant Cavern of Zebbug, as a well-defined, but more deeply submerged, ridge, connecting the south-eastern end of Malta with Tripoli, and which I have named the "Medina Bank," after my ship, 'The Medina.'

So that if we were to have an upheaval of about 250 fathoms of the whole sea-bed of the Malta channel, we should have both these banks or ridges dry land, with the exception of a narrow channel through each, that would not be impassable to either animal at the seasonable times for migration; and Malta would be connected with Sicily, and Sicily with Italy, but with a deep, steep-sided and enclosed sea lying between these upraised banks, viz. between Sicily, Malta, Tunis, and Tripoli, with the extinct volcanos of Linosa Island and Graham's Shoal on either side of the basin, to show that its somewhat crater-like form, as it would then appear, from the abruptness of its sides, was really due to proximate volcanic upheaval and downcast, and that this was a basin to account for the origin of which a glacial excavation is not necessary, as seems to be the creed of some geologists regarding the greater part of such deep depressions.

And I am induced to add also, in respect to this supposed physical change in the relative positions of land and sea, that it most probably existed at no very distant geological time, and that it bore a remarkable resemblance to the Sea of Marmora, with its Bosphorus and Dardanelles as straits connecting it with the Black Sea and Mediterranean. For there would now remain, with an uplift of 250 fathoms of the entire Malta strait, a deep internal sea, nearly 200 miles long and 60 broad, and from 50 to 500 fathoms deep, and with a narrow strait between the Adventure and Medina Banks, connect-

Fig. 3.—*Chart showing the position of the Adventure and Medina Banks, connecting Sicily with Africa.*

The figures denote the present depths in fathoms. The dotted line shows the parts of the Malta Channel that would be converted to dry land by an uplift of 200 fathoms, and the narrow Straits that would remain through the Adventure and Medina Banks. The deepest water is indicated by the black portions, the banks by the dark tint, and the land by the light shading.

ing this basin with the east and west basins of the Mediterranean (see fig. 3).

The abundance of the remains of *Hippopotamus* that have been accumulated in the Malta caverns lying over the bold coastline of this island, as also in the caverns over the north shore of Sicily, and also in another at the level of the sea or, indeed, partially below its level, that was discovered by the late Dr. Falconer near Syracuse, seems therefore to point to the necessary existence of large areas of land and fresh water when these Hippopotami existed in great abundance, as well as of abundant vegetation and of forests at that time. The late Mr. Leonard Horner, when President of the Geological Society, in referring to my notice of the discovery of the Crendi cavern with such abundant remains of *Hippopotamus*, in his Address for the year 1861, consequently conceived that a large river must have flowed between Malta, Sicily, and Africa, at the time these creatures were so numerous; and Dr. Leith Adams, in a subsequent notice of the Crendi cavern, adopts the same view, and thus considers that bold coast of Malta to represent the bank of an ancient river.

But the same reasoning and conclusion, if sound for the south coast of Malta in explanation of the existence there of *Hippopotamus*, must be likewise applied to the north coast of the island under the Melliha cave, and likewise to the whole of the north and east coast of Sicily opposite Palermo and Syracuse, where similar remains are found, but in much greater abundance; and therefore to suppose that a river meandered round all these coasts at one time, since the known caverns with *Hippopotamus* are all confined to the coast, involves the combination of many contingencies, for the maintenance and confinement of such a river, not usually met with, and certainly not indicated by the geological facts and physical features in connexion with either of the localities.

I therefore am induced to repeat what I have before advanced, that it seems, in my humble judgment, rather to point to a freshwater, or perhaps brackish-water condition of the whole Mediterranean area at that time, especially as we find these ossiferous caverns mainly upon the margin of its steepest coast-line; and singularly too they are mainly over the deepest parts of the sea at present surrounding these islands; and thus where an *opposite bank* for even an unusually wide river is in no way identifiable by any existing bank or submerged ridge within those deeps, viz. not within a distance of 60 miles directly opposite the Crendi Cavern, and with a depth of 500 fathoms between, at only 5 miles from the cavern. And opposite to the Sicily caverns we must cross to Sardinia and Greece for such a feature, there being from 50 to 1500 fathoms between.

The different elevations of these caves, from those at the sea-level (as the Syracuse cavern) to others at heights of from 300 to 600 feet above it, show the great and varied movements of the whole land that have occurred since the existence of these creatures—that is, both upcasts and downcasts of considerable amount.

Now, as Malta and Gozo were most probably elevated above the sea at the close of the Miocene period (since there is no indication of any purely marine deposit of a more recent time upon them anywhere), it is therefore very possible that the caverns formed by the long action of the sea upon the first upraised zones may contain the relics of animals of more than one, if not of each, subsequent geological period; and we may possibly with reason infer that there are some of them with animal remains characteristic of one era only, and others of another, according to their local convenience, at the several periods, for the resort of the associated animals of prey, and from their size and situation &c.

Thus we may have caverns that, although formed simultaneously and at the same level, may be found to contain now the débris of extinct animals of distinct geological times, precisely as seems to be indicated by the facts before noticed in reference to the distinct Mammalia that characterize the Hippopotamus-cavern near Crendi and the Elephant-caverns near Zebbug.

Dr. Leith Adams and Captain Hutton have both communicated, through the Geological Magazine*, that they have found the remains of the Elephant in the scattered débris of subangular fragments and red earth which occur in fissures and hollows in various parts of the island of Malta, and which I believe to be due to a wave of translation rather than to river-floods, and to have resulted from a huge wave-stroke from the subsidence of neighbouring lands, or from a sudden subsidence of the greater part of Malta itself below the sea at a very recent geological period, but which subsidence was of too short a duration to produce a purely marine deposit—since no perfect marine shell is common to any of the débris, although entire land shells of existing species are very numerous.

Therefore the Pigmy Elephant and its associates seem probably to have become extinct during the Post-Pliocene period, when the subsidence took place; for fragments of this drift deposit, or débris, are found on several parts of the low coast as well as in the interior. It closely resembles a drift-deposit that occurs along the whole of the lower part of the African coast, extending between Alexandria and Tripoli, in which marine and blown sands are mingled with beds of red earth, and sometimes small subangular fragments of the adjacent rocks, as well as *entire land shells* in the sandy or red earthy deposits, just as occurs in the Malta drift-beds. It contains no entire marine shells, only small fragments of the harder marine species, showing that no tranquil condition of the waters existed for any time during the accumulation of this drift, but that it is clearly due to waves of translation that swept the adjacent plains and lower hills during sudden and brief submergences that have occurred on the African coast, at least three times on the Tripoli and Cyrene coasts and other places eastward towards Alexandria, as I have briefly shown in the Geological Appendix to 'Travels in Crete,' vol. ii.

The most instructive of these beds of débris on the coast of Malta

* Vol. ii. p. 488, and Vol. iii. p. 145.

is to be seen on the north side of the Bay of Melliha, where a bed of red vegetable soil from 4 to 5 feet thick, with subangular fragments of the parent rock, exists in a sheltered part of the bay a little above the sea-level, and is overlain by irregular beds of red earthy sand and soft calcareous sandstone, that can be traced to have reached a height of nearly 50 feet, and much more in other parts.

The sand, for the most part, seems to be an admixture of blown and drifted beach-sand, and to contain minute fragments of sea-shells, and the spines of sea-eggs, the most abundant of all living creatures in the shallows of the sea surrounding the island; *and the only entire shells in this débris anywhere are land shells of existing species, which are common.*

The explanation of such an anomalous admixture of only minute fragments of the marine fauna as a general characteristic, but with entire land shells, although so much more fragile, can only be accounted for by regarding it as the result of a huge wave that suddenly swept over the surface of the island, and was probably accompanied by a short subsidence. For the dead land shells, through being filled with air when caught up by such a wave as it rushed over the surface of the land, would, by their consequent greater buoyancy than the fragments of bones and stones and surface débris caught up with them, have floated with the silt and lighter matter, and thus have been preserved and finally deposited entire with the more earthy débris, as we find here, and exactly as I found repeated in numerous places on the north coast of Africa, and without any indication of an associated tranquil layer or bed, or any entire marine shell to indicate a subsidence sufficiently long to have caused a return of the marine fauna to it. As in excavating the new and old naval docks at Malta the same beds of red vegetable earth and fragments of surface débris with land shells were found in caverns and crevices that were broken into at 20 feet and more below the present level of the sea, there seems reason to conclude that the island has not risen again quite to the level it reached previously to this subsidence and wave-overflow from which I presume the débris to have mainly resulted.

Now I am strong in the opinion that we must give waves of translation their due power and effect in contemplating the origin of some high-level as well as low-level accumulations of similar débris, in which land shells and the bones of land animals alone exist in conjunction with small unworn fragments of the native rock. We have had many evidences in the historic and even recent times of waves of the sea having swept over lands adjacent to the coast to heights of 50 and 100 feet during earthquakes, and where sudden but comparatively small uprisings or subsidences have occurred, as on the coast of Peru and Chili.

I have previously shown the improbability of these Malta beds of débris having resulted from any ancient local river, independent of the absence of any rolled pebbles or gravel to indicate it in any manner—or even from land-floods, which, as they generally follow the low lands bordering rivers, would, I consider, have left some rolled material intermixed with the débris. Next, glacial action cannot have been their origin in Malta—first, from their containing no transported blocks of any size to require or indicate such a moving power, and, secondly, because glacial conditions are inconsistent with the indications of a prolific land-fauna and vegetation that must have existed there, from the large quantity of the larger species of land shells (*Helix* &c.) that are found in it, independently of the Elephant-bones that are also confusedly intermingled in these beds of subangular fragments, sand, and red earth. Therefore I believe that a wave of translation was the true cause of these accumulations of *land-shell drift-beds* found in Malta and Africa, and such as my friend Mr. Busk, F.R.S., has stated to exist also at very high levels in Gibraltar; and I believe that they are generally the indications of sudden uprisings and subsidences of lands adjacent, or of the localities themselves, that have caused waves of translation and accumulation, when unaccompanied by any tranquil marine bed or marine shells, except such as have been confusedly swept up from an adjacent shore. And this general discussion of the question is probably not out of place here, from the general interest existing regarding such beds of débris and drift, and which glaciers, floods, and waves are each capable of producing, without doubt; but each have their special characters and influences, that require close study to solve, so that the great power and effect of a sea-wave accompanying sudden uprising and subsidences of broad or narrow areas of land may have their due acknowledgment in the past as in present times.

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2. *On the* Lower Lias *of the* North-east *of* Ireland. By Ralph Tate, Esq., A.L.S., F.G.S.

Contents.

1. *Introduction*.—From a more extended survey of the Liassic strata in the province of Ulster during the summer of 1866 than I had previously made, and from an examination of the fossils of the Lower Lias of that area, I am constrained to make some slight modifications of my views on the correlation of the members of the Lias of Ireland, as given in a paper entitled "The Liassic strata in the neighbourhood of Belfast," published in the Quarterly Journal of this Society*.

In that paper I pointed out the occurrence of beds of Rhætic age, embracing the *Avicula-contorta* shales and the White Lias, and of beds of the age of the Lower Lias, which I had regarded as equivalent to the zone of *Ammonites Bucklandi* of the English Liassic series.

I have examined every exposure of the Lias in the north-east of Ireland, and have no reason to take exception to Sir Richard Griffith's mapping of this formation—that is, viewing the Rhætic series as a subformation of the Lias. But the principal portion of

* Vol. xx. p. 103 (1864).

the Lias belongs to the *Avicula-contorta* series, which is invariably the underlying stratum to the Lower Lias; however, on the shores of Lough Mourne and Larne Lough, and on the coast at Ballintoy and Portrush, the base of the Lower Lias is not seen. And although the shales of the *Avicula-contorta* series are usually covered by the Lower Lias, yet, on the other hand, they are the last to disappear in the thinning-out of the strata between the New Red Sandstone and the White Limestone, which takes place beyond Garron Point, on the north-east*.

With regard to the Lower Lias, I have several emendations to make—changes of slight importance when palæontology is a secondary consideration, but at the present of some value as exemplifying the persistency of faunas over a large area, and elucidating the nature of a *zone*.

The Lower Lias in Ireland is capable of division into four members; the first, second, and third divisions I would correlate respectively with the zones of *Ammonites planorbis*, *Ammonites angulatus*, and *Ammonites Bucklandi*, the three lowest groups of the Lower Lias in the Anglo-French and German basins. The fourth zone represents the beds of the Lower Lias which are superior to the zone of *Ammonites Bucklandi*.

The first zone, that of *Ammonites planorbis*, is fairly developed, but is questionably separable from the second, that of *Ammonites angulatus*, which constitutes the greater mass of the Lower Lias, and is most frequently the only portion present. The third zone, that of *Ammonites Bucklandi*, is (palæontologically) easily to be distinguished from the zone of *Ammonites angulatus*. The zone of *Belemnites acutus*, the fourth of the series, represents the Belemnite-beds of the Lower Lias of France, Germany, and England, and is the highest member of the Irish Lias which I have seen; it is lithologically and palæontologically well defined.

2. *Section at Waterloo, Larne.*—This section is the key to the reading of the Liassic strata in Ireland; and I regret my inability to place on record a more detailed representation of this fine cliff-section than is here given.

I may observe that at this locality the *Avicula-contorta* series is, as a whole, a mass of indurated grey or brown marls, some few beds of which are oolitic, and even pisolitic in structure †; there is here no line of demarcation between the beds with *Avicula contorta* and the White Lias; but this may be seen elsewhere in Antrim. The base of this series is not seen; but as the cliff, known by the name of Bank Heads, 100 feet in height, is entirely composed of these beds, dipping at an angle of 27°, their thickness cannot be less than 50 feet, and, from other data, I compute the thickness of the *Avicula-contorta* series at about 120 feet.

Superior to certain grey marls are:—

1. A succession of whitish marls and black shales; these contain

* The *Avicula-contorta* series reappears in the Tircreven Burn, on the north-west, and a little beyond Colin Glen, near Belfast, on the south-west of the Liassic area.

† Quart. Journ. Geol. Soc. vol. xxi. p. 17 (1865).

no fossils, but the beds serve to establish a lithological transition from the *Avicula-contorta* series to the Lower Lias.

2. Black indurated shales with flattened specimens of *Ammonites planorbis*, and a few Mollusca, about 40 feet in thickness. These shales represent the zone of *Ammonites planorbis*.

3. An alternation of shelly subcrystalline limestones of a blackish or greyish colour, from 1 to 2 feet in thickness, and blue marly clays varying from 4 and 6 to 10 feet in thickness—the whole about 35 feet. The limestones are very fossiliferous, and the fauna is that which characterizes the zone of *Ammonites angulatus*.

4. Compact blue argillaceous limestones, weathering white, charged with *Gryphæa incurva*.

A few feet only of this zone is exposed beneath the raised sea-beach near the Coast Guard Station.

5. In the Museum of the Philosophical and Natural History Society at Belfast, there are a few fossils imbedded in a micaceous clay, obtained near Waterloo at low water. The fossils and clay are like those of Ballintoy, where the beds, hereafter to be described, are superior to those yielding *Gryphæa incurva*, and are referable to the zone of *Belemnites acutus*.

3. *The Zone of* Ammonites planorbis.—There are few sections which exhibit the series embraced from the top of the New Red Marls to the fossiliferous beds *par excellence* of the Lower Lias, as it is generally masked and disturbed by slips. But in every known exposure, black shales with few fossils are interposed between the zone of *Ammonites angulatus* and the *Avicula-contorta* shales and marls. These black shales I refer to the zone of *Ammonites planorbis*, the lithology of which, in other parts of Europe, as in Ireland, partakes more of the nature of shale than of limestone. Its fauna is not characteristic, and it is only when contrasted with that of the overlying zone that it is worthy of note; it comprises a few species of the *Avicula-contorta* series, possibly a few peculiar forms, and some species common to it and to the zone of *Ammonites angulatus*. If in the *Avicula-contorta* zone we have a foreshadowing of Liassic types of life, then the fauna of the *Ammonites-planorbis* zone is the dawning of the rich series called Hettangian.

The "Planorbis-beds" are readily recognized by their lithological characters and by the paucity of species; and I have determined their presence in the following localities:—

(1.) *Colin Glen, five miles south-west from Belfast.*—The beds Nos. 3 and 4 of this section *, which I had referred doubtfully to the Lower Lias, I would now place as the representatives of the bed No. 2 of the Waterloo section †; they consist of shales and shelly limestone, of an aggregate thickness of 21 feet 3 inches, which overlie White Lias, and are subordinate to beds of the *Ammonites-angulatus* zone.

(2.) *Whitehead.*—Similar shaly beds to those at Colin Glen have been observed by my valued friend J. Anderson, Esq., F.G.S., in the undercliff of this locality, whence he has obtained *Ammonites planorbis*, *Mytilus minutus*, and *Hemipedina*.

* Quart. Journ. Geol. Soc. vol. xx. p. 109 (1864). † *Vide supra.*

(3.) *Glenarm.*—Beds of the horizon of the *Ammonites-planorbis* zone are seen in the Little Deer Park, one mile south of Glenarm, where the following succession can be made out:—

a. Black shales with a few bands of grey argillaceous sandstones, with *Schizodus cloacinus, Avicula contorta,* &c.
b. Grey and yellow marly sandstones.
c. Black, shelly, laminated sandstones, with *Ostrea irregularis.*
d. Blue clay, with nodular and bedded shelly limestones containing *Ammonites Johnstoni.*

Beds *b* and *c* represent the zone of *Ammonites planorbis*; whilst the shales of series *a* are referable to the *Avicula-contorta* beds, which comprise a large moiety of the whole section, having a thickness of about 40 feet*.

(4.) *Garron Point.*—Here the "Planorbis-series" is represented by stiff shales, with the characteristic Ammonite, interposed between the *Avicula-contorta* shales and the limestone and arenaceous beds of the zone of *Ammonites angulatus* with *Cardinia ovalis.* The Lias is very much reduced in thickness, and entirely disappears on approaching the entrance to Glenariff Glen, to the west of this locality.

(5.) *Portrush.*—The remarkable and isolated mass of Lias at this place, which has been the subject of much discussion, consists of porcellanous shales, being the extreme of alteration† of the soft shales of the "Planorbis-zone" at Colin Glen and elsewhere, of which metamorphoses indurated shales of the same horizon at Waterloo are the first result.

Oppel‡, writing of the "Schichten des *Ammonites angulatus,*" states that "these beds appear to exist in the north of Ireland, and certainly on the coast at Portrush, from which locality I have seen in the collection of Professor John Morris an example of an undoubted *Ammonites angulatus.*" Now the presence of a single specimen of this *Ammonite* is no evidence that the bed from which it was obtained belongs to the zone of *Ammonites angulatus,* as this species ranges up into the zone of *Ammonites Turneri,* whence I have obtained it, at Ashley, near Bristol.

I take this opportunity to explain the meaning I attach to the term *zone.* The Lias can conveniently be subdivided into zones or stages, characterized by organic remains, and generally by lithological features, the former being more or less a consequence of the conditions which produced the latter; and thus the zones mark different conditions of sea-bottom and of life. Species of *Ammonites* being the most restricted in range of the common fossils of the Lias, and, moreover, easily identified, have been selected as *indices to the zones*; but their presence alone does not warrant us in assigning this limestone to the zone of *Ammonites angulatus,* or that clay to that of

* North of Glenarm, as at the Deer Park, the *Avicula-contorta* zone contains a limestone band with *Cardium Rhæticum,* and a meagre representative of the bone-bed in the neighbourhood of Belfast.

† "The true Position of the Metamorphosed Lias was established by Bryce," Portlock, Rep. on Geol. of Derry, p. 97 (1843). *Vide* Dr. Bryce's paper.

‡ Juraformation, p. 34.

Ammonites Turneri, as the case may be; for they may range through several zones. And the Ammonite which gives its name to a zone is but one of many which mark a determinate stage in the life-history of the formation. Hence the zone is a zoological one, and signifies an assemblage of species, and not the range of an *Ammonite*; and, whether you call it Lias α, Lias β, &c., or the zones of *Ammonites planorbis*, *Ammonites angulatus*, &c., the succession of faunas in the Lower Lias still remains patent, and it is to these several faunas that the term "Ammonite-zone" is applied.

I am of opinion that the Portrush rock belongs to the zone of *Ammonites planorbis*. The fossils are few in number, and are somewhat indeterminable; and though I have carefully studied a large series collected by the late R. MacAdam, F.G.S., and have observed others *in situ*, yet I can only enumerate, from personal inspection, six species as composing the fauna of the Portrush Rock. Portlock cites 12 species from it: these are reduced by the elimination of synonyms to 10; and one is given doubtfully as from that rock; 4 of the 9 have come under my observation, leaving 5 on that geologist's authority.

The species are:—*Ammonites angulatus*! (very rare); *A. Johnstoni*! (very abundant); *A. armatus*?; *Pecten vimineus*!; *Lima acuticosta*!; *L. rustica*?; *Mytilus minimus*! (common); *Avicula inæquivalvis*; *Pholadomya ventricosa*; *Cardinia ovalis*!; and *Panopæa elongata*.

TABLE *of the* FOSSILS *of the* ZONE *of* AMMONITES PLANORBIS.

No.	Species of the Zone.	Localities.	Special to the zone.	Passing to superior zones.
1	Ammonites angulatus, *Schloth.*	Portrush	......	*
2	—— armatus?, *Sow.*	Portrush (*Portlock*) ..	*	
3	—— Johnstoni, *Sow.*	Portrush	......	*
4	—— planorbis, *Sow.*	Waterloo; Whitehead; Garron	*	
5	Ostrea irregularis, *Münst.*	Colin; Waterloo	......	*
6	Pecten calvus, *Münst.*	Waterloo	......	*
7	—— vimineus?	Portrush	......	*
8	Lima acuticosta, *Münst.*	Waterloo; Portrush..	......	*
9	—— rustica?	Portrush (*Portlock*)..	*	
10	Avicula inæquivalvis?, *Sow.* ..	Portrush (*Portlock*)..	......	*
11	Perna infraliassica, *Quenst.* ..	Waterloo	......	*
12	Gervillia acuminata, *Tqm.*	Waterloo	*	
13	Mytilus minimus, *Sow.*	Waterloo; Whitehead; Portrush; Colin Glen	*	
14	Lucina cardioides, *Phil.*, sp. ..	Waterloo	......	*
15	Cardinia ovalis, *Stutchb.*	Waterloo; Portrush..	......	*
16	Pholadomya ventricosa (Juv.)..	Portrush (*Portlock*)..	......	*
17	Panopæa elongata, *Röm.*	Portrush (*Portlock*)..	......	*
18	Hemipedina Bechei, *Wr.*	Colin; Whitehead; Waterloo	......	*
		Total........	3†	13

† I have not included species 2 and 9 in this enumeration, as they are doubtfully determined.

The proportion of the number of species peculiar to the zone to those appearing in higher horizons is great compared with that observed in other districts: thus Terquem and Piette enumerate 67 species belonging to this zone, only 9 of which are special to it, whilst 58 pass to superior horizons, and, moreover, 2 of the 9, though confined to the "Planorbis-zone" in the east of France, are fossils of higher stages in other parts of Europe. Thus the zone of *Ammonites planorbis* is really wanting in palæontological characters; even the Ammonite which gives its name to the set of beds is not peculiar to it, and the horizon is recognized, independently of its position and lithology, by the absence of certain forms rather than by an assemblage of species.

4. *The Zone of* Ammonites angulatus.—That portion of the Lower Lias of Ireland which is undoubtedly the representative of the Infra-lias (true) of the Continent, comprises, as before stated, the greater mass of that formation. The zone attains its greatest development, in thickness and in organic remains, on the east coast of Antrim (where it is exposed), on the eastern shore of Larne Lough, at Waterloo, Larne, at Glenarm, and at a few other localities. It consists at these places of a series of thinly bedded shelly limestones alternating with marls or clays, and at Waterloo is not less than 35 feet in thickness. This zone is represented in Colin Glen near Belfast by 1 foot of calcareous marl, the fossils of which, though not numerous, are those which characterize the highly fossiliferous beds of the before-mentioned localities.

In the north-west extremity of the Liassic area, as at Craig and Gortmore, and in the Tircreven Burn, the rock is a calcareous grit. General Portlock, who obtained many fossils from this grit, stated* that they were wanting in the other localities. This is no longer true, as I have found all the species in the shelly limestones of Island Magee, Glenarm, &c.

The fossils of the *Ammonites-angulatus* zone have been extensively collected, especially at Island Magee, where the beds occupy, at the base of the Cretaceous escarpment, a narrow strip of low ground extending for about a quarter of a mile along the east shore of Larne Lough, opposite to the hamlet of Magheramorne. The number of species obtained amounts to 98; the most characteristic of these, the majority of which may be collected by hundreds, are:—

Ammonites Johnstoni, Sow. (*A. intermedius*, Portlock); *Cerithium gratum*, Terq.; *C. Semele*, D'Orb.; *Turritella inornata*, Terq.; *Phasianella Morencyana*, Piette; *Turbo subelegans*, D'Orb.; *Actæonina fragilis*, Dunker, sp., *Ostrea irregularis*; *Terquemia arietis*, Quenst., sp.; *Lima gigantea*, Sow.; *L. punctata*, Sow.; *L. Terquemi*, Tate; *L. acuticosta*, Münst.; *L. Hettangiensis*, Tqm.; *Leda tenuistriata*, Piette; *Astarte consobrina*, Chap. & Dew.; *Cardinia ovalis*, Stutchbury; *Unicardium* (vel *Lucina*) *cardioides*, Phill., sp.; *Cidaris Edwardsi*, Wr.; *Pentacrinus Briareus*, Mill.; *Montlivaltia Haimei*, Chap. & Dew.; and *Serpula socialis*, Goldf.†

Several of the species given in the above list of fossils are known

* *Loc. cit.* p. 139.

† For a complete list of species see pp. 311–313.

in this country as good forms of the "Bucklandi- or Lima-beds;" but I cannot now regard them as a proof that the beds containing them belong to that series. I so placed this zone in my former paper; this error arose from an imperfect knowledge of the fauna of the *Ammonites-angulatus* zone; but the thorough acquaintance which I now have of it enables me to rectify the mistake.

The fauna viewed as a whole is Hettangian; that is, it is identical with that of the Grès infraliasique de Hettange, with that of the zone of *Ammonites Moreanus* of the Côte d'Or, and that of beds which in other districts are known by local names, but all of which represent one stage in the vertical series of the Liassic deposits, and are inferior to the beds with *Ammonites Bucklandi* and *Lima gigantea*.

5. *The Zone of* Ammonites Bucklandi.—At Waterloo, Larne, compact blue limestones with thin shaly bands, and containing *Gryphœa incurva*, overlie the shelly limestones of the "Angulatus-zone;" and the stratigraphical superiority of a series of beds charged with *Gryphœa* at Glynn, two miles south of Larne, to the Angulatus-beds is incontestable. Again, beneath the "Hibernian Greensand," in the Tircreven Burn, Downhill, Londonderry, limestones and shales similar to those at Waterloo, and containing *Gryphœa*, are to be seen resting on the calcareous grits peculiar to the north-west of the Liassic area, which I have referred to the zone of *Ammonites angulatus*.

These beds, characterized by *Gryphœa incurva*, constitute a higher horizon than the shelly limestones of the "Angulatus-zone," and are separable from them by lithological and palæontological features.

The *Gryphœa arcuata* (*G. incurva*) is the ever-accompanying fossil to those characteristic of this zone; it occurs in great profusion, and is in striking apposition to the *Ostrea irregularis*, one of the dominant forms of the "Angulatus-beds" below. *Gryphœa arcuata* is unquestionably here and there a fossil of the zone of *Ammonites angulatus*, but is of rare occurrence. In England I record it as very rare in the "*Angulatus*-zone" at Marton, Lincolnshire; Terquem quotes it as *très rare* from the same horizon.

If Mr. John Jones's notion, that *Ostrea irregularis* and *Gryphœa incurva* are but different states of the same species, be true, then it favours, keeping in view the restricted range of these two forms, the supposition that the zones of *Ammonites angulutus* and *A. Bucklandi* are contemporaneous in the same region. The marked variations of form of the aggregate species conveniently designated *Ostrea gryphus*, Linnæus, thus would arise from difference in habitat, the subspecies *O. irregularis* being the shore form, and *O. arcuata* (*Gryphœa incurva*) representing that of the deeper water. This may be correct; for the large Gasteropod fauna of the zone of *Ammonites angulatus* demonstrates that the beds of that series were deposited in comparatively shallow water, whilst those of the *Ammonites-Bucklandi* zone, with few Gasteropods and numerous Cephalopods, were accumulated in deeper seas. The more frequently occurring species are:—*Ammonites Bucklandi*, *A. semicostatus*, *Ostrea* (*Gryphœa*) *arcuata*, *Lucina ovalis*, *Cardinia Listeri*, *Pleurotomaria similis*, *Pentacrinus basaltiformis*, and *Montlivaltia Haimei*?

6. *The Zone of* Belemnites acutus.—In the small bay of Ballintoy, the base of the White Limestone is conglomeratic, and measures 1 foot in thickness; it rests on black micaceous clays, with some calcareous nodules and numerous specimens of *Belemnites acutus*. The majority of the fossils, principally Ammonites enclosed in calcareous nodules, which are offered for sale at the Giant's Causeway, are obtained during the winter on the shore at Ballintoy; these I have no doubt are derived from submerged beds of this zone.

TABLE *of* FOSSILS *of the* ZONE *of* BELEMNITES ACUTUS.

	In lower zones.	Special to the zone.	
! Ammonites armatus	......	*	
—— Bucklandi (juv.)	*		
—— Conybearei..........	......	*	
—— elegans	......	*	
—— hastatus	......	*	
—— læviusculus	......	*	
—— rotiformis	......	*	
—— striatulus	......	*	
—— subradiatus	......	*	
Belemnites acutus	......	*	B. abbreviatus, *Portlock*.
—— penicillatus	......	*	
Pleurotomaria similis	*	......	Trochus Anglicus, *Portlock*.
Phasianella Pattersoni, n. sp.	......	*	
Turritella percincta	......	*	
! Ostrea Maccullochi	......	*	Gryphæa cymbium, *Portlock*.
! Plicatula spinosa	......	*	
! Lima acuticosta	*	......	L. alternans, *Portlock*.
! —— punctata............	*		
! Arca	......	*	Cucullæa cucullata, *Portlock*.
Astarte consobrina........	*	......	A. tetragona, *Portlock*.
! Avicula inæquivalvis	*		
! Leda tenuistriata	*		
! —— oxynoti ?	......	*	
Mytilus lamellosus, *Tqm*. ..	......	*	
! Pecten Hehlii............	......	*	
! —— æqualis	......	*	
Hippopodium ponderosum	......	*	
Cardinia Nilssoni	......	*	Unio, *Portlock*.
! Goniomya rhombifera	......	*	
Corbis ? ovalis	......	* ?	
Pholadomya longirostris ..	......	*	
! —— ventricosa	*		
Panopæa elongata	*		
Sanguinolaria undulata....	......	*	Waterloo (Belfast Museum).
Terebratula obovata	......	*	Possibly *Waldheimia perforata*.
! Waldheimia perforata	*	......	Ballintoy (Belfast Museum).
! Rhynchonella ranina......	......	*	Coll. Mr. W. Gray.
Montlivaltia Haimei ?	*	......	Belfast Museum.

Clays of the same character are exposed at low water on the coast at Castle Cichester, Carrickfergus, and near the coast-guard station, Waterloo, Larne, both localities in the co. Antrim.

There is no positive evidence of the superior position of these micaceous clays to the "Bucklandi-beds;" for at Ballintoy no inferior zone is exposed, and at Castle Cichester no clear downward succession from the "Belemnite-beds" can be made out; and I have yet to learn more of the clays at Waterloo, which, from their position and the dip of the underlying strata, undoubtedly repose on the limestone with *Gryphæa incurva*. The fossils of these clays are indicative of an horizon on the parallel of, or newer than, that of *Ammonites Turneri*, which elsewhere is the next higher zone to that of *Ammonites Bucklandi*. This is to be inferred from the presence of Belemnites alone, which "are almost never absent from the section till we reach the zone of *Ammonites Bucklandi*. Only in the upper part of this zone have they been found"*.

Though *Belemnites acutus* and *B. penicillatus* characterize in England the zones of *Ammonites Turneri* and *A. obtusus*, yet, from the fact of their association in Ireland with *Hippopodium ponderosum* and *Ammonites armatus*, belonging to the zone of *A. raricostatus*, and with other species ranging throughout the upper part of the Lower Lias, I cannot regard the clays conaining them as belonging to any one of the zones of the Lower Lias superior to the "Bucklandi-beds."

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3. *On the* Fossiliferous Development *of the* Zone *of Ammonites angulatus*, Schloth., *in* Great Britain. By Ralph Tate, Esq., A.L.S., F.G.S.

Contents.

I. Introduction.

The beds comprised between the *Avicula-contorta* series and the limestones of the zone of *Ammonites Bucklandi* vel *bisulcatus* have been divided into two lithological horizons, the lower of which, that of *Ammonites planorbis*, presents no marked zoological facies when contrasted with the upper, that of *A. angulatus*, which has a fauna exceeding in richness of species the remainder of the Lower Lias. The term "Infra-lias" has been given to this group of beds; but as its applicability varies with the classificatory views of individual authors, it seems, therefore, inadmissible; and, in my opinion, that of "Hettangian," as suggested by Prof. Renevier†, should be used instead.

The classification of the members of the Lias would then stand thus:—

* Phillips, "Liassic Belemnites," Mon. Pal. Soc. for 1864, p. 32: 1866.
† L'infralias des Alpes Vaudoises, Bull. Soc. Géol. de Fr. vol. xxi., 1864.

Formations.	Groups.	Zones.
Upper Lias.		
Middle Lias.		
Lower Lias.	Belemnite-beds.	*A. raricostatus.* *A. oxynotus.* *A. obtusus.* *A. Turneri.*
	Arietian.	*A. Bucklandi.*
	Hettangian.	*A. angulatus.* *A. planorbis.*
Avicula-contorta Series.		White Lias (*sensu stricto*). *Avicula contorta.*

In England the Hettangian series contains a well-developed zone of *Ammonites planorbis*, whilst according to Dr. Wright* "the zone of *Ammonites angulatus*, so far as it has been exposed, appears to be imperfectly developed in the British Isles; and from the difficulty experienced in separating its beds from the Bucklandi-series, they were grouped with the latter in my memoir."

This difficulty I have been enabled to overcome; and the determination of the zone of *Ammonites angulatus* with its characteristic fauna, in the localities hereafter to be mentioned, rests on lithological, stratigraphical, or palæontological evidence, or on a combination of two or all of these *indices* to the age of the horizon in question.

II. Occurrences of the Zone of Ammonites angulatus.

1. *Ireland.*—The development of this zone in the neighbourhoods of Larne, Belfast, Glenarm, and other places in the counties of Antrim and Londonderry has been pointed out in my previous paper †. The section at Waterloo, Larne, I would employ as typical for the rest of Great Britain; for there the fauna is rich and characteristic, the lithology is distinct, and the stratigraphical position well-defined.

The fossils from the north-east of Ireland are given in column 1 of the Table, pp. 311–313.

2. *Marton, near Gainsborough, Lincolnshire.*—The palæontological evidence of the presence of this zone in the above locality, consists in a large collection of fossils made by Messrs. F. M. Burton, F.G.S., and H. Waugh, F.G.S., on the line of railway from Gainsborough to Lincoln. No continuous section is exposed; but the dull-blue earthy and shelly limestones yielding the organic remains are known to occupy a position intermediate between the marly clays and shales with *Ammonites planorbis* and the blue compact limestones of the "Bucklandi series;" whilst lithologically and palæontologically they present the closest analogy to those of the zone of *Ammonites angulatus* of several localities in Antrim.

The fossils from this locality are given in column 2 of the Table.

3. *Warwickshire.*—"This zone was well exposed in the Harbury

* British Fossil Echinodermata, vol. ii. p. 63 (Pal. Soc. 1863).

† *Ante*, p. 302.

cutting of the Great Western Railway, near Warwick, although very few Mollusca besides *Ammonites angulatus* were obtained therefrom" (Wright*). One of the commonest species is *Lima succincta*, Schloth., a very characteristic fossil of the zone.

4. *North Gloucestershire.*—Blocks of shaly limestones from Down Hatherly, Gloucester, forwarded to me by the Rev. P. B. Brodie, F.G.S., for examination of the Gasteropods exposed on their weathered surfaces, are referable from their fossil contents to the zone of *Ammonites angulatus*. These limestone blocks were obtained in drain-cuttings and the like, for no open section of the beds is to be met with; and they would appear to occupy a position beneath the "Bucklandi-beds" (which near Churchdown are seen dipping to the south-east), and above the *Avicula-contorta* series of Wainlode (which is in the line of dip, and to the north-west of Down Hatherly). Therefore, if the *Avicula-contorta* beds of Wainlode and the Lias resting on them dip uniformly to the south-east (there is no evidence of a transverse fault), the beds intermediate between them and the Bucklandi-limestones must occur between the outcrops of these two series. The position of Down Hatherly in relation to Churchdown and Wainlode favours the assumption that the blocks of limestone, incomparable with any known limestone of or above the "Bucklandi-beds," are derived from strata in place, having such an intermediate position—that is, of the horizon of *Ammonites angulatus*.

5. *Glamorganshire. Brocastle, &c., near Bridgend.*—Not wishing to encroach on the legitimate domain of Mr. Charles Moore, I refrain from entering into details regarding my views, which are the result of actual survey, of the relations between the remarkable deposits of Brocastle, the "Bucklandi-beds" at Bridgend, and the Sutton Stone. Dr. Duncan† has already shown that the Madreporarian fauna of these deposits is that which characterizes the zone of *Ammonites angulatus* in many parts of the Continent. My independent examination of the Mollusca, especially of the Gasteropods, which are numerous in species, has led me to a like conclusion.

III. The Sutton Stone.

Through the liberality of Dr. Milligan, my attention had been engaged with the organic contents of the Sutton Stone some time previously to the reading of Mr. Tawney's paper on the Rhætic beds of South Wales‡; and subsequently I have visited Sutton with the special view of seeking further palæontological evidence of the age of that limestone, which I had regarded from its fossil contents and mineralogical characters as the direct equivalent of, *i. e.* deposited at the same time and under similar conditions as, the "Calcaire de Valogne," which approximates to the zone of *Ammonites angulatus*.

I am induced record to my observations on the fossils of the Sutton Stone in consequence of what I consider the erroneous determinations of Mr. Tawney; and it was simply with this view that I

* *Loc. cit.* p. 64.

† Quart. Journ. Geol. Soc. vol. xxiii. p. 23.

‡ *Ib.* vol. xxii. p. 69.

undertook a critical examination of the species, which I think have been too hastily regarded as differing from known forms.

Mr. Tawney claims the Sutton Stone as Rhætic*, and believes it probable that the Sutton series was slightly anterior in time to the *Avicula-contorta* series. These inferences as to its age are based solely on the following palæontological premisses :—

(1.) That *Plicatula intusstriata* is exclusively a Rhætic fossil.

(2.) That the absence of the usual Liassic species of *Ammonites* is confirmatory of the Pre-liassic age of the beds.

(3.) That many of the species have been noticed in the Rhætic beds on the Continent, or show strong affinities to the Upper Triassic fauna.

That these premisses are faulty I will endeavour to prove. And, first, as to the statement that *Plicatula intusstriata* is "a shell acknowledged to be characteristic of the Rhætic series, and never, I believe, really found out of it" †. This shell is, in fact, quite as characteristic of the lower part of the Lower Lias as it is of the *Avicula-contorta* series. In the east of France it occurs in the zones of *Belemnites acutus*, *Ammonites bisulcatus*, and *A. angulatus*, in the last of which it is common at Charleville, Moselle. Dumortier states that it is one of the most characteristic fossils of the *Ammonites-planorbis* zone of the Bassin du Rhône. It occurs in Great Britain in other than the *Avicula-contorta* series, and in the Sutton Stone at Island Magee, co. Antrim, whence I have obtained it in the zone of *Ammonites angulatus*,—at High Lyme, Dorset, whence I have seen specimens in the collection of Mr. Bott, attached to *Gryphæa incurva*,—at Bridgend, specimens from which locality, obtained from the interpolated shales in the Bucklandi-series, I have examined in the collection of Dr. Milligan.

Secondly, as to the absence of the usual Liassic Ammonites. This negative evidence is of no moment, inasmuch as Ammonites are few in number as regards species in the Hettangian series of beds. It is rare to find more than two or three species in one locality, though these are sometimes represented by numerous individuals ; but two species of *Ammonites* are recorded from the Sutton Stone which are allied to the "Planorbes." Thus this positive evidence, slight as it is, points rather to the probably Liassic age of the deposit.

Thirdly, as to the Rhætic and Triassic affinities of the species. That the position assigned to the Sutton Stone is at variance with Mr. Tawney's own palæontological determinations is patent to all, when the list of species from the Sutton Stone is compared with that of the species from undoubted *Avicula-contorta* beds as given by that author. The only species common to the beds in question are *Myophoria postera*, *Monotis decussata*, and *Plicatula intusstriata*, which last I have stated to pass up high in the Lower Lias. May there not be some mistake with the others, perhaps inadvertently ranked among the Sutton-stone fossils‡? Thus, on the author's own showing, the fauna of the Sutton Stone is not Rhætic; but a careful study of the fossils has led me to regard it as Liassic, and I offer the

* *Loc. cit.* p. 72. † *Ib.* p. 78.

‡ The * opposite *Gyrolepis Alberti*, in the column headed Laleston, refers to *Plicatula intusstriata*.

following amended list of species, upon which I base my conclusions:—

List of Fossils of the Sutton Stone.

Species of Mr. Tawney's List.	Species adopted.
Ammonites Dunravenensis, *Taw.*	A. sp. indet.
„ Suttonensis, *Taw.*	A. Johnstoni, *Sow*?
Pecten Etheridgei, *Taw.*	P. texuratus, *Münst.* (juv.).
—— Suttonensis, *Taw.*	P. Valoniensis, *Defr.*
Lima tuberculata, *Tqm.*	L. Terquemi, *Tate.*
—— subduplicata, *Taw.*	L. Hettangiensis, *Tqm.* ? (juv.).
—— Dunravenensis, *Taw.*	L. Valoniensis, *Defr.* (? L. exaltata, *Tqm.*)
—— angusta, *Taw.*	L. angusta, *Taw.*
—— planicostata, *Taw.*	L. planicostata, *Taw.*
Ostrea lævis, *Taw.* Anomia socialis, *Taw.*	} O. irregularis, *Schloth.*
Ostrea multicostata (*Münst.*), *Taw.*	Terquemia arcitis, *Quenst.*, sp.
Pinna insignis, *Taw.*	P. semistriata, *Tqm.*
Pinna? Ramsayi, *Taw.*	P. infraliasina, *Quenst.*
Cardinia Suttonensis, *Taw.*	C. regularis, *Tqm.*
—— ingens, *Taw.*	C. crassiuscula, *Sow.*
Mytilus imbricatoradiatus, *Taw.*	Mytilus imbricato-radiatus, *Taw.*
Cardita? rhomboidalis, *Taw.*	Astarte? sp.
Astarte Duncani, *Taw.*	Cardita, sp.
Cyprina normalis, *Taw.*	Lucina, sp.
Plicatula intusstriata, *Em.*	Plicatula intusstriata, *Em.*
Patella Suttonensis, *Taw.*	Patella Hettangiensis, *Tqm.*

To the above I have added:—

Patella Milligani, *Tate.*
Neritopsis exigua, *Tqm.*
Dentalium tenue? *Portlock.*
Pleurotomaria nucleus, *Tqm.*
Trochus Andersoni, *Tate.*

The majority of the species of the above list occur in other parts of Great Britain, and are well-known fossils of the Continent; they incompletely represent the fauna of the beds beneath the zone of *Ammonites Bucklandi.*

Lithologically the Sutton-stone beds are somewhat exceptional as regards this country; but the development of dolomitic limestones at the base of the Lower Lias is by no means an unusual occurrence in many parts of France &c. As a general rule, this lithological feature is presented by the base of the Lias when it rests on, or is in close proximity to, reefs of pre-Secondary age—as, for example, the "Calcaire de Valogne," the characteristic fossils of which are among the commonly occurring species in the Sutton Stone. The physical conditions under which these limestone beds were deposited were identical. The Calcaire de Valogne, however, overlies beds of the age of the zone of *Avicula contorta*, whilst the Sutton Stone rests directly on the Carboniferous Limestone.

If the Calcaire de Valogne be identical with the Sutton Stone, the intermediate position of the latter between the *Avicula-contorta* series, and the zone of *Am. Bucklandi* is established, were any such proof required.

My conclusions are:—

(1.) That the Sutton Stone is not Rhætic, nor of pre-Rhætian age, is not only proved by its fossil contents, but also by the absence of any similar stratum, or with a like series of fossils, between the Trias and the *Avicula-contorta* series, or forming a part thereof.

(2.) That the Sutton Stone is a part of the Lower Lias, to which it was referred by Sir H. De la Beche.

(3.) That the fossils of the Sutton Stone are those of the Hettangian fauna.

(4.) That as the Sutton Stone and the Southerndown beds cannot be clearly referred by their organic remains, the one to the zone of *Ammonites planorbis*, the other to that of *A. angulatus*, it would be preferable to regard the two as the equivalents of the beds intermediate between the White Lias and the Bucklandi-beds.

(5.) That the Sutton Stone presents in many particulars a close analogy to certain beds erroneously called White Lias in the Bristol district.

IV. Liassic Beds inferior to the Limestones of the Ammonites-Bucklandi Zone in the Bristol District.

In the neighbourhood of Bristol two well-marked horizons are known. These are the blue limestones of the "Bucklandi-series" and the "Cotham Marble" (the upper limit of the White Lias). It is true that the shaly beds containing *Avicula cygnipes* and *Ostrea liassica* at Horfield, which immediately underlie the Lima-beds, are referred to the zone of *Ammonites planorbis*; but I suspect that certain grey and greyish-white arenaceous limestones below these shales have been erroneously regarded as belonging to the White Lias; and as they very closely approximate to the Sutton-stone series, it would be well to define their characters.

There appears to be no development of the zone of *Ammonites angulatus* in contra-distinction from that of *A. planorbis* in the neighbourhood of Bristol; but the Hettangian group is represented lithologically by whitish and greyish limestones and shales containing a larger assemblage of species, the majority of which more especially belong to the zone of *A. angulatus*, than has hitherto been recorded from the zone of *A. planorbis* of this country. These species enable one very readily to define the base of the Lower Lias and the top of the White Lias. This zone is exposed at Cotham, Wall's Court, Whitchurch, Pyle Hill, and Bedminster, at which last locality the limestones which overlie the bed with *Naiadites acuminatus* closely resemble lithologically those of the Sutton series, and, moreover, contain one of the characteristic fossils (*Lima Terquemi*) of that deposit.

The species of the following list, with the exception of *Pholadomya prima*, collected by myself at Wall's Court, have been obtained by Mr. C. O. Groom-Napier, F.G.S., at Cotham, Bristol. The determinations are mine.

Ammonites Johnstoni, A. planorbis; Astarte consobrina; Lima exaltata, L. Hettangiensis, L. gigantea, L. punctata, L. succincta, L. tuberculata; Lucina cardioides; Ostrea irregularis; Terquemia arietis; Pecten calvus, 2 species undetermined; *Perna infraliasina; Pinna semistriata; Pholadomya glabra, P. prima; Terebratula perforata; Cidaris Edwardsi.*

V. The Zone of Ammonites angulatus in Dorsetshire.

Mr. E. C. H. Day, F.G.S., has recognized the presence of the zone of *A. angulatus* at Charmouth, Dorsetshire. I have no information regarding it, further than that specimens in the Geological Survey Museum, among which are *Terquemia arietis*, *Lima Terquemi*, &c., collected by Mr. Day, are referred by him to that zone.

I have no doubt that further research will establish the continuity of this well-marked horizon from North Gloucestershire to Lincolnshire, and its extension into Yorkshire. Fossils that have been forwarded to me from Abbot's Wood, Cracombe, and a few other places on the border country of the Lias and the New Red Sandstone, appear to be referable to this zone.

VI. List *of* Fossils *of the* Zone *of* Ammonites angulatus.

Species.	Ireland.	Marton.	Down Hatherly.	Brocastle.	Sutton.	
Ammonites Johnstoni, *Sow.*	v. c.	c.	...	...	*	
—— angulatus, *Schloth.*	r.	v. c.				
—— semicostatus ?	...	*				
Belemnites, sp.	v. r.					
Nautilus striatus, *Sow.*	*	*				
—— Malherbi, *Tqm.*	...	v. r.				
Actæonina fragilis, *Dunk.*	v. c.					
Cerithium semele, *D'Orb.*	c.	c.	*	*		
—— gratum, *Tqm.*	v. c.					
—— acuticostatum, *Tqm.*	...	...	*	*		
—— Quinetteum, *Piette*	...	...	*	*		
Chemnitzia punctata, n. sp.	*					
—— Tylori, n. sp.	*					
Dentalium tenue, *Portlock*	c.	...	*	?	*	
Neritopsis exigua, *Tqm.*	...	...	...	c.	*	
Patella Schmidti, *Dunk.*	...	...	v. r.			
—— Hettangiensis	...	...	...	...	*	
Phasianella Morencyana, *Piette*	v. c.	*	...	*		
Pleurotomaria trocheata, *Tqm.*	*					
—— Mosellana	...	*				
Cryptænia expansa ?	*	c.	...	...	...	? Young of *P. Brycei.*
—— cæpa	*	? *				
—— heliciformis	...	* r				
—— Brycei, n. sp.	*					
Turbo subelegans, *Münst.*	v. c.	v. c.	*	*		
—— liassicus, *Martin*	*					
Turritella Zenkeni	...	...	*			
—— tenuicosta, *Port.*	*	...	...	*		
—— crassilabrata, *Tqm.*	*					
—— Dunkeri, *Tqm.*	...	v. r.	*	*		
—— semiornata, *Tqm.*	*					
Tornatella inermis, *Tqm.*	c.	*				
Turbo Burtoni, n. sp.	...	*				
Littorina semiornata, *Münst.*	...	r.				
Trochus Chapuisi, *Tqm. & P.*	...	*				
Arca (Cucullæa) Hettangiensis, *Tqm.*	c.	c.	*	?		

TABLE (_continued_).

SPECIES.	Ireland.	Marton.	Down Hatherly.	Brocastle.	Sutton.
Anomia pellucida, _Tqm._	...	v. r.			
Astarte consobrina, _Chap. & D._	v. c.	...	c.		
Avicula Sinemuriensis, _D'Orb._	*				
—— Dunkeri, _Tqm._	...	...	...	*	
Cardinia Listeri, _Sow._	*	v. c.			
—— ovalis, _Stutch._	v. c.	v. c.	v. c.		
—— Deshayesi, _Tqm._	*	*			
—— amygdala, _Ag._	*	*			
Cardium Phillippianum, _Dunk._	*				
Cardita Heberti, _Tqm._	r.	r.	*	*	
Ceromya gibbosa, _Eth._	*				
Gervillia acuminata	?				
Goniomya Sinemuriensis, _Opp._	*				
Leda Heberti, _Mart._	*				
—— Bronni, _Andler_	...	*			
—— tenuistriata, _Piette_	n. c.	v. r.			
—— Dewalquei	*				
Lima acuticosta, _Mart._	c.	v. c.	...	*	
—— succincta, _Schloth._	*	v. r.			
—— gigantea, _Sow._	c.	c.			
—— Terquemi, _Tate_	c.	c.	...	*	
—— punctata, _Sow._	c.	c.			
—— exaltata, _Tqm._	*				
—— Hettangiensis	...	n. c.			
Myoconcha scabra, _Tqm. & Piette_	c.	...	...	...	
Mytilus Hillanus	v. c.	c.			
—— lævis	*				
—— minimus ?	*				
Lucina cardioides, _Phil._	v. c.	v. c.			
Nucula navis	*				
—— Dewalquei	..	*			
Terquemia arietis, _Quensted_, n. sp.	c.				
Ostrea irregularis	v. c.	v. c.			
—— (Gryphæa) arcuata	...	r.			
Pecten Hehli, _D'Orb._	*	*			
—— texturatus	*				
Pecten calvus, _Goldf._	c.	? *			
—— textorius, _Goldf._	*				
—— punctatissimus, _Quenst._	...	v. c.			
Perna infraliasina, _Quenst._	c.				
Pinna semistriata, _Tqm._	c.				
Plicatula Hettangiensis, _Tqm._	r.				
—— intusstriata, _Em._	r.	...	...	*	
Pleuromya Galathea, _Ag._	*	c.			
Pholadomya glabra, _Ag._	*				
—— prima, _Ag._	*				
Lingula Metensis, _Tqm._	*				
Terebratula perforata, _Piette_	*				
Rhynchonella costellata, _P._	*	...	...	*	
Discina Holdeni, n. sp.	*				
Pollicipes liasinus, _Dunk._	*				
Serpula socialis, _Goldf._	c.				

Table (*continued*).

Species.	Ireland.	Marton.	Down Hatherly.	Brocastle.	Sutton.	
Serpula olifex, *Quenst.*	c.					
—— capitata, *Phil.*	*					
Cidaris Edwardsi, *Wr.*	v. c.	*				
Hemipedina Bechei, *Wr.*	*					
Pentacrinus Briareus	v. c.	*				
Ophioderma, sp.	*					
Montlivaltia Haimei	c.	r.				
—— papillata, *Dunk.*	*	v. r.				
—— hibernia, *Dunk.*	*					
Septastræa Fromenteli	v. r.	v. r.				
Oppelosmilia gemmans, *Dunk.*	v. r.					

[The list of corals given by Dr. Duncan from Brocastle is not included in this table.]

VII. Descriptions of New Species.

Pleurotomaria (Cryptænia) Brycei, spec. nov.

Shell subdiscoid, depressed; test thin. Whorls four, nearly flat or slightly concave; bluntly carinated; upper surface of the whorls transversely striated, base convex, smooth; callosity large, circumscribed by a sulcus, slightly excavated near the columella-lip. Siphonal band narrow rather above than below the keel. Aperture subtriangular.

P. Brycei is somewhat intermediate between *P. cœpa* and *P. expansa*; it is related to the latter by the concave and carinated whorls, by the band being above the keel, and by the large callus, but differs in its more regularly conoid form, without the ventricosity of the under surface, and by the absence of the raised border to the posterior suture.

Locality. Island Magee, co. Antrim. Collected by W. Gray, Esq.

The species is dedicated to Dr. Bryce, F.G.S., in remembrance of geological excursions made together in the North of Ireland.

Cerithium Tylori, spec. nov.

Shell turreted, elongated, 10 whorls separated by a deep suture, concave and ornamented by about twenty very prominent curved ribs; ribs and sulci smooth; base slightly carinated, smooth or faintly radiated (resulting from the prolongation of the ribs of the last whorl); canal short.

Dimensions. Length 6 millim., height of last whorl 1·5 m., breadth of last whorl 1·5 m.

Affinities and Differences. By its ornamentation closely allied to *C. Arduennense*, Piette, and *C. Henrici*, Martin; but the ribs in the former are serrated; the shell, however, is proportionately much longer; from *C. Henrici* it differs in the relative proportions of all its parts, being only about half the length of that shell, and is provided with ten whorls, while in *C. Henrici* there are only eight.

Locality. In great abundance in the limestones of the zone of *Ammonites angulatus*, Island Magee, co. Antrim.

Turbo Burtoni, spec. nov.

Shell heliciform, small, as broad as high; spire short, apex obtuse, composed of 4 smooth whorls, the last inflated and rounded; aperture orbicular, umbilicus proportionately large; columella flattened.

Var. *carinatus*, whorls obtusely carinated.

Locality. Marton, near Gainsborough. Collected by Mr. Waugh, F.G.S. Zone of *Ammonites angulatus.*

The species is named in compliment to F. M. Burton, Esq., F.G.S., whose collection of Lias fossils has materially increased the value of the present communication.

Discina Holdeni *, spec. nov.

Orbicula reflexa, Tate, Q. J. G. S. vol xx. p. 110 (1864).

Discina, sp., Terquem and Piette, Lias inf. de l'Est de la France, t. xiv. f. 33, 34, p. 113 (1865).

Shell small, regularly conical; base orbicular, the length and breadth in the proportion of about 5 to 4; summit central; test concentrically striated. Colour black to brownish-black; yellowish-brown in the young shell.

Dimensions of an average-sized specimen:

	millimetres.
Long diameter	4·5
Short diameter	3·6
Height	2·3

This form is distinguished from the other Liassic species by its regularly conical form and central apex; and it is readily separated from *D. reflexa*, Sow, by the latter character.

Distribution. D. Holdeni is somewhat common in the zone of '*Ammonites angulatus*" of Island Magee, co. Antrim, whence the type specimens. Usually attached to *Cardinia ovalis* and *Astarte consobrina*. I have collected the same species in the zone of "*Ammonites ibex*," at Cheltenham, and have seen numerous examples attached to *Ammonites Henlayi*, probably from the zone of "*Am. capricornus*," in the Collection of the Geological Survey.

Mr. T. Davidson informs me that *D. Holdeni* has been obtained by Mr. J. Wilson, F.G.S., from the lower lias at Rugby.

* In compliment to my esteemed friend J. S. Holden, M.D., who assisted me in working out the geology of the east coast of Antrim.

4. *On the* Rhætic Beds *near* Gainsborough.

By F. M. Burton, Esq., F.G.S.

At the Meeting of the British Association at Nottingham in 1866, I announced the discovery of the Rhætic beds at Lea (a village about two miles to the south of Gainsborough), which the lowering of the gradients of the Great Northern line from Gainsborough to Lincoln had laid bare. At the time this announcement was made, the cutting at Lea was only partially worked out. Now, however, that the line is in a more complete state, I am enabled to give more accurate sectional and stratigraphical details than I could then.

The following is a section of the various beds in the order in which they occur.

Section of the Rhætic Beds at Lea, near Gainsborough.

No. of bed.	Lithology.	Organic Remains.	Thickness. ft.	in.
	Drift	Fragments of White Lias, &c.		
20	Black fissile shale........	*Avicula contorta, Schizodus cloacinus.*	2	0
19	Dark-grey stone with veins of black fibrous gypsum.	*Pecten Valoniensis, A. contorta, S. cloacinus, Modiola minima.*	0	3
18	Black fissile shale, highly fossiliferous, with nests of pyrites, veins of black fibrous gypsum, and septaria.	*A. contorta, S. cloacinus,* &c.	3	0
17	Dark rubbly sandstone ..	....	0	2
16	Black fissile shale........	*A. contorta, S. cloacinus.*	1	6
15	Dark highly pyritous sandstone.	....	0	0½
14	Black fissile shale........	....	1	0
13	Dark sandstone	....	0	2
12	Black fissile shale........	*A. contorta, S. cloacinus,* &c.	1	6
11	Dark sandstone	....	0	2
10	Black fissile pyritous shale	*A. contorta, S. cloacinus,*	0	4
9	Hard grey laminated micaceous sandstone with pyrites.	Casts of *A. contorta, Pullastra arenicola, Perna* ——?, *M. minima,* with teeth, bones, coprolites, ripple-marks, and drift-wood.	1	5
8	Black fissile pyritous shale highly fossiliferous, with septarian nodules.	*A. contorta, S. cloacinus,* &c.	2	4
7	Hard fine-grained micaceous and highly pyritous sandstone, the mica in some places in large loose scales.	*A. contorta,* teeth, scales, and coprolites.	0	6
		Carried forward....	14	4½

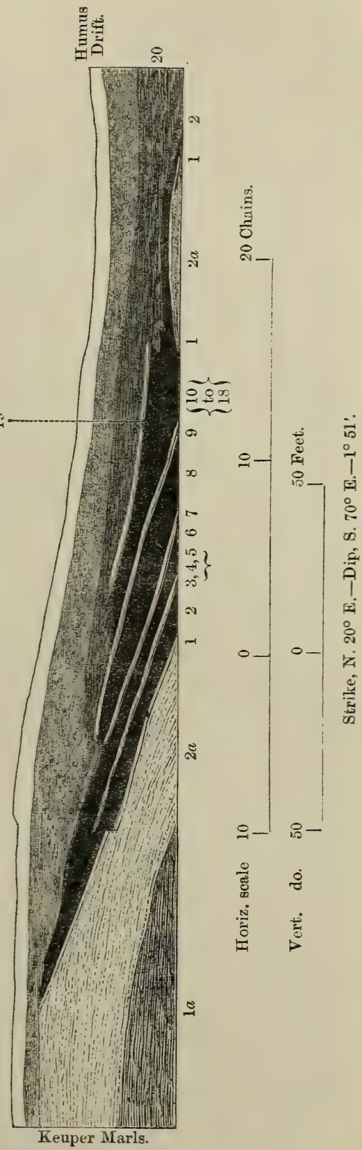
TABLE (*continued*).

No. of bed.	Lithology.	Organic remains.	Thickness. ft. in.
		Brought forward	14 4½
6	Black fissile shale........	*A. contorta* &c.	2 0
5	Second bone-bed, loose in texture.	Coprolites &c.	0 0½
4	Loose grey micaceous sandstone, highly fossiliferous.	Bones, teeth, scales, and coprolites, spines of *Hybodus* and *Nemacanthus*, casts of *M. minima*, *Pullastra arenicola*, &c.	0 4
3	Bone-bed imbedded in a pyritous matrix	Coprolites, worn bones, small pebbles, scales, and spines, portion of jaw of *Lepidotus* (*Giebeli*?), teeth of *Hybodus minor*, *H. plicatilis*, *Sargodon tomicus*, *Gyrolepis Alberti*, *Acrodus minimus*, *Saurichthys apicalis*, *Termatosaurus Alberti*, and *Ichthyosaurus*.	0 1
2	Black fissile shale with thin veins of grey pyritous stone.	*A. contorta*, *S. cloacinus*, coprolites, &c.	8 0
1	Loose grey micaceous sandstone.	*A. contorta*, portion of jaw of *Pliosaurus*?, bones, teeth, and coprolites.	1 0
2a, 1a	Blue marl of the Keuper.		
			25 10

The first traces of this Rhætic tract, for it can boast of only a very limited surface-area, occur a little beyond the third bridge, about a mile and a quarter from the new station at the south end of the town of Gainsborough, where the lowest bed of the series, No. 1 in the section, is seen resting unconformably, though with parallel stratification, on the blue marl of the Keuper beneath. This bed consists of a rather loose micaceous sandstone of a greenish grey colour, containing a few specimens of *Avicula contorta*, with worn bones, teeth, and coprolites, and is (where not affected by the unevenness of the underlying Triassic marl, the hollows of which it fills up) on the average about a foot in thickness. In one part, near the outcrop of this lowest bed, lying directly on the blue marl beneath, I found part of the right ramus of the lower jaw of a large Saurian, probably that of *Pliosaurus*. This sandy bed, as a commencement of the Rhætic series, does not seem to be elsewhere of usual occurrence,—the lowest stratum below the bone-bed, in most other localities, being the well-known black shale, of a character more or less indurated, which at Garden Cliff, Wainlode, Coombe Hill, Penarth, and elsewhere, as described by Dr. Wright in vol. xvi.

of the Society's Journal, and at Batheaston and Westbury, as described by Mr. Moore in vol. xvii. of the same publication, forms the base. At Beer Crowcomb, however, as described by the latter, we find a pale-blue stone, 1 foot 2 inches thick, with vegetable-like markings, followed by blue shaly marl, given as the lowest bed of the series, which may be taken as the equivalent of the lowest Gainsborough bed; and perhaps at the well-known Aust Cliff locality, where the bone-bed is described by Dr. Wright as lying abruptly on the Keuper, the stratum of pale arenaceous marl, 1 foot in thickness, which, though placed by him on the top of the Keuper, in texture apparently resembles the lowest Rhætic bed of Gainsborough, may be another of its equivalents. This, however, I hazard only as a conjecture, and on the slight supposition that the fossils of the Rhætic type, should it contain any, are so few as to have hitherto escaped observation. Following the line in a southerly or south-easterly course towards Lincoln, which coincides with the direction of the dip, we find in corresponding order the various beds of the series laid bare, the next of which, No. 2 in the section, consists of a stratum of black fissile shale, 8 feet in thickness, containing nests of pyrites, and having several thin, non-continuous veins of grey pyritous stone imbedded in it. The main bulk of this

Fig. 1.—*Section of the Rhætic Beds near Gainsborough.*



deposit seems to be entirely wanting in fossil remains; but, after a minute search, it has yielded a few coprolites and specimens of *Avicula contorta* and *Schizodus cloacinus* lying close above the lowest bed No. 1, the presence of these bodies being indicated by layers of iron pyrites, with which mineral the entire series is thickly studded. This black shale is succeeded by the coprolite- or bone-bed (No. 3), a narrow band about an inch thick, entirely composed of worn bones, teeth of various kinds, scales and coprolites, imbedded in a hard cement of sulphuret of iron. Amongst the fossils found in this bed are a portion of the jaw of *Lepidotus Giebeli*, Alb. ?, teeth of *Hybodus minor*, *H. plicatilis*, *Sargodon tomicus*, *Saurichthys apicalis*, *Acrodus minimus*, *Gyrolepis Alberti*, *Termatosaurus Alberti*, and *Ichthyosaurus*, with scales of *Gyrolepis*, spines, and other animal remains, for the naming of which, as well as of most of the other fossils mentioned in this paper, I am indebted to the kindness of Mr. R. Tate, F.G.S. The unbroken condition of the soft coprolite bodies in this deposit points, so far at least as the Gainsborough bed is concerned, to its formation in a moderately deep sea, or, more likely, in a quiet lagoon or semi-inland sea, where the attrition of the waves was not great; and the curious nature of the contents of the bed seems to denote it as simply of fæcal origin: nor is this view irreconcileable with the invariably fragmentary nature of the harder animal portions imbedded in it; for, mixed with the fæces, would naturally be found the teeth, scales, and other insoluble fragments of the animals preyed upon: and the idea of its being simply a fæcal deposit is borne out further by the occurrence, here and there in the bed, of small smooth pebbles, principally quartz, which in all probability the fishes of those days, like the cod and other fishes of our own, that take their food off the ground, had swallowed, either by chance or purposely (for the sake of the zoophytes and other substances incrusting them). Resting upon this bone-bed we find a stratum of loose grey micaceons sandstone (No. 4 in the section) about 4 inches thick, which is by far the most productive bed for fossils in the series, literally abounding in bones, teeth, scales, and coprolites, with spines of *Hybodus* and *Nemacanthus*, and casts of *Modiola minima*, *Pullastra arenicola*, and other well-known Rhætic fossils. Above this richly fossiliferous bed lies another narrow band of animal *débris*, No. 5 in the same section, about ½ an inch thick, which may be regarded as a second bone-bed, similar to those found in various other localities. The remains in this band are chiefly coprolites; and, unlike those in the bone-bed below, they are not consolidated in a matrix of pyrites, but lie loose and free in a sandy coating of a composition similar to that of the bed last described, though of a slightly darker colour. This second bone-bed is succeeded by another band of black shale (No. 6), 2 feet thick, containing *Avicula contorta* and other fossils, and that again by a rather hard fine-grained micaceous sandstone (No. 7), 6 inches in thickness, the mica in some parts lying in large loose scales. This bed is highly pyritous throughout, and contains a few teeth, scales, and coprolites, with abundance of *Avicula contorta* on its upper surface. Above this comes another bed of black pyritous shale (No. 8), 2 feet 4 inches thick, containing immense numbers of compressed *Avicula contorta, Schizodus cloacinus,* and other fossils, and having at wide intervals large, flat-shaped, concretionary nodules, of homogeneous texture throughout, imbedded in its mass. In the more fossiliferous parts this bed is very flaky, and separates easily; and the flakes, which may be split up into the thinnest slices, seem to be composed of nothing but dead organisms, of which the shells of *Schizodus cloacinus* form the bulk.

These last-mentioned shales are capped by a band of very hard, compact, laminated, micaceous sandstone (No. 9), 1 foot 5 inches thick, of a light-grey colour, containing numerous casts of *Avicula contorta*, *Pullastra arenicola*, *Modiola minima*, and *Perna*, sp., with teeth, bones, coprolites, and drift-wood. This band forms by far the most important of the stone-beds, and has been used largely for the roadways round the new station at Gainsborough. The fossils in it have not uncommonly a bright pyritous covering, rendering them very distinct and clear in the surrounding matrix of grey. The markings on this stone-bed are most singular, many of the slabs presenting apparently traces of the mollusks and annelids that crawled over and burrowed in them, with smooth wave-ridges and hollows, the latter filled with shells and fish-remains, just as may now be seen on any sandy shore which the retreating tide has laid bare. This is followed again by a bed of shale (No. 10), 4 inches thick, similar in composition to the other shaly strata, containing *Avicula contorta* and *Schizodus cloacinus* in great numbers, above which comes another narrow band of rather dark sandy stone (No. 11 in the section), 2 inches thick. Then another bed of fissile shale (No. 12), 1 foot 6 inches thick, containing the same fossils as before; above which is another band of stone (No. 13), similar to No. 11, 2 inches thick, and above it shale, as before, 1 foot thick (No. 14). Then comes a remarkable narrow band of highly pyritous stone (No. 15), $\frac{1}{2}$ an inch thick, apparently unfossiliferous; and succeeding it is another bed of shale (No. 16) 1 foot 6 inches thick, similar to all the preceding. Then a band of stone (No. 17), 2 inches thick, much broken, resembling in this respect the beds of rubble found at the top of Oolite cliffs. This band, which, so far as I have observed, is wanting in fossils, is followed by another bed of shale (No. 18), 3 feet thick, containing, like No. 8, immense numbers of compressed *Avicula contorta* and *Schizodus cloacinus,* with here and there non-continuous veins of black fibrous gypsum running horizontally through the mass, and having near its surface large oval-shaped nodules of septaria, differing from those in No. 8 (which are of solid and homogeneous texture throughout) in being partly hollow, and having their interstices filled with small crystals of carbonate of lime. It is worthy of remark that, where these septaria occur, the black shales directly beneath them dip for a certain distance, and are rounded and compressed by their weight, while the stone-bed above bulges out in a dome-shaped mass, apparently showing that the concretionary action to which these bodies owed their growth was at work at the time the shales in which they are imbedded were deposited, and before the overlying stratum was formed. Above this bed of shale we have a thin band of dark-grey stone (No. 19), varying from 1 inch to 3 inches in thickness, containing *Pecten Valoniensis, Avicula contorta, Schizodus cloacinus, Modiola minima,* and what appear to be worm-tracks, or casts of the traces of crawling mollusks or crustaceans. This stone band, the only one in the series where (owing to the indefatigable researches of my friend Mr. Waugh, of the Great Northern staff, to whom I owe the accurate diagrams accompanying this paper) I have met with the well-known *Pecten Valoniensis,* so common in other similar localities, lies just above the septarian nodules in the shales below, sometimes reclining on them; and where these bodies occur, the stone assumes, as just stated, a dome-shaped curve, being thinnest on the raised summit of the nodules, and thickest in the intervening spaces, while, resting on the stone, in the hollows between the swellings caused by the septaria, lie veins of black fibrous gypsum similar to those described in the shale-bed (No. 18) below. Next in order comes another bed of black fissile shale (No. 20) from 1 foot to 3 feet thick, similar in character to all the others, and forming the highest bed of the series in this locality, all above it being, as far as the railway-cutting extends, denuded and worn down by the drift, which, at a distance of about 90 yards above Lea-bridge, suddenly cuts clean through all the intervening beds down to the main stone band (No. 9), crushing and distorting the various strata, and making the smooth slippery surfaces of the shales appear as if they had been polished*. At this point also the strata from beneath rise again, and the grey Keuper marl becomes visible at the base of the cutting, showing the form of the Rhætic beds in this locality to be that of a shallow synclinal basin. That higher beds of the series existed in these parts is evident from the clean-fractured uneven fragments of White Lias which are found in the overlying drift, containing *Myacites musculoides, Cardium Rhæticum,* and other fossils, with the old perforated tubes of boring mollusks, the latter pointing, as Mr. Moore, in his paper already cited, observes, to a quiet period of deposition, when such delicate operations could take effect. One of the most remarkable characteristics of the Gainsborough beds is the presence of the immense quantity of iron pyrites found in the different strata, all of them, whether shale or stone, being literally filled with this mineral. In the shale it occurs as a simple cube, or number of cubes, and in the stone as a bright metallic layer or streak; and so filled is the entire series with this substance, that I have seen, after heavy rains, the sides of the cutting in places stained yellow, as if with rust, completely effacing the lines of bedding. How far the surface-limits of this Rhætic tract extend it is not easy to ascertain with exactness; judging, however, from the contour of the surrounding land, an estimate of its size and position may, I think,

* Since this paper was read, I have discovered, in the old undisturbed parts of the cutting, traces of strata *in situ* belonging to the Rhætic series higher than those described.

with some degree of probability be made out; and I have endeavoured in the accompanying map, taken from the Ordnance Survey, to define them. To the east of the Triassic escarpment, extending from the Rhætic cutting at Lea northwards towards Gainsborough, the land lies in a gentle slope, rising again, though very slightly, at a distance of less than a mile on the average, with an outcrop of Liassic clays; and in the hollow between these ridges, judging from

Fig. 2.—*Sketch Map showing the extent of the Rhætic Beds near Gainsborough.*

the direction of the dip, and the general trend of the land, it appeared to me likely that the Rhætic beds would be found on the surface; and hearing that a well had been dug in the line of this depression, near a farm-house marked on the map, about 3 miles north of the Lea-beds, I examined the earth thrown up, and found, as I anticipated, the various stones and shales of the Rhætic zone, undiminished to all appearance in size and thickness, the main stone band and the other prominent strata, with their accompanying fossils and stock of pyrites, seeming all to be present as at Lea.

Taking the entire depression between the Keuper and Lias outcrops, and presuming it to be occupied with the Rhætic beds, as in all probability it is, we get an area of from 3 to 4 miles long, and from ½ a mile to 2 miles broad, as the surface-extent of this northern deposit; but whatever its size may actually be now, there can be no doubt that it once formed part of the north-western boundary of a vast Rhætic sea, which extended, it may be, from Norway*, across the German Ocean, to Ireland, and southwards down the continent of Europe, and which, save in such patches as these, has long since been swept off the earth's surface, or buried beneath more modern deposits; and it is from such considerations, and the light the discovery of these outlying strata casts on what would otherwise be vague and obscure, that the interest and value of their examination mainly depend.

June 5, 1867.

SPECIAL GENERAL MEETING.

The following addition to the Bye-laws was proposed by Mr. S. R. Pattison, seconded by Mr. J. W. Flower, and adopted by ballot, with one dissentient:—

Section XIX. 5. The Society shall not and may not make any dividend, gift, division, or bonus in money, unto or between any of its members.

ORDINARY GENERAL MEETING.

Augustus Wollaston Franks, Esq., F.R.S., F.S.A., Keeper of Antiquities, British Museum, W.C., was elected a Fellow.

The following communications were read:—

1. *The* Alps *and the* Himalayas: *a* Geological Comparison. By Henry B. Medlicott, Esq., A.B., F.G.S.

[The publication of this paper is postponed.]

(Abstract.)

Current opinions on Alpine geology are first fully discussed by the author, especially as regards the abnormal nature of the actual boundary of the Molasse with the rocks of the higher Alps, including the explanation usually given of this phenomenon, and of the contortion of the inner zone of Molasse—namely, the direct upheaval of the main mountain-mass. Mr. Medlicott then describes some of the

* The probable existence of the Rhætic beds on the Island of Bornholm, and in the province of Schoonen, is indicated on Dittmar's map showing the distribution of the formation; but at present there is no fossil-evidence to prove with certainty the age of the beds in question.

sections exposed on the south flank of the Himalayas, and suggests a parallelism between them and those exhibited in the Alps. The clays, sands, and conglomerates of the Sivaliks are very like those of the Molasse; and in both regions the coarser deposits prevail towards the top. In the Himalayas also the younger Tertiary deposits almost invariably dip towards the mountain-range which they fringe,—the plane of contact inclining in the same direction, and thus producing actual, though not parallel, superposition of the older rocks. All the arguments which have been used to prove prodigious faulting in the case of the Alps would therefore, the author states, be quite as applicable to that of the Himalayas. But, as regards the latter range, Mr. Medlicott brings forward evidence which appears to him sufficient to prove that the present contact of the Sivalik formation with the mountains is the original one, modified only by pressure, without relative vertical displacement; and that the *sinking* of the mountain-mass is the proximate cause of the contortions of the Tertiary strata. He then endeavours to show that this explanation is equally applicable to the Alps, especially as it seems also to account for collateral phenomena which appear difficult of explanation consistently with the ordinary hypothesis; and he concludes by discussing the current theories of the formation of lake-basins, in relation to the more immediate subject of his paper.

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2. *On some* STRIKING INSTANCES *of the* TERMINAL CURVATURE *of* SLATY LAMINÆ *in* WEST SOMERSET. By D. MACKINTOSH, Esq., F.G.S.

CONTENTS.

1. *Introduction.*—During the last two years I have been making a series of observations in the West of England and in Wales, with the hope of being able to throw some fresh light on the relative nature and extent of oceanic and atmospheric denudation, and on the origin of superficial accumulations. In some parts of Siluria, during the spring of last year, I supposed I had met with a proof of tranquil marine deposition in horizontally arranged chips of slate resting on the edges of highly inclined laminæ, until I found that I had been looking on a continuation of these edges in a curved-back position, instead of seeing the curvature in profile.

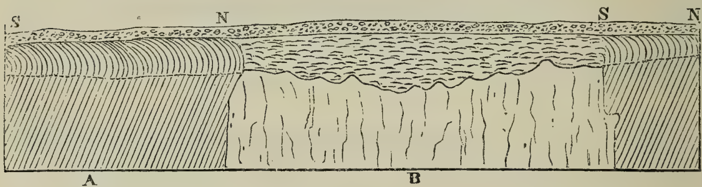
In the autumn of 1866 I noticed several instances of the above phenomenon, which have not yet been described by geologists *. On the *nearly level* floor of one of the valleys which indent the southern slope of the eastern part of the Quantock range of hills, I found the

* For an instance near Ashburton, noticed by Mr. Godwin-Austen, see Trans. Geol. Soc. 2nd series, part ii. vol. vi. p. 437.

laminæ of the Devonian (Carboniferous ?) slate very regularly and distinctly bent or curved backwards, or towards the south. The idea of a more powerful agency than rain or frost then seemed to suggest itself; but it was not until I had examined more extensive sections further to the west, on the east Exmoor hills, that I became convinced of the necessity of having recourse to a more uniformly efficient cause than even the most exaggerated form of what is commonly called atmospheric action. The object of this paper, however, is not so much to theorize on the precise nature of this cause, as to state several important facts.

2. *Sections in a Quarry near Wiveliscombe.*—In a quarry about a mile and a half from Wiveliscombe several very instructive sections of the terminal curving-back of laminæ are exposed. The slates (which have a southerly dip) appear to be very flexible; and this may be partly the reason why they have been so little broken. But the wonderful continuity of the curvature here exhibited must, I think, be partly due to an extreme uniformity in the movement. The bed of curved slates (represented in the figure), on the western

Sections of curved laminæ near Wiveliscombe.



A. The profile of the laminæ. B. Their face.

side of the entrance to the quarry, is from three to four feet thick. The line of demarcation between the commencement of the curving back and the undisturbed mass of slates below is remarkably distinct and straight on looking along the strike of the cleavage; but on looking at nearly right angles to the strike, the surface formed by the edges of the laminæ beneath, though equally distinctly marked, is very uneven, as if the once superincumbent moving agent had exerted considerable inequality of pressure, so as to give rise to irregular grooves and ridges. The upper surface of the bed of curved laminæ, which is very uniform, is overlain by a layer, nearly two feet thick, of reddish loam, containing fragments of quartz &c. On the opposite side of the entrance to the quarry the curving back for some distance is on a nearly level plane. Here the bed of displaced laminæ is from two to three feet thick. It exhibits a double curvature, approaching the shape of the letter S. Over it there is a layer of about two feet of loam, with many quartz fragments, chiefly angular, but occasionally a little rounded.

3. *Terminal Curvature of Laminæ near Raleigh's Cross.*—There are several facts connected with the foregoing sections which obviously point to a powerful and uniformly operating cause; but the belief in such a cause becomes irresistible as one surveys the nume-

rous sections exposed in the mineral-railway-cuttings near Raleigh's Cross, on the summit of Brendon Hill. Here the bending and curving back of the slates is seen to prevail over a large area, with a uniform direction nearly S.S.E.* The laminæ in many places are much broken, and shattered to a considerable depth; but still the line of separation between the bent masses and the slates *in situ* can generally be traced. The most important fact in connexion with these sections is this:—*the bending and curving-back over extensive areas has taken place on perfectly level ground, with a depression instead of an elevation on the side whence the movement must have come.* There are, indeed, instances in which the curving-back has been forced up a slight acclivity. I could find no indications on the northern slope of Brendon Hill† of the movement under notice; and should this prove true with regard to all the northern slopes of the Great Exmoor tableland, it will clearly point to a wide-spread agency operating in a southerly direction, and affecting only the summit-levels or southern declivities. At the same time the possible discovery of *local* variations, or even reversions, in the direction of curvature, would prove nothing further than a deflection of the course of the moving agent.

4. *Transportation of Blocks.*—The cause of the displacement of slaty laminæ on Brendon Hill (or a subsequently operating cause) must have been capable of driving forward or carrying large blocks of quartz to considerable distances from their native veins‡. Many of these were pointed out to me in the cuttings by Mr. Morgan Morgans (Captain of the mines), not only near the surface but imbedded at depths of from three to five feet, in the more shattered parts of the curved-back laminæ. Overlying and intermixed with the slaty débris and transported fragments, there is a considerable thickness of reddish loam §.

5. *Apparent Reversal of Dip near Gupworthy.*—In the neighbourhood of Gupworthy, about three miles from Raleigh's Cross, a horizontal adit was excavated some years ago, in search of copper. It passes through a rich iron- "lode," which at the time was apparently overlooked. This tunnel reveals a section of the uniform curving-back of laminæ on a very gigantic scale, the vertical extent of curvature amounting to at least twenty feet. The direction of the curvature, as elsewhere in this locality, is about south-south-east.

* During these visits I had not the means of very accurately determining the dip of the slaty cleavage or the *precise* direction of curving-back of the laminæ in different sections.

† On the sides of the very steep railway-incline to the north of Raleigh's Cross, the edges of the slates in many places come within a few inches of the surface, and exhibit no sign of disintegration.

‡ These veins run along one side of the "lodes" of iron-ore, and often present a considerable thickness.

§ That the descent of matter by atmospheric action could never have given rise to a great part of the angular detritus, with its loamy matrix, which forms so general a covering of the earth's surface, was long ago clearly shown by Sir Roderick I. Murchison. See chapter on Drift in 'Silurian System,' and more especially a paper on the "Flint Drift" of the South-east of England, Quart. Journ. Geol. Soc. vol. vii. p. 349.

Any one not prepared to find a curving-back on such a scale, might easily mistake the superficial dip for the real dip. I confess I was at first disposed to look on the dip as the result of a fault in the adjacent valley, or as a part of a denuded or truncated anticlinal fold; but further inspection convinced me that it was only an exaggerated continuation of the general curving-back above described; and this conclusion was corroborated by Mr. Morgans, who is familiar, from daily experience, with the internal structure of the district.

6. *Concluding Remarks.*—I think all will admit that the sections to which attention has been directed present indications of a cause to which the term "stupendous" may be justly applied. Was it a southerly progression of a crust of land-ice filling up the basin of the Bristol Channel, and levelling the area between the Black Mountains of Wales and the Exmoor tableland? Was it a grounded iceberg? or floating ice in any other form *? Was it a swift oceanic current exerting a pressure on the underlying slates by means of a forcible drifting forward of detritus? Or was it a still more violent rush of waters caused by a sudden upheaval or depression of the land †?

Postscript.—Since writing the above, I have seen other instances of the curving-back of slaty laminæ. Within half a mile of Union Street, Plymouth, in a cutting of the Exeter and South Devon Railway, the edges of the slates are slightly but uniformly curved on nearly level ground, in a southerly direction, or in the direction of the cleavage-dip. On the left-hand side of the road leading from Torquay to Bishopstowe and St. Mary's Church, and at no great distance from the Torquay Post Office, an artificial excavation (April 15th, 1867) reveals an instance of terminal curvature on a rather extensive scale; and here, as in West Somerset, the line of demarcation between the undisturbed slate and the regular bed of curved laminæ is very distinctly marked. The direction, as in all the other instances, is southerly, or nearly so, and the ground in that direction is only very slightly inclined. I believe that in most parts of Devon, West Somerset, and Cornwall, if not in other districts, where the slates are *flexible*, and where the cleavage-laminæ dip at a considerable angle to the south, or where they are vertical with an approximately east and west strike, similar appearances might be discovered, irrespective of the outline or inclination of the ground. It is not difficult to conceive how the uniform curving-back would only occur where the laminæ leaned towards the moving agent (or at least did not lean away from it), so as to offer a certain degree of resistance to its action. In other places the planing-off of the edges

* See a notice of supposed ice-marks on the Mendip Hills by the author, in the 'Geological Magazine,' vol. iii. p. 574.

† The Rev. Maxwell H. Close, in a very elaborate paper on the "Glaciation of Ireland," read before the Royal Geological Society of Ireland, March 14, 1866, and just published, has expressed his belief that the "broken and bent over" edges of mica slate, in a quarry near Innishowen, cannot be explained by the "weight of the hill," but are the result of a flow of land-ice. (See Journ. Roy. Geol. Soc. Ireland, vol. i. part 3. p. 207.)

of the laminæ would either leave them cleanly cut, or very irregularly shattered. The edges of the strata of the limestone hills of South-east Devon, where they have not been left as cliffs or rocky projections, have either been planed down to a level surface, or smoothly rounded off, the solid rock being often covered with only two or three inches of loam or vegetable soil (excepting in fissures, grooves, recesses, or valleys), as may be seen in the quarries near Torquay, and on the line of railway between Newton and Totnes.

Whatever theory of denudation one may previously have entertained, on coming to contemplate such phenomena it is sometimes difficult to resist the impression that a great weight of *solid* matter, powerfully propelled in a southerly direction, must have curved back the slaty laminæ, and, with an almost geometrical exactness, rounded the forms of the limestone and other eminences of the South-west of England. But so far as South-east Devon is concerned, the mode of occurrence of perfectly preserved *lithodomous perforations* up to at least 240 feet above mean tide, as discovered by Mr. Pengelly, and lately examined by myself, clearly shows that the sea has been the last modifying agent to which the land has been subjected *.

June 19, 1867.

William T. Lewis, Esq., Aberdare, South Wales, was elected a Fellow.

The following communications were read:—

1. *On* Cyclophyllum, *a new genus of the* Cyathophyllidæ, *with remarks on the genus* Aulophyllum. By P. Martin Duncan, M.B. Lond., Sec.G.S., and James Thomson, Esq., V.-P. Geol. Soc., Glasgow.

[Plate XIII.]

Contents.

1. *Introduction.*—A very fine series of specimens of the Palæozoic corals usually classified under the genus *Aulophyllum* †, Milne-Edwards and Jules Haime, has been submitted by us to careful examination. Numerous sections of the specimens have been made, and especial attention has been given to the anatomy of weathered fossils of the genus. Our examination has resulted in the determination that the corals called *Aulophyllum fungites* ‡ and *Aulophyllum Bowerbanki* cannot remain in the genus *Aulophyllum* as established and defined by Milne-Edwards and Jules Haime. Numerous specimens were examined which had their calices perfect; and these gave evidences of a columella, whose structure was revealed both by transverse and longitudinal sections. One form, however, had no columella; and

* See a paper by the author in Geol. Mag. vol. iv. p. 296 (1867).
† Brit. Foss. Corals, Introd. p. lxx (1850).
‡ Hist. Nat. des Corall. vol. iii. p. 406.

the space which ought to have been filled by it was noticed to be occupied by tabulæ. This was clearly an *Aulophyllum*, but it differed from *Aulophyllum fungites* and *A. Bowerbanki* as described by Milne-Edwards and Jules Haime.

We propose to form a new genus which will admit the species with a columella. Thus *Aulophyllum fungites* will become *Cyclophyllum fungites*, Fleming, sp., and *A. Bowerbanki* will be called *Cyclophyllum Bowerbanki*, Edw. and Haime, sp. The new form will be named *Aulophyllum Edwardsi*, Dunc. and Thomson.

M'Coy suspected that the *Aulophyllum* of Edwards and Haime had a columella, but he mistook the general anatomy of the calicular structures: he named the genus *Clisiophyllum*, or rather did not separate it from *Clisiophyllum*. The genus *Clisiophyllum* has a lamellar columella, and the larger septa are continued over the central space of the calice. The *Aulophyllum* of Edwards and Haime was determined from imperfect specimens of two species whose calices were wanting. A circle of small septa, surmounting a central columnar mass which was separated from the inner ends of the large external or true septa, was considered very characteristic. The absence of the columella and the paucity of tabulæ were considered generic.

Our specimens prove that the species included in *Aulophyllum* by Edwards and Haime had deep calices, and laminate septa springing from the epithecal wall externally, some reaching far towards the circle of smaller septa, and others passing but a short distance in the same direction; that the small circle of septa bounded a very complicated and more or less essential columella, and that the endotheca was developed in an extraordinary manner.

2. *Description of the genus* Cyclophyllum *and its species*:—

CYCLOPHYLLUM, gen. nov.

The corallum is simple, tall, cornute, or more or less cylindrical. The wall is very thin and is formed of epithecæ. The calice is deep, and its margin sharp; there is a central projection at the bottom of the fossa, separated from the ends of the larger septa by a deep groove. This central mass consists of an endothecal covering, with numerous septa attached to it internally, and coalescing to form some large septa, which ramify over the central depression which represents the top of the columella.

The columella is essential, and is made up of laminæ which arise from the base of the corallum, and from the dissepiments which unite them. The endotheca is largely developed and the septa are very numerous. There is a fossula with three small septa in it, and a process of the endotheca of the central mass projects into it.

1. CYCLOPHYLLUM BOWERBANKI. Pl. XIII. figs. 1–3.

Aulophyllum Bowerbanki, Edwards and Haime *.

The corallum is long and subcylindrical. The central mass is very prominent at the bottom of the deep fossa, and it is separated from the ends of the septa which arise from the wall by a fold of

* Brit. Foss. Corals, Pal. Soc. p. 189.

endotheca which forms a groove; one portion of the endotheca surrounds the central mass and sends a process into the fossula, and the other is reflected between the septa.

The septa which arise from the wall are alternately long and short, the shorter being attached to the longer by a very regular endotheca, which is vesicular in longitudinal sections. The septa are not exsert, and do not project much in the calice; but in transverse sections they are seen to end at the groove, to be rarely quite straight, and to form a fossula by three of them being rudimentary. The septa are about 140 in number in a corallum $1\frac{1}{10}$ inch in diameter. The small septa of the central mass are about 144 in number, and they unite to form about 40 large septa. The endotheca between the large septa is curved, and between the small and other septa of the central mass it is very vesicular. The endotheca of the columella is very delicate and vesicular. The height of the corallum is several inches.

2. Cyclophyllum fungites. Pl. XIII. figs. 4–8.

Turbinolia fungites, Fleming.

Aulophyllum fungites, Edwards and Haime.

The corallum is cylindro-conical, curved, and cornute, and marked with circular enlargements; the calice is wide and deep, and presents a central projection, which has an encircling endotheca, many small and a few large septa. The columella is essential; and the lamellæ are close, irregular, and joined by much endotheca.

The septa springing from the wall are alternately large and small; there is a fossula, and the endotheca is greatly developed. There are about 120 septa; and the central mass has about 80 small septa. The height of the corallum is several inches.

The shape of the corallites is very constant, and is the great specific distinction.

The foldings of the endotheca to form the lining of the interseptal spaces of the central mass are very distinctive of the genus. This central structure distinguishes the genus from all others, except *Aulophyllum*, in which the mass is less prominent and the columellary space in it is filled up with delicate and close tabulæ.

3. *Description of the species of* Aulophyllum:—

Aulophyllum Edwardsi, spec. nov. Pl. XIII. fig. 8.

The corallum is cylindro-conical and cornute in shape. The calice is wide, not very deep, and the central mass is not very prominent. The septa of the wall are alternately long and short, very numerous, probably 160 in number. The columellary space, encircled by the septa of the central mass, is occupied by very close tabulæ. Height of the corallum 1 inch. Locality, Bathgate.

4. *The geological position of the Corals.*—In all the localities where these corals have been found, namely at Brockley, Lesmahagow, Dunlop, Beith, and Bathgate, there are many fossils associated with them. Amongst the corals there are:—

Heterophylliæ.
Lithostrotion junceum.
—— fasciculatum.
Syringopora ramulosa.
Clisiophyllum, several species.
Cyathophyllum, several species.

And the following Brachiopoda:—

Productus semireticulatus.
—— longispinus.
—— punctatus.
—— fimbriatus.
Spirifer bisulcatus.
—— glaber.
Spirifer lineatus.
Athyris Roysii.
—— ambigua.
Rhynchonella pleurodon.
Terebratula hastata.

The coralliferous beds are a few feet above the lowest limestone beds of the Carboniferous series. At Brockley the corals occur in an arenaceous shale overlying the lowest beds of limestone. At Dunlop they are found in a calcareous band of shale intercalated between the thin beds which overlie the lowest bed. At Bathgate, where they abound, and where their perfection of preservation is remarkable, they are not only found in the intercalated shales, or partings of the thin beds so characteristic of this part of the Scottish Carboniferous series, but also in a limestone, 2 feet thick, which overlies the main or under bed.

The perfection of most of the details of the Bathgate specimens would indicate that they had not been rolled, but had been entombed where they grew—in deep water, with the Brachiopoda.

EXPLANATION OF PLATE XIII.

Figs. 1–3. *Cyclophyllum Bowerbanki*, Edwards and Haime, sp.:—1. Calice, natural size; 2. Central mass, natural size; 3. Columella, magnified.
Figs. 4–8. *Cyclophyllum fungites*, Fleming, sp.:—4. Central mass, natural size; 5. The base, natural size; 6. Transverse section, magnified; 7. Longitudinal section, magnified; 8. Transverse section of septa showing the epitheca, highly magnified.
Fig. 9. *Aulophyllum Edwardsi*, Duncan and Thomson, longitudinal section, magnified.

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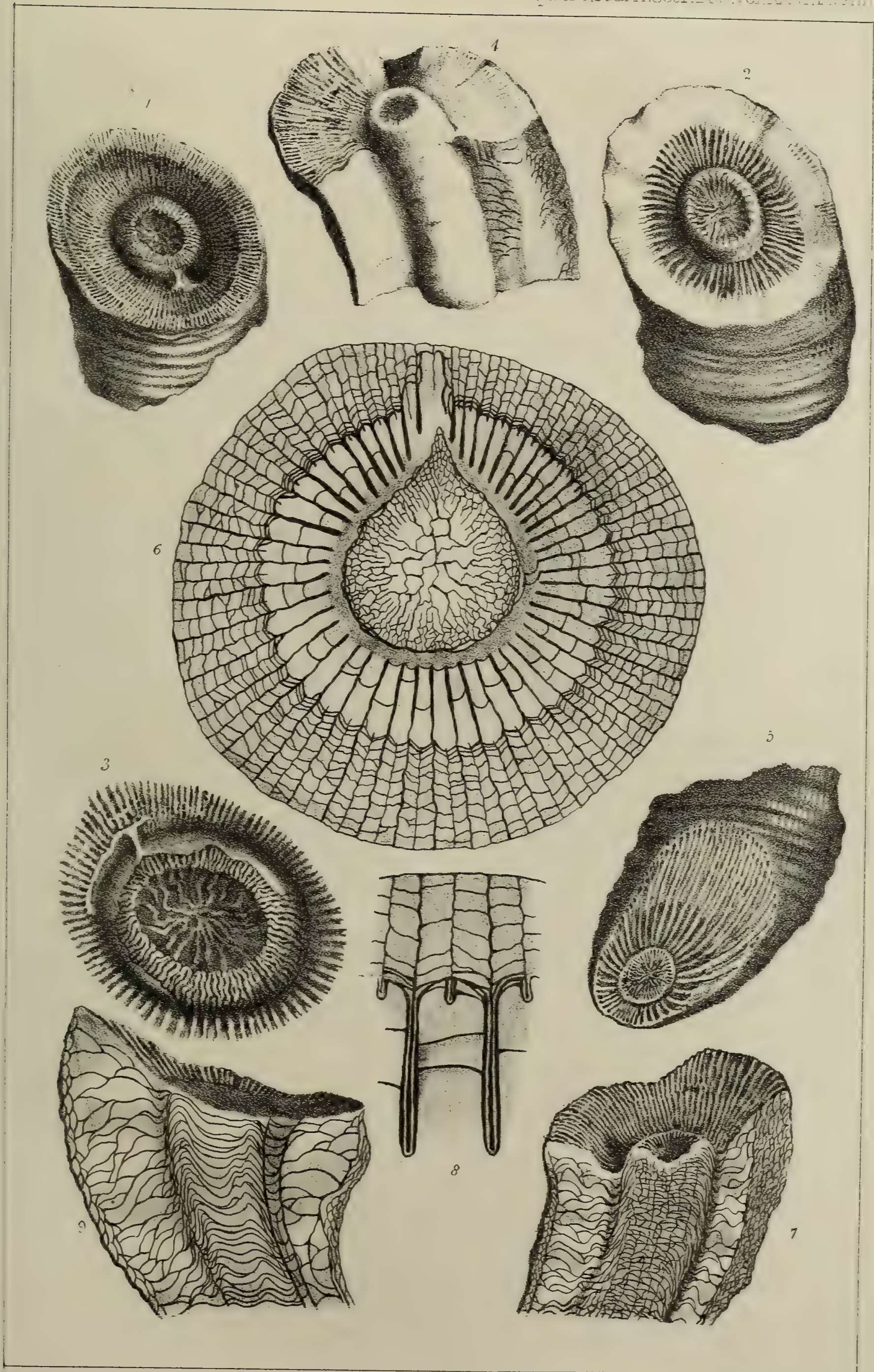
2. *On the* Discovery *of a* New Pulmonate Mollusk [Zonites (Conulus*) priscus, *Cpr.*)] *in the* Coal-formation *of* Nova Scotia. By J. W. Dawson, LL.D., F.R.S., F.G.S. *With a* Description *of the* Species; *by* Philip P. Carpenter, M.D.

The little shell to which the following description refers was found last summer in the course of excavations made under my direction in the bed in Subdivision VIII. of the Joggins Section, between coals no. 37 and no. 38 of Logan's sectional list, already referred to in previous papers † as containing great numbers of shells of *Pupa vetusta*. This bed is 1217 feet below that in which *Pupa vetusta* was originally discovered in trunks of erect Sigillariæ, and about 42 feet below

* *Conulus*, Fitz., 1833 (=*Trochiscus*, Held., 1837, non Sly.; =*Petasia*, Beck, 1837; = *Perforatella*, Schlüt.), is a subgenus of *Zonites*, Montf. (non Leach, Gray), according to Messrs. Adams, 'Genera of Recent Shells,' vol. ii. p. 116, and their follower Chenu, 'Manual de Conch. et de Paléont.', vol. i. p. 422. Those who do not care to enter into the modern divisions of the land-shells, may quote the species as a Zonites—or even, speaking loosely, as a Helix.

† Quart. Journ. Geol. Soc., Feb. 1862, and May 1866, p. 121.



De Wilde lith.

M & N Hanhart imp

AULOPHYLLUM AND CYCLOPHYLLUM.

coal no. 37 *, or nearly in the middle of the band of reddish and grey sandstones and shales intervening between coals no. 37 and no. 38. Its immediate associations are as follows, in descending order:—

	ft.	in.
Hard reddish shale with ironstone nodules	4	0
Pupa-bed, a variable layer, in some places of grey indurated clay, with a tendency to concretionary structure, in other parts laminated and carbonaceous with remains of plants..............	0	3
Shale, mottled, arenaceous	0	8
Sandstone, hard calcareous, light chocolate, weathering rusty	1	0
Shale, chocolate and mottled..................	2	8
Grey sandstone	0	6
Shale, chocolate and mottled..................	5	0
	14	1

In digging into the bed, I found that the shells of *Pupa* are irregularly disposed in nests, and are in some spots very abundant, especially in the argillaceous and nodular parts, while in other places, and especially in the more carbonaceous portions, none were found. In the last-mentioned parts of the bed, there are numerous obscure vegetable remains, especially leaves of *Cordaites*, leaflets of *Sphenopteris*, and *Trigonocarpa*, apparently of the same species (*T. sigillariæ*) found with Pupæ in the original repository in the erect Sigillariæ. The appearances were such as to confirm the impression, stated in a previous paper, that the land-shells were drifted along with vegetable matter by some quiet stream, and deposited on the muddy bottom of shallow water.

One object in excavating the bed was to ascertain if any other species of land-animal than *Pupa vetusta* could be obtained from it; and in the first instance the result appeared purely negative, except in the presence of minute fragments of bone, and of what might have been the chitinous integument of insects. On a more careful examination of the large quantity of fragments of *Pupa* obtained, I was able to select a few small specimens, all of them more or less crushed, which seemed to differ materially from the young of *Pupa vetusta* in form and surface-markings. On submitting these to Dr. Philip P. Carpenter he at once recognized their distinctness from *Pupa vetusta*, and has kindly furnished me with the following description and note on the affinities of the species.

Zonites (*Conulus*) *priscus*, Cpr.

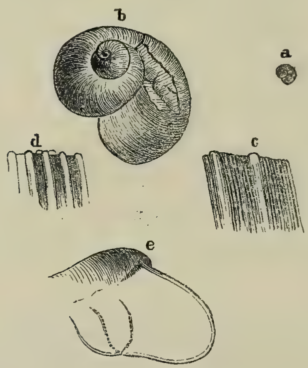
"C. t. parvâ, tenuissimâ, parum elevatâ; nucleo minimo; anfractibus iv., subplanatis, omnino tenuissime rugoso-striolatis, interdum rugulis incrementi magis conspicuis, suturis parum impressis; circa peripheriam angustatâ, vix subangulatâ; basi concavâ, ut

* Incorrectly stated as 12 feet in the paper last mentioned.

supra striolatâ, umbilico majore; aperturâ subovali, satis regulariter excavatâ; labro simplici. Long. circ. 1 poll., div. circ. 130°.

"*Hab.* In stratis carboniferis Acadiæ, *Dawson.*"

Zonites (*Conulus*) *priscus*, Carpenter.



a. Natural size.
b. Magnified.
c. Portion of surface highly magnified.
d. Portion of the surface of *Pupa vetusta*, highly magnified.
e. Fragment of *Zonites* (*Conulus*) *priscus*, showing lip; the dotted lines indicate a portion of the columella (crushed) and the umbilicus.

"A few specimens only of this shell were found, in company with numerous individuals of *Pupa vetusta*, Dawson, from which species it differs in form, sculpture, nuclear whirl, and texture. *Pupa vetusta* closely resembles the living race of small Pupæ, and seems to have been (for its size) solid, and coarsely sculptured parallel to the axis. The present species has a different colour, though in the same matrix, and seems to have been an extremely thin shell, of a horny (though not glossy) texture, like the British *Helix* (*Conulus*) *fusca* and similar species. The markings consist of rather irregular striolæ with occasional coarser ridges of growth, somewhat slanting toward the periphery, which is rather flattened though not angular. The base is concave, similarly sculptured, and gradually curving into a rather large umbilicus. At least such is the inference from the only portion that has been cleared from the matrix. The nuclear part in this shell is much smaller than in *Pupa vetusta.* In the Pupa the first whirl is large and swollen, the next suddenly assumes the normal cylindrical form; and it is not until the end of the third whirl that the normal sculpture is developed. In the present species the growth, form, texture, and sculpture of the shell appear nearly uniform from the beginning.

"It is difficult to state exactly what was the original shape, as even in the most perfect specimen the body-whirl is broken; but it was probably like *Paryphanta Caffra*, Fér., on an extremely small scale. It might possibly rank with *Hygromia*, or, with the living American species *minuscula* and *exigua*, under *Pseudohyalina*, Morse.

It is, however, until better specimens attest its true relationships, placed with *fusca* in the group *Conulus*, which (according to Messrs. Adams, Gen. ii. p. 116) is a subgenus of *Zonites*.

"It is probable that there is a third species among the fragments which have been found; presenting a shape more resembling the *H. conulus*, and other trochiform snails. It would be premature, however, to venture on a description until more perfect specimens have been obtained."

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3. *On some* Tracks *of* Pteraspis (?) *in the* Upper Ludlow Sandstone. By J. W. Salter, Esq., F.G.S., A.L.S.

The Society has always received with patience communications tending to explain those surface-markings on our beds of rock which may be referred to the movements of animals. In many cases, indeed, these are the only proofs left us of the existence of certain types; while in others the remains of the animals themselves have been discovered after we had learned to guess at their nature from the impressions they had left behind them.

There is an obvious reason for the more certain preservation of the track than of the animal which made it, when such imprints have been made upon the sea-shore; for the impressions have generally been made between tide-marks, their preservation being due to the covering up of the imprinted layer by another upon the return of the tide. It is certain, then, that this portion of the stratum must, in general, be unfit for the preservation of the animal itself, even if it were not expecting too much to find it dead where we have the best proof of its having been alive and in the enjoyment of its functions. The wash of the tide, throwing up as it does dead shells, and hard parts of the crust of jointed animals, is very destructive even of these; and the majority of waifs upon the shore are decomposed and destroyed by the atmosphere soon after they are thrown beyond the reach of ordinary tides, and before there is a chance of sufficient sediment being accumulated to resist the next incursion of the waves. In deeper water the relics are abundant, but the tracks are, of necessity, rare.

We may take for an instance the fine cliff of Caradoc or Bala sandstones, which is so well known, at Aberystwith. Here ripple-marks and tracks and trails are copious enough, but not a fossil has been detected. The Coal-measure cliffs at Waterwinch near Tenby furnish another example. In the Lingula-flags, too, we find whole surfaces scored by the *Hymenocaris*, without a fragment of the artist who engraved them; and every collector of fossils knows that he need not, as a rule, expect to find good fossils where tracks abound.

The Downton or Upper Ludlow sandstones of Kington, on the borders of Herefordshire, are unquestionably a shallow-water, and in part a shore deposit. The irregular silty character of the bed itself, the disjointed fragments of crustaceans and fish, the numerous vegetable fragments, the scarcity of shells (for even *Lingulæ* are rare), attest this. And we know from other evidence that the close of the Silurian epoch was, in Britain, marked by the silting up of shallow seas, to form land-locked estuaries for the deposit of the Old Red Sandstone.

Even the characteristic tide-wash-mark (if I may coin a triple term) is present; and fig. 1 shows as good an instance of this shore-character as can be seen on the paving-flags of Forfarshire, or, still nearer, on those of the Yorkshire Coal-measures.

And on these surfaces Mr. R. Banks, of Ridgbourne, found (I am ashamed to say how many years back) the beautiful impressions on the two slabs upon the table, for which I am much indebted to him. To my mind these slabs show all but conclusive evidence of the tracks of Ludlow fishes, two (if not three) species of which have been described by Prof. Huxley and myself in a former volume of the Journal*, from this locality. My reasons for believing the tracks to be the work of Pteraspid fish † are partly drawn from the character of the imprints themselves, and partly from the fact that, except the large *Pterygotus*, which occurs in the same bed, no creature of size or weight enough to make these imprints is known, either from Kington or elsewhere in the Downton Sandstone. Of course the argument from negative evidence will be stronger with some than with others. But if (for the purpose of inquiry) it be admitted that our choice is narrowed to the kinds of animals known to have existed at the period, I should have no hesitation whatever in rejecting the crustaceans and mollusks, and deciding for the fish; and *Pteraspis* and its allies are the only fishes known to exist in Upper Ludlow Rocks, except the small Dogfishes or Sharks (if indeed they were so, for we do not know their teeth, and they may have been Acanthodians) which are found in the Ludlow bone-bed. At Kington, though I did find the bone-bed by its peculiar shells, I cannot remember that it showed any traces of fish. But fin-spines of fishes do occur in plenty in these flaggy sandstones; and the reasonable inference would be that they may have belonged to Pteraspid fish, unless it can be shown that such fishes could not have had defensive spines to their fins.

I will describe the slabs first, of which I have only two:—Fig. 1 represents the smaller, about 18 inches square by $\frac{1}{3}$ of an inch thick, and shows traces of three tracks made by a larger individual than those which have left traces on No. 2 (see fig. 2). The latter is a much thicker slab, with many tracks (confused for the most part) over a space a foot square. It has two contiguous layers imprinted by them (α and β), separated by only a thin layer of sandstone; while a third or upper layer (γ) is free from markings, so far as it is seen. The tracks on this larger slab can, I think, best be interpreted by reference to the smaller and more perfect one. But with this help they enable us to observe some characters not plainly visible on No. 1.

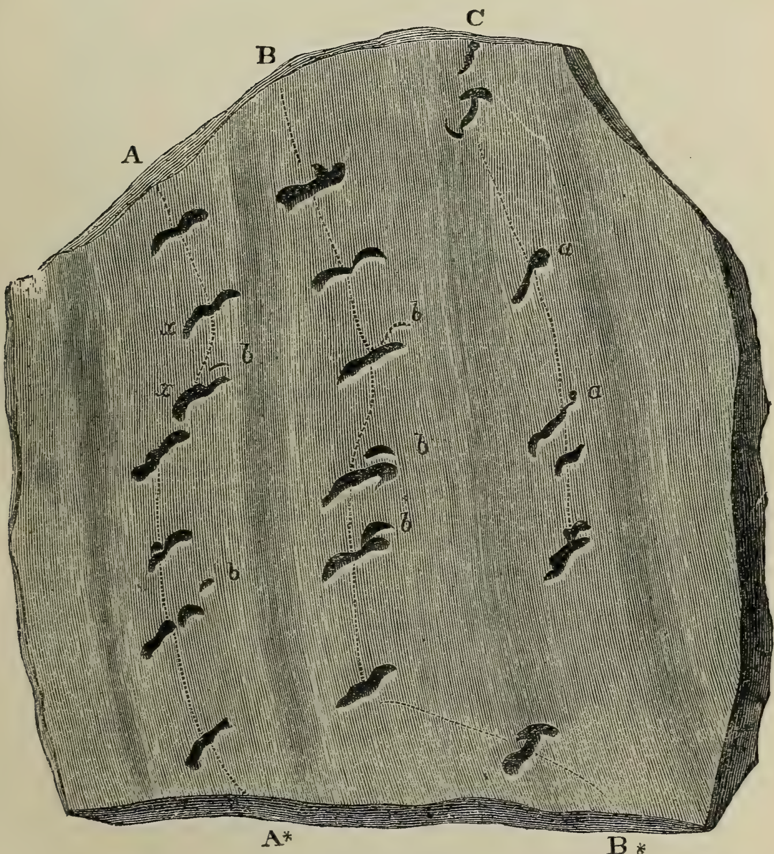
Fig. 1 shows three undulating lines of imprints, neither parallel

* Quart. Journ. Geol. Soc. vol. xii. p. 100.

† A fine slab of markings, probably due to *Cephalaspis*, exists, or did exist a few years back, in the great Jermyn Street Collection. It is from the Cornstone beds of the Old Red. A still finer one is in the Worcester Museum.

nor equidistant, nor alike in their depth or direction; nor is the number of imprints the same in each track. So that we are at once relieved of the supposition that a single individual with three series of appendages could have left this as its compound track; and we are at liberty to treat each as independent, though their main direction is the same—namely, along the line of the tide-wash, as indicated by the stripe A to A*, B to B*, &c.

Fig. 1.



Two of these, at least, are the track of the same creature, repeated in its double journey from water to shore or *vice versâ*; and I think (but am not sure) the third track is evidence of another advance of the same individual in a parallel direction. We may suppose, then, the effort of the animal (whatever it was) to reach the deeper water from the shore, twice obstructed by the forward wash of the surf, which stranded it again. The tracks A and B are exactly similar, except that one is deeper than the other, and the imprints are at unequal distances; and they have every appearance of being made by the same individual. But the difference in depth of the three tracks shows clearly the direction to have been from A to A*, or the reverse; and it will be observed that this line of direction is transverse, but a little oblique also, to that of the linear imprints themselves.

The more confused slab (fig. 2) shows none of these points so strongly; but is easy of interpretation by the help of the more perfect one; and the evidence of the two together is conclusive on one point—namely, that the successive imprints were made in solitary lines, and are not the results of a track of any animal with numerous appendages.

Our attention is therefore limited to the possible nature of the organ or organs which could produce a transverse (slightly oblique) bilobed or double impression at each stroke, at intervals of about an inch.

The most perfect of these imprints are $\frac{3}{4}$ of an inch long, not quite $\frac{1}{4}$ of an inch broad, and about a line deep in their strongest impression. They are slightly curved, deepest forward on the inner side of the curve, and sloping behind. I take the direction of the track to be from A to A*.

Each imprint is double; and on slab 1 the longer and shallower lobe is on the right, the deeper and shorter lobe on the left; and behind this shorter lobe, at a distance varying from one to two lines, is a shallow pit, in the same direction as the main imprint, and a little wider than long. These supplementary imprints are wanting behind most of the shallower main impressions.

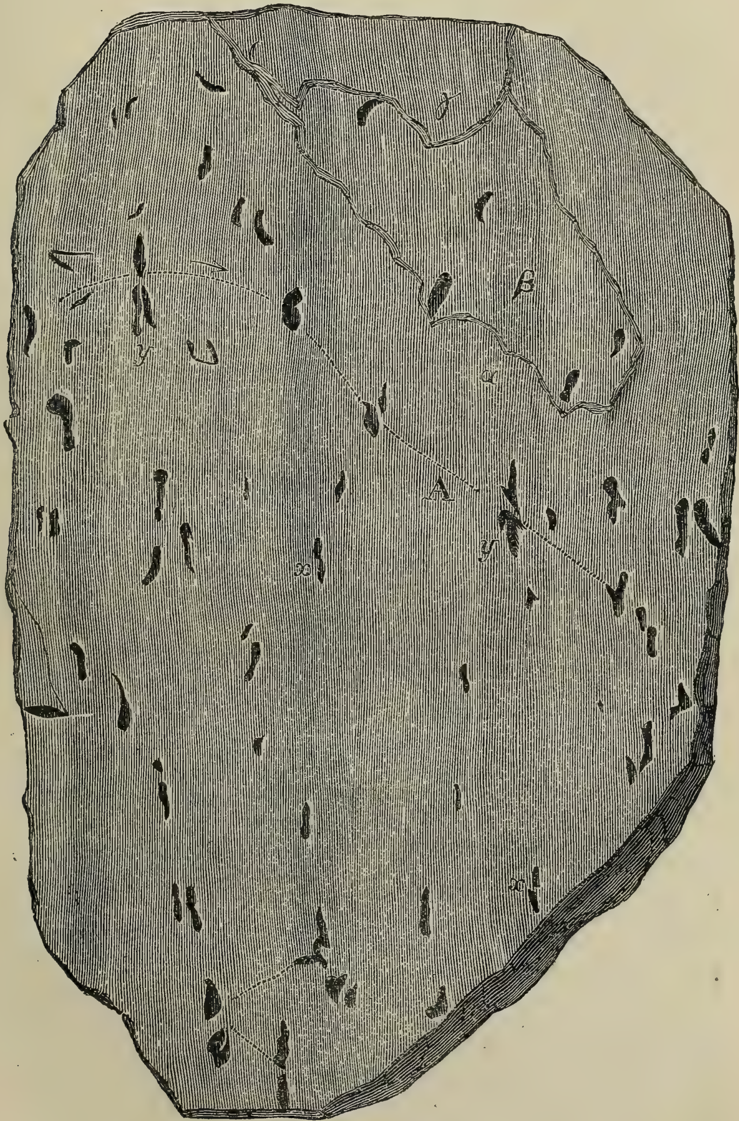
Between the two lobes of the imprint the sand is always more or less pinched up, as if the action had been (and I believe it was so) from without inwards. It is as if a pair of rude blunt forceps had been used, whose arms were occasionally of unequal length. Sometimes, as at *x* in fig. 2, the points of the forceps have not met closely, one being a little behind the other. This character, however, is rare, though seen on both slabs; while the appearance of a pinching action is visible on most of the imprints in each case.

In one, or possibly two instances (*y*, fig. 2), there is a short return stroke, as if the forceps, after meeting near the centre, where the deepest indent is made, had escaped in a somewhat different direction. In this case the lobes or strokes are equal, and there is no supplementary impression. More commonly still, two short punctures in the sand, a line or two apart, are equal in strength; and in these instances, again, no supplementary indentation has been made.

Lastly, on the larger slab are several examples in which the sand has been heaped up on one side or the other, or even *between* the imprints when the stroke has not closed, as if the instrument on leaving the surface had driven the sand forcibly outwards.

Single indentations occur; but the double ones are so much more numerous and characteristic, that I am compelled to believe a pair

Fig. 2.



of instruments were present, and in use, upon all occasions. These instruments were driven first inwards so as nearly to meet, and then opened suddenly outwards with various degrees of force. The stroke was, if I interpret the direction of the tracks rightly, a little backward as well as inward in each case, and the return stroke also backward.

The evidence, then, as far as I understand it, is, that one pair of organs placed near each other, and acting in a direction transverse to the progress of the animal, were the means by which the creature was propelled through the shallow water. Also that a posterior lobe or supplementary organ, shorter than the other, touched ground in the deeper imprints; but as it occurs only behind the deeper ones, which happen in this case to be on the left side, the inference is that there were a pair of such shorter organs immediately behind the longer pair.

Such an arrangement excludes, of course, the gigantic crustaceans described by Prof. Huxley and myself*, and now being so thoroughly examined by Mr. Henry Woodward. The *Pterygoti* are indeed plentifully found in the Kington Sandstones. Perhaps the largest of them all, at least the *P. gigas*, rivals the great Forfarshire species in size, and must certainly be 6 or 7 feet in length, as I at first supposed. But the struggles of such an animal in the shallows would leave, not a bilobed imprint, at times unequal-sided, but a number of impressions, arranged along a central line. Such are shown in Prof. Owen's illustration of the *Protichnites* of Canada, which that distinguished naturalist refers without much hesitation to large Limuloid or Eurypteroid Crustacea. In that view I thoroughly agree with him, and believe we have yet to discover the ancestor of all the Pterygoti in the Potsdam Sandstone.

That we may eliminate all the contemporary crustaceans from consideration, I may mention that I have myself described tracks of the Phyllopod Crustacea found in Lingula-flag and Silurian rocks, and made with double or triple forked caudal extremities (Quart. Journ. Geol. Soc. vol. x. p. 211, vol. xviii. p. 347). Such impressions have nothing in common with these. They were made in the opposite direction to that of these imprints, namely, fore and aft, in the line of the track itself.

But if we turn to the abnormal Ludlow fishes, *Pteraspis* (the earliest known of these) is common enough in the Kington Sandstones, as Mr. Banks's researches first proved to us†. These seem to give a clue to the impressions before us. If such fish, evidently fond of shallows, were endowed with stiff defences to their pectoral or ventral fins, they might produce with them somewhat such a pair of combined strokes as would lift the animal forward or backward. The slight obliquity of the stroke is not against the supposition; for the motion of a fish's fin is not quite in a direct line, but more like that of a screw propeller.

That *Pteraspis* had such stiff defences I do not know. But a not very distant ally among these abnormal cuirassed fishes (*Pterichthys*)

* Monograph of *Pterygotus* and *Eurypterus*, Mem. Geol. Survey, 1859.

† Quart. Journ. Geol. Soc. vol. xii. p. 93.

had very decided bony crutches as a modification of its pectoral fins; and therefore I think we need not reject such a supposition too hastily in the case of *Pteraspis.* We have not yet been able to refer all the bony defences (*Onchus*, as they are called) which abound in the Ludlow bone-bed, the Downton Sandstone, and the fish-beds of the Old Red, to Placoid fish; and we may yet be led by these few tracks on sandstone to look out for such adjuncts to the fore limbs of Cephalaspidæ.

At least, all I can say is, that if *Pteraspis* had not such a bony crutch, I do not see how he could make such an impression on the sand; and if my impression is not a correct one, I cannot offer a better, nor suggest what aquatic or amphibious creature could possibly produce successive impressions of the form and direction I have shown to occur in these, unless it were *Pteraspis,* or the Acanthodian or Squaloid fishes before mentioned.

And now comes a very interesting point in proof that these imprints were made by fishes. If the water were not quite deep enough to float the animal (and that it was not, in the case of track A A*, is certain), then the stroke made by the leaning side must necessarily be shorter and somewhat deeper, and the fin itself behind the defence would touch the ground. In proof that these imprints (fig. 1) are the records of a struggle to attain the water, I need only refer to the specimens (which are placed in the Society's museum), where, on the back of slab 1, the weight of the instruments has been such as to indent the sand for more than half an inch, and to penetrate into a layer below, which is, of course, not seen in this specimen.

I owe the recognition of this circumstance to Prof. R. Owen, whose acumen in determining track-markings is almost an instinct; and to whom I showed the slab, telling him that I had come to the conclusion it was made by a fish (*Pteraspis*), and could be made by nothing else. His reply was very characteristic; for, turning up the back of the slab, which I had neglected to do, he at once pointed out the depth of the two impressions, which must have been made when the creature was struggling on the shore; and though he did not hastily adopt my conclusion, he at least convinced me that, if the track was made by a fish, it was a fish out of water.

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4. *On a* NEW LINGULELLA *from the* RED LOWER CAMBRIAN ROCKS *of* ST. DAVIDS. By J. W. SALTER, Esq., A.L.S., F.G.S., and H. HICKS, Esq.

FOSSILS in the red Cambrian rocks are so rare, that no apology seems due for introducing a single small specimen, lately gathered, after great research, by one of the authors of this paper. The search has been systematically pursued since 1862, when the first fossil of the Menevian group was described by Mr. Salter from this neighbourhood; and the labour has chiefly fallen upon Mr. Hicks, who resides at St. Davids. He has literally not left a stone unturned to find the true place of *Oldhamia*, and, if possible, of the mythical *Palæopyge*, in these old red rocks. He has been rewarded, during the search, by many additions to the Menevian fossils, found at successively lower and lower horizons, in the grey rocks which form the passage from the Lower to the Upper Cambrians. But, until quite lately, not a vestige had occurred to him in the actual red rocks themselves.

The fossil is but a small one, a line and a half long; but it is unquestionably a *Lingulella*, and apparently of the same species as one very common in the lowermost of the layers which have yielded *Paradoxides*, and the fossils of which will be described in our next memoir. With the *Paradoxides Hicksii*, Salter (the species formerly published in Siluria, 2nd edit., as *P. Forchammeri*?), several species of shells, Brachiopod and Pteropod, occur—and among them a *Lingulella*, of which figures and a description are appended, and which appears to be the same as that now found 200 feet lower in the red Cambrian slates.

LINGULELLA FERRUGINEA, Salter, spec. nov. Fig. 1.

Length fully 2½ lines. Form ovate-oblong, the front rather obtuse, but not straight-edged; the sides nearly parallel; the obtusely pointed beak includes an angle of about 75°. Generally convex, especially down the median area; the sides bevelled obliquely; the surface concentrically and very finely striated; the inner surface rather coarsely sulcate concentrically, indicating close ridges or sharp waves of growth upon the outer surface (not visible in our specimens). The inner surface (and probably the outer) shows radiating lines (rather coarse ones) over the median area, but not on the sides.

The pedicle-groove is so wide and pyramidal as to open at an angle of 40°; and its edges are so strongly pronounced as to give the appearance of hinge-plates. A short median ridge divides this area, and extends but a very short distance. A specimen, apparently of the shorter valve, has also a median line, but fainter and longer. This is uncertain, the specimen being much crushed.

Loc. Lowest strata of the black flags in the Menevian group, Pen-y-pleidiau, St. Davids.

Figs. 1–3.—*Lingulella ferruginea*, Salter.

2 3 1

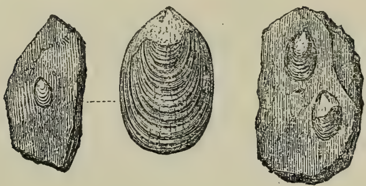

Fig. 1. *Lingulella ferruginea*, Salter. Natural size.
2. *L. ferruginea*, var. *ovalis*, Hicks. Natural size.
3. The same, magnified.

Var. *a.* OVALIS, Hicks. Figs. 2 & 3.

Shell ovate, 1½ line long: front edge rounded, not obtuse.

Loc. Red Rocks of the Menevian group, near St. Davids.

Except the shape of *the front edge* of this small shell, which *is rounded off, and not squared at all,* this variety is not to be distinguished from the other.

We give this variety a distinct varietal name, as it is important to distinguish all marked forms. When there is a difference in geological position, as well as some peculiarity in the form, it is wiser to distinguish, at least as a variety, any important specimen. Until it shall have been clearly proved, by intermediate forms, to belong to the self-same species, there can be no reason for allowing a theoretical opinion of descent with modification to influence us, as naturalists, in determining the nomenclature of a fossil or recent shell. And the contrary proceeding would throw all our useful binomial or trinomial appellations into oblivion; while it would not advance by one iota the real study of the group to which the fossil belongs.

That *Lingulella ferruginea*, var. *ovalis,* may have been the progenitor of the more ordinary variety, which is found in rather newer beds, is probable. That both may be only steps in the series by which we at last reach, through several Lower Lingula-flag species, the characteristic *Lingulella Davisii* and *L. lepis* of the Ffestiniog and Tremadoc groups, is also possible, if not highly probable. But we have no proof of it. Still less have we any proof that *Lingulella* merges into *Lingula*, or this into *Obolella*, or the last into *Discina*, &c., or that any or all of them had some common *ancestor of whose nature we know nothing.*

I only intend by these remarks to show the importance of still adhering, in our nomenclature, to old and well-established rules. Whatever may be our theory as to the derivation of species, it behoves us, as descriptive naturalists, to keep our minds free from the delightful fetters of theory, while we strictly and truly describe the medals of creation as they are shown to us.

I think my friend Mr. Davidson, in whose acumen and talent I have profound confidence, has of late years set us a bad example in this particular. He merges *Lingulella* in *Lingula* (though one has a pedicle-groove, and the other has not), and *Trematis* in *Discina* (though one has a marginal foramen and a radiated surface, and the other a closed foramen, and a horny concentrically ribbed shell).

I may mention, while speaking of fossils from the Lower Cambrian rocks, which I regard as a portion of the great Menevian group, that Mr. Alfred Marston, of Ludlow, has within the last few years found other portions of the so-called *Palæopyge*, or some allied crustacean form. They are in the truly rich museum in Jermyn Street. He has also lately sent me word that my small Arenicolites are not the only tenants of the Longmynd. A large worm-tube, comparable to the *Histioderma* of the Wicklow rocks, has been found in the Longmynd by him.—J. W. S.

5. OBSERVATIONS *on* CERTAIN POINTS *in the* DENTITION *of* FOSSIL BEARS, *which appear to afford good* DIAGNOSTIC CHARACTERS, *and on the* RELATION of U. PRISCUS, Goldf., *to* U. FEROX. By GEORGE BUSK, Esq., F.R.S., F.G.S.

[The publication of this paper is unavoidably deferred.]

(Abstract.)

AFTER noticing the difficulties which attend the study of the bones of the skeleton generally in fossil Bears, and the somewhat confused and contradictory opinions as to the distinction of species which have arisen in consequence, Mr. Busk states that his object in the present communication is merely to call attention to some points in the dentition which seem to afford more certain and more readily ascertainable characters than can at present be drawn from the bones, and which, at any rate in the absence of other evidence, are a sufficiently sure guide in the distinction of species.

The characters derived from the teeth depend—

1. On their dimensions, absolute and relative.
2. On their form.

It is not necessary, however, to consider all the teeth. The canines vary too much even within the limits of one species to be of much utility; and, with certain exceptions, the differences exhibited in the molars are not sufficiently marked to allow of their being employed.

The teeth upon which reliance is to be placed are the upper and lower fourth premolars, and the last molar in each jaw; and the distinctive characters of these teeth in *U. spelæus*, *U. priscus*, *U. ferox*, and *U. arctos* are pointed out by the author.

It is also endeavoured to be shown that in the size, proportions, and form of the teeth no essential differences can be perceived between *U. priscus* and *U. ferox*; and the opinion is expressed that, so far as cranial and dental characters are concerned, those two species are at present indistinguishable.

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6. *Notes on the* GEOLOGY *of the* PROVINCE *of* CANTERBURY, N. Z., *principally in reference to the deposits of the* GLACIAL EPOCH *at the western base of the* SOUTHERN ALPS. By JULIUS HAAST, Ph.D., F.G.S., &c.

CONTENTS.

I. INTRODUCTION.

IN a paper laid before the Society at its Meeting of the 7th December, 1866, I offered a résumé of my views on the causes by which the glaciation of the Southern Island of New Zealand had been produced in Postpliocene times, giving at the same time a short description of the deposits of that interesting epoch, by which the slopes and valleys on the eastern side of the dividing range are almost everywhere covered.

The western side of that important mountain-chain, called properly the Southern Alps, in this Province, was then not known to me; but I had the satisfaction of visiting that part of the country last year, and of finding that the physical features confirmed in many respects my former deductions, based upon my researches on the opposite slopes.

My notes on such an important subject would not be complete did I not lay before the Society a short description of that interesting region, where, perhaps more than anywhere else, the deposits of the Glacial (or here perhaps better named glacier) epoch are developed on such a huge scale that even the morainic accumulations on the eastern side sink into insignificance when compared to those of the opposite slopes. Moreover any addition to the knowledge of the Postpliocene beds in the southern hemisphere, deposited by glacial or glacier action, and of the changes wrought by them in the physical aspect of the country, will not be unwelcome to those who are occupied in unravelling the nature of the deposits of the same epoch in Europe and North America. All beds observed by me hitherto are of subaerial glacier-origin; and I have met with no deposits which might lead to the conclusion that they have been thrown down from icebergs. As they form, as far as I have examined them along the coast, bald and often vertical cliffs, sometimes several hundred feet high, the arrangement of these beds, thrown down along and in front of the Postpliocene glaciers, can be well studied.

At the same time the character of the blocks of rocks which we find imbedded in the smaller débris, gravel, and silt, gives us an excellent insight into the working of these glaciers, and shows, more than any reasoning by induction can do, the great triturating power of huge ice-masses on the slopes and in the valleys of Alpine chains, as well as the enormous power of ridge-making which they possess.

II. Geological Structure of the Southern Alps.

Before entering into a description of the beds under review, I shall offer a few notes on the geology of the Southern Alps in this Province.

The Southern Alps proper form the eastern wing of a huge anticlinal arrangement, of which the western portion has been greatly destroyed, and submerged below the Pacific ocean. The axis of this anticlinal consists of granites, which do not appear, however, in this section, but which, more to the north, in the western part of the Nelson Province, are still partly in existence, and are certainly of early Secondary if not of Palæozoic age.

Younger granites of Secondary age appear in low wooded hills at the western base of the central chain proper. They support on their flanks semimetamorphic beds, mostly silky slates. In some localities the latter seem to overlie unconformably the gneiss-granites—the western base of the Southern Alps; in others they appear to owe their present position to faults or upheaval. The eastern side of the anticlinal forms a succession of huge folds, dipping throughout at a very high angle, but so much destroyed that at present the synclinals form generally the summits of the mountains, whilst the anticlinals of the folds appear now on both sides of the broad and deep valleys between.

These strata consist of dioritic sandstones, clay-slates, indurated shales, and aphanitic conglomerate or breccia beds, which follow each other in endless succession, and have a thickness of at least 25,000 feet. They appear to have been deposited during the gradual depression of the sea-bottom, whereby they obtained such an enormous thickness.

It is evident from the character and position of the beds in question, that the rivers entering the Palæozoic ocean came from the high land situated to the east of the present Southern Alps, and that this land consisted of gneissic schists, quartzites, felstones, and true clay-slates, as well as of dioritic sandstones, and other rocks similar to those under consideration.

I have, in some instances, although rarely, met with small rolled pebbles of granite, syenite, and porphyry. The conglomerate and brecciated beds of the Southern Alps invariably thin out towards the west.

I may here observe that I have obtained from the Chatham Islands specimens of fine-grained gneissic schists resembling closely the lower series of our Alpine beds.

It is remarkable that limestone rocks occur very rarely, as I found only a few beds of dark calcareous flagstones. Fossils are also exceedingly scarce: as far as I have searched, over hundreds of square miles of these rocks, I have found only a few minute bodies resembling Tentaculites, a few fragmentary remains like Serpulites, some impressions of Fucoids, and one single specimen of indurated shale with the tracks of Annelides. It is difficult to conceive that such a paucity of animal and vegetable life in the Palæozoic seas should have existed during the formation of these huge sedimentary strata, or that the necessary conditions for the preservation of its fauna or flora were so seldom offered.

The very summit of the central chain, as for instance Mount Cook, consists, as before observed, of these sedimentary rocks, except in some few localities, where its S.W. and N.E. direction is somewhat altered by westerly bends, and the underlying newer fine-grained gneissic schists, felstones, quartzites, and contorted clay-slates make their appearance; the latter by their hardness have generally resisted the disintegrating agencies much better than any rocks in the Southern Alps.

Below them, again, advancing towards the west, we meet with silky clay-slates, changing soon into micaceous and chloritic schists, which are succeeded by true mica-schists, gneiss, and gneiss-granite, forming the western base of the Southern Alps, and invariably dipping at a very high angle towards the east. To these two latter series the auriferous rocks in this province are confined.

On the eastern side of the Southern Alps, and unconformably overlying the older Palæozoic strata, occur two fossiliferous beds, of which one occurs in the Clent hills, the other being situated ten miles north of it, on the western slope of Mount Potts, of which the Mount Guy range is a continuation.

The latter, which I named the Spirifer-beds, are, according to Prof. M'Coy, of Melbourne, either Upper Devonian or Lower Carboniferous. They are situated near the junction of the main branches forming the river Rangitata, and consist of indurated shales, clay-slates, and coarse sandstones. One of the commonest fossils is *Spirifer lineatus*, M'Coy, which occurs in great masses; besides it, some other Spirifers are represented, as, for instance, *S. duodecimcostatus* and *latus*,—also the genera *Productus, Orthis, Murchisonia*, and some others.

The Clent-hill beds consist mostly of shales and conglomerates, the latter made up of pebbles of plutonic, metamorphic, and trappean rocks, of every possible variety, many of which have disappeared from the surface of New Zealand. In fact, a complete Museum of the former crust of the earth is here presented to us. In the shales of these beds numerous beautiful impressions of plants occur, mostly ferns and belonging to the genera *Pecopteris, Sphenopteris, Camptopteris*, and *Tæniopteris*; a few of them are identical with Australian forms, as for instance the *Tæniopteris Daintreei*, M'Coy, to which that distinguished palæontologist assigns a Jurassic age.

The Southern Alps proper are bounded on their eastern side by a belt of old Tertiary volcanic rocks, quartzose trachytes, and pearlstones, which have without doubt risen in a semifluid state in longitudinal fissures; they form generally dome-shaped mountains, some of them 4000 to 5000 feet high; but nowhere is the least sign of a crater or lava-stream discernible.

The trachyte zone surrounds Banks peninsula as the segment of a circle, distant from it about 50 miles, in a direction east and west, but only approaching the seashore, north and south, at a distance of 100 miles.

Thus the great foldings of the Southern Alps proper are bounded on both sides by igneous rocks, which circumstance may account in some degree for the steepness of the folds throughout the whole region. At the same time the difference of age and composition of these igneous zones on both sides, the granites on the western and the trachytes on the eastern flanks, may lead us to conclude that the great anticlinal and synclinal arrangements did not take place simultaneously, but that its western portion was formed when, at the beginning of the Tertiary period, deep-seated disturbances began to occur on its eastern side, by which the strata were brought into their present position. Longitudinal fissures were at the same time opened, through which the volcanic rocks made their appearance.

On these, the oldest volcanic rocks in the Province, repose our Tertiary series, beginning with extensive agglomeratic and tufaceous deposits, made up from the disintegration and destruction of trachyte rocks, followed by argillaceous beds and sands, with lignite-seams often of good quality (Browncoal). They are again overlain by thick-bedded calcareo-arenaceous strata, called by Dr. Hector the Oamaru series, and are broken through by newer volcanic rocks, mostly dolerites, sometimes forming large sheets, and with palagonite tufas associated with them. These are again covered by sands, clays, &c., and some small beds of shell-limestone, probably of Pliocene age. These Tertiary rocks appear either on the slopes of the lower range, on the eastern or western side of the Southern Alps, or they form small isolated hills in front. Otherwise they are mostly concealed by the great Pliocene alluvium forming the Canterbury plains on the eastern side, through which the present watercourses have cut deep channels on the higher or western portion, whilst near the sea they have covered them by recent deposits, of which I have given a description with sections in my Report on the formation of the Canterbury plains.

It is often in the deep gorges where the rivers leave the mountains that the Tertiary rocks are well exposed.

Banks peninsula is a volcanic system of some complication. The two larger harbours, Port Victoria and Port Akaroa, are true Calderas formed by doleritic rocks, consisting of lava-streams and agglomeratic and tufaceous beds derived from them, of the succession and structure of which the railway-tunnel between Lyttleton and Christchurch, crossing the Caldera-wall of the former, offers an excellent and very instructive section. Between these two Calderas a large volcanic cone, now partly destroyed, has been raised by trachy-doloritic and andesitic lavas, while the last centres of eruption are apparently two islands in the middle of the two older Calderas, consisting of a number of basaltic lava-streams having a columnar structure. On the western side of the peninsula we meet a large zone of quartzose trachytes, which seem to have made their appearance after the doleritic and before the andesitic lavas.

I shall return to this interesting subject after the railway-tunnel has been completed.

III. Moraine-accumulations of the Postpliocene or Glacial Epoch.

I have not as yet alluded to the extensive morainic accumulations found on both sides of the Southern Alps, as I wish to call especial attention to them in treating of them separately. The eastern glacier-beds are extensive, and reach to a much greater distance from the summit of the central chain than those of the opposite side, but they do not descend to such a low position.

Owing to the remarkable steepness of the western slopes of the Southern Alps, these Postpliocene accumulations reach the sea-level, for more than fifty miles covering the country uniformly with their stupendous masses.

This is quite in accordance with the relative position of the present glaciers on both sides, of which I shall give an example. The great Tasman glacier, the largest in New Zealand, about 16 miles long, and, near its terminal end, still 1¾ mile broad, descends only to 2772 feet, whilst the opposite and smaller, Francis Joseph glacier, descends to 708 feet above the level of the sea, its foreground being formed by a luxuriant vegetation, amongst which arborescent ferns, pine, and fuchsia trees are conspicuous.

Before proceeding to describe the morainic accumulations under review, it will perhaps be well if I give in a few words a description of the configuration of the west coast of this province, principally in reference to the direction of the central chain; and to do this more effectually, I have appended a small sketch map of that country, in which I have distinguished in general lines between the existing glaciers and snow-fields, and the extent of the morainic accumulations of our great ice-epoch.

The Southern Alps approach nearest to the sea at the point where they attain their highest mean elevationânamely, in Mount Cook, and in the lofty snow-clad peaks adjoining it, north and south. Continuing to follow them in their north-east direction they very soon become lower, and at the same time recede towards the centre of the island. Thus, if we draw a line at right angles to the direction of the coast, Mount Tasman is only fifteen miles distant from the Pacific ocean, whilst Mount Kaimatan, where the principal sources of the Waimakariri are situated, is fifteen miles further inland, or thirty miles from it. As the greatest glaciers descend from the principal mountain-system, or Southern Alps proper, between the sources of the Rakaia and Waitaki (east coast) and of the Whataroa and Makawiha (west coast), we find that during the glacier-epoch also the ice masses extended here furthest on both sides, of which circumstance, for the east coast, I have already had the pleasure of laying the principal facts before the Society.

On the west coast, near the northern boundary of the Province, we find the morainic beds descend in the Teramakau to 227 feet above the sea-level, forming lakes Brunner and Poerua, ten miles from the coast; in the valley of the Hokitika river, at the head of which the central chain assumes much more gigantic dimensions than at the head of the former river, they reach to an altitude of 150 feet at a distance of six miles from the mouth of the river. But as soon as the Mikonuhi is crossed, it is seen that the Post-pliocene glaciers were of such an enormous size that they not only reached the sea, but must have advanced into it, until their termination was carried off in the form of icebergs.

The morainic accumulations south of the Mikonuhi cover the lower country, as far as I have travelled along the coast, for fifty miles; but intelligent travellers, who have followed the coast-line still further south, have informed me that for more than forty or fifty miles they still continue to form the low hills bounding the sea.

An examination of these remarkable deposits convinced me at once that, as before stated, they form only the lower portion of a huge sheet of morainic accumulation which covers the whole lower western region in that zone, and that they are the lateral, central, and, in some instances, the terminal moraines of huge glaciers which descended from the Southern Alps in Postpliocene times. The present rivers have invariably excavated their courses in them; and the swell of the ocean, having a northerly direction, has connected the more advanced portions together by forming a dam of sands, behind which estuaries and lagoons of greater or less extent have been formed, washing the western foot of those morainic accumulations which have not advanced so far. The headlands are those portions of the moraines in which the greatest number of large blocks are enclosed; in fact they correspond generally with the central and lateral moraines.

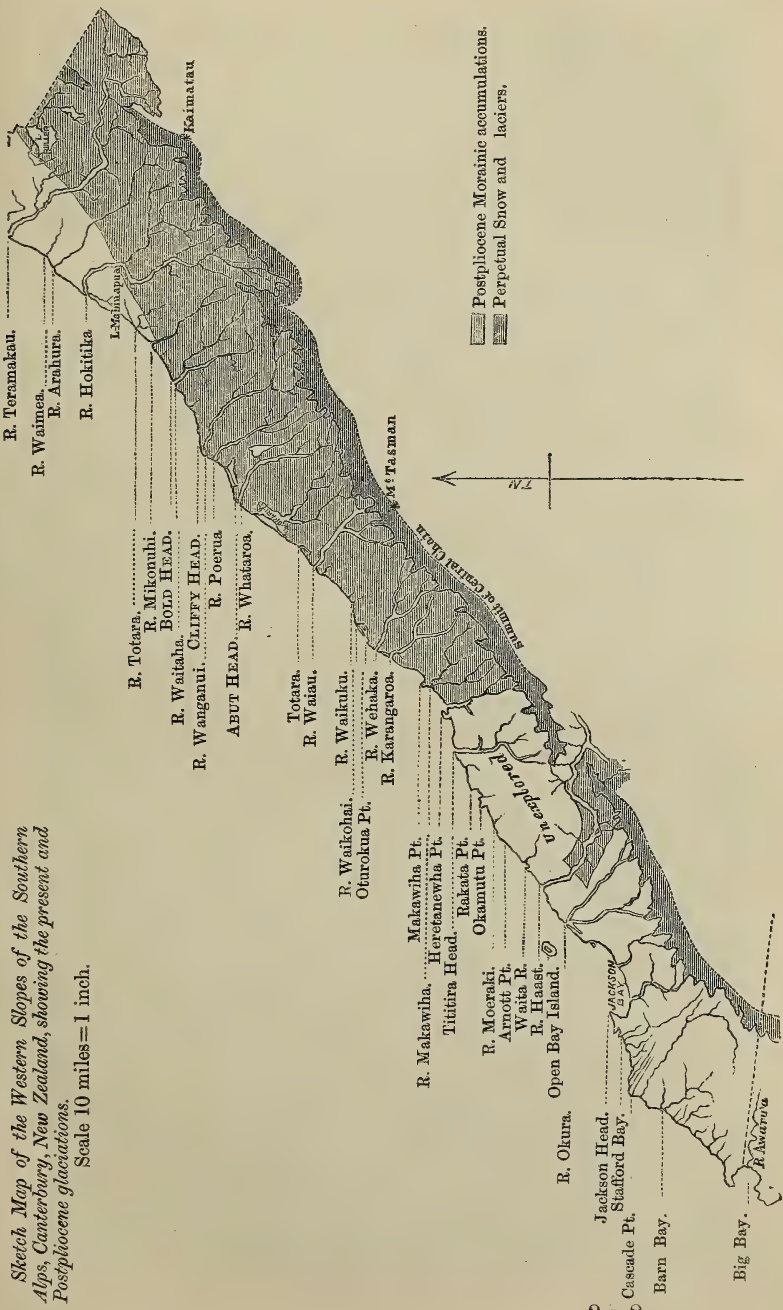
At the same time a partial destruction of these headlands has offered the means for their further protection by raising at their base huge masses of rocks, which extend into the sea for a considerable distance, and against which the waves break furiously but ineffectually; whilst the softer beds between them, which have not this protecting talus, are, if not constantly, at least during the frequent gales along this coast, quite unprotected from the fury of the waves, and are much less able to withstand their destructive power.

Some of the imbedded blocks are of enormous size, often larger than the celebrated Pierre-à-bot in the Jura. One of the most striking examples is the large block lying in front of the centre of the Baldhead moraine, to which it owes, without doubt, in some degree its preservation. This block, which consists of contorted clay-slate with layers of quartz, is from 30 to 40 feet in diameter, and covered on its summit with a luxuriant vegetation.

It is instructive to observe the manner in which the huge blocks, when washed from the cliffs, or fallen from above when any portion of the latter has been undermined by the waves, are soon buried, in many places, in the marine sand which the southerly swell brings incessantly along with it. These blocks, if not too large, will very often sink considerably during one tide, the sand below and around them being washed away, whilst another tide covers them up entirely with sand left behind. Thus it will often happen that their angles remain quite sharp after their burial in the sand, and are thus preserved from further abrasion. But the upper portions of many of the larger blocks remain uncovered, and are thus exposed to the fury of the waves for a considerable time; but, owing to their extreme hardness, their angles become less rounded than might have been expected. Of course there are many blocks which have not only their edges worn off, but present that perfectly smooth appearance so peculiar to rocks lying in the tidal way.

These recent marine accumulations, in which former glacier-deposits are imbedded in marine sands with marine mollusks and other exuviæ, lead me to offer the following observations suggested by a contemplation of this phenomenon.

There is no doubt that, at least in some portions of the west coast, the land is sinking rapidly, a conclusion repeatedly forced upon me in passing the remains of forests now standing below high-water-mark. Should this western side sink about 800 feet more by further geological changes, by far the greater portion of these moraines



Sketch Map of the Western Slopes of the Southern Alps, Canterbury, New Zealand, showing the present and Postpliocene glaciations.
Scale 10 miles = 1 inch.

would be destroyed, the large blocks would bcome imbedded in true marine sands, with shells of mollusks now inhabiting our western shores, either entire or in broken pieces, bones of cetaceans, fishes, and remains of plants occurring between.

The land rising again, the drainage-channels cut through the marine deposits, would offer sections of a very curious structure; and there is no doubt that in many instances the conclusion arrived at would be, that these extensive beds were of glacial origin, deposited by icebergs, and that the fossil flora and fauna imbedded in them belonged to a much colder climate than that which existed in reality when these beds were deposited.

It struck me at the same time that many beds in the northern hemisphere which are called glacial, are probably similar beds rearranged; and that many apparent difficulties will disappear if such a process is taken into consideration. Furthermore may we not assume that at least some of these beds in older formations, in which similar rounded and sharp-edged blocks are associated together, have a similar origin?

In any case the formation of these recent marine beds from the destruction of Postpliocene accumulations is highly suggestive to the physical geologist; and deductions drawn from such observations may claim some consideration at the hands of those who are attempting to account for the various characteristic features of the glacial beds in the northern hemisphere.

If we examine the structure of the large moraines under consideration, and the lithological character of the rocks imbedded in the débris, some important facts are revealed to us, to which I beg to draw your special attention.

In my short explanation of the structure of the Southern Alps, I have pointed out that their very summit consists of dioritic sandstones, cherts, &c., and that towards the west they are immediately underlain by the newer gneissic schists, below which follow mica-schists &c., until the gneiss-granites which form the base of the Southern Alps are reached.

This peculiarly regular succession of the strata according to age and metamorphic change, from east to west, assists us, when we examine the débris of which the huge Postpliocene moraines consist, to obtain a clear conception of the extent, breadth, and other conditions of the huge glaciers to which they owe their existence. Thus we observe, as there is no débris of truly metamorphic rocks amongst the component parts of these enormous deposits, but only diorite-sandstones, felstones, true clay-slates, and other similar rocks which form the summit of the central Alps of the present day, that the height of land was the same in the glacial epoch as it is now. In fact, the present huge glaciers on the eastern slopes of the central chain are covered with débris of the same lithological character as that of which the Postpliocene moraines along the west coast are composed. The total absence of true mica- and chlorite-schists, gneiss, and gneissic granite, which form the western foot of the ranges under consideration, as well as of the granite and sericiteslates which constitute the isolated low wooded cones or ridges rising at present above the morainic accumulations, suggests at once that the whole country was uniformly covered with one continuous sheet of ice, grinding and planing down the whole lower region in a remarkable degree. And, if we go further, may we not assume that the enormous triturating power by which the auriferous beds were ground down to nearly their present outline, may in some degree account for the presence of the fine dust-like gold found in large quantities along the shores of that coast for several hundreds of miles?

The older alluvial beds, lying, in several instances, upon these morainic accumulations, show convincingly, when their contents are examined, that at the time they were deposited a great change in the relative position of the Alpine glaciers had taken place.

Although many rolled boulders from the very summit of the central chain may still be collected amongst them, derived either from the younger moraines of the smaller glaciers, or from the older moraines through which their outlet had cut a passage, we find that the metamorphic schists and gneiss-granite of the Southern Alps proper, and the newer granites and syenites of the hills in front, are also well represented. Such a total change in the nature of the beds proves convincingly that the glaciers have not only retreated considerably, but have now formed distinct channels on the lower slopes of our Alps, the streams issuing from them being able to bring down the débris from the granite bosses in front.

These Postpliocene river-beds, of such distinct lithological character, mostly repose upon, or occur near the moraines. But there is one instance, in Boldhead, which at first sight seems to indicate that at least one oscillation occurred during the glacier-epoch, during which the Boldhead glacier must have retreated so considerably as to bring the lower metamorphic and hypogene rocks within the denuding action of its outlet. These interesting fluviatile deposits consist of beds of sedimentary and semimetamorphic rocks, which form the morainic accumulations of well-rounded boulders of granite, gneiss, and metamorphic schists, which, during the great glaciation of the country, were covered uniformly by a sheet of ice. In fact, these Postpliocene fluviatile beds cannot be distinguished from the present river-beds of the same region, except by the somewhat larger size of their blocks of stone.

At first sight it thus appears that such a considerable change has taken place during the glacial epoch that the Boldhead glacier could retreat at least ten miles, so as to uncover the coast-ranges, which, although in that neighbourhood from 3000 to 4000 feet high, have the peculiar rounded forms of true roches-moutonnées. But as signs of such enormous oscillations are nowhere else discernible, a second explanation may be more correct—namely that the alluvial river-beds were deposited by the river Mikonui, which enters the sea a few miles north, during a slight oscillation of the Boldhead glacier. There occur also in Boldhead, and in some other cliffs further south, very large deposits, consisting of the finest glacier-mud, which are often stratified in such thin layers that many hundreds of them go to the inch, and which were without doubt formed in lakes amongst huge ice-masses.

In ascending from the level of the sea to the slopes of the Southern Alps there are many sections in the banks of the river which show well the gradual retreat of the Postpliocene glaciers; in some other localities, on the other hand, there is ample evidence offered to us that there has been an advance of the glaciers during more recent times, since the broad river-beds were formed. Thus, to give only one instance, three miles from the present terminal face of the Francis Joseph glacier, we meet a moraine curving across the shingle-bed of the Waiau river, which is here more than a mile wide, and by which this newer moraine has been destroyed in many spots, through which its structure has become visible. An examination of these beds reveals the important fact that the channel of the Francis Joseph glacier was cut deeply into the ranges during their deposition, as we find many blocks of truly metamorphic rocks mixed up with those derived from the summit of the Southern Alps. Finally, I beg to point out that glacier-lakes are not altogether missing on the western side of the Southern Alps proper: a few of them, like lakes Brunner and Kanieri, are dammed up by enormous morainic accumulations; others, from the descriptions given to me by trustworthy miners, appear to be true rock basins, some of which I hope to visit in the course of next autumn.

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7. *On the* Chemical Geology *of the* Malvern Hills.

By the Rev. J. H. Timins, F.G.S., M.A.

In the year 1861, I commenced an examination of the rocks composing the Malvern Hills; and the results of the analyses of some of the eruptive rocks, taken from various parts of the chain, were published in the Edinburgh New Philosophical Journal, vol. xv. pp. 1–7. Since then, a minute and accurate description of the structure of these hills has been given by my friend Dr. Harvey B. Holl (Quart. Journ. Geol. Soc. vol. xxi. p. 72), to which I shall have to refer, in the course of this paper, for a more particular account of the physical geology of the district under investigation. I have also had the advantage of visiting the hills with him, and, with his assistance, I have been able to make many valuable additions to my collection of specimens of the various rocks for analysis.

In the present communication I propose to examine the rocks with a view to the discovery of the sources from which they have been derived, and the chemico-physical processes which have resulted in their development, confining myself more especially to the consideration of those which appear to be, wholly or in part, the products of eruptive action, whether they occur as intrusive masses, lava-flows, or beds of ash mechanically deposited. Those of which the materials were originally furnished by the decomposition and disintegration of other rocks, and the nature of the metamorphic influences to which they have been subsequently exposed, I hope to investigate in another paper.

I. *Lava and Volcanic Ash overflowing, or interstratified with, the Black Shale.* Holl, *op. cit.* pp. 90, 91; Professor Phillips, Mem. Geol. Survey, vol. ii. pt. 1. pp. 55, 56, "Interposed Traps."

I have already shown the composition of many of these rocks*; it is therefore only necessary to notice a few which I have since analyzed, with some calcareous rock possessing similar characters, from the Herefordshire Beacon.

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper†.	Oxide of Manganese†.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
I.	44·65	19·29	10·18	....	....	4·28	9·93	5·80	5·87
II.	47·14	21·46	11·37	....	....	3·82	4·60	5·31	6·30
III.	41·85	17·80	11·14	....	....	8·17	5·56	7·45	8·03
IV. a.	....	2·89	0·37	....	....	6·26	0·95 }	14·52	
b.	41·79	19·61	8·46	....	....	1·82	3·33 }		
c.	51·63	24·24	10·45	....	....	2·24	4·11	....	7·33
V.	45·22	14·98	11·88	0·80	....	6·73	8·81	6·20	5·38
VI.	43·99	18·72	11·39	....	....	5·05	11·16	6·08	3·61
VII.	43·22	17·56	11·58	....	....	6·14	8·29	5·82	7·39
VIII.	44·17	17·97	14·28	....	0·50	1·92	7·57	6·04	7·55
IX.	45·75	17·91	11·34	0·22	0·58	2·05	9·01	5·96	7·18
X.	48·00	21·99	13·24	....	....	1·65	2·41	8·34	4·37
XI. a.	....	3·50	0·67	....	....	16·31	0·24 }	17·24	
b.	35·16	15·25	8·70	....	....	1·25	1·68 }		
c.	52·35	22·70	12·95	....	....	1·86	2·51	....	7·63
XII.	35·12	15·84	11·93	....	0·54	13·62	4·54	CO_2 9·11, HO 3·74	5·56
XIII.	56·12	21·84	5·90	0·38	0·20	1·75	1·74	4·65	7·42
XIV.	42·42	18·49	14·40	....	....	9·96	4·40	7·02	3·31
B. a.	....	2·32	1·51	....	....	9·59	}	13·04	
b.	38·17	16·36	12·43	....	0·70	2·41	3·47 }		
c.	50·00	21·39	16·26	....	0·92	3·11	4·54	....	3·78
XV. a.	....	2·66		....	....	11·30	...... }	17·03	
b.	43·16	15·85	6·09	....	....	1·65	2·26 }		
c.	60·08	22·05	8·48	....	....	2·30	3·14	....	3·95

I. Lava forming a thick bed north of Coal Hill: contains hornblende and felspar; indistinctly crystallized.

II. From a narrow band of smooth rock, from one to two inches thick, of a blue colour, resembling indurated shale; associated with the lava-flow at Keys End Hill.

* Ed. New Philosophical Journal, *loc. cit.*

† The oxides of copper and manganese, especially the latter, are generally present in the Malvern rocks, though often in such small quantities as to make their separation unnecessary. Where the quantities have not been specified, the oxide of copper was weighed with the oxide of iron, and the oxide of manganese with the magnesia.

III. Calcareous lava, with imperfectly crystallized hornblende, and minute red felspar crystals; from the valley of the White-leaved Oak.

IV. Another fragment of the same rock. The rock after being finely pulverized, was digested with distilled water acidulated with 25 per cent. of glacial acetic acid; and the soluble and insoluble portions were separately analyzed.

a. The portion dissolved.

b. The portion undissolved.

C. The composition of the undissolved portion.

V. Lava, from a boss in a small plantation south of the Eastnor Road; contains hornblende; the felspar is not crystallized; G=2·739.

VI. From the interior of a loose spherical fragment of the same rock. A confused mixture of hornblende and felspar indistinctly crystallized, and with a little calc-spar.

VII. From the same fragment, nearer the surface.

VIII. Lava from the footpath from Fowlett's farm to the valley of the White-leaved Oak, in contact with the black shales, which are there bleached by it; uncrystallized; contains hydrated peroxide of iron in vesicular cavities; partly decomposed.

IX. Porous ash, of a light-brown colour, east of Coal Hill.

X. Thin bed of calcareous ash, interstratified with shale, east of Coal Hill.

XI. Another thin calcareous bed from the same place. The carbonates were dissolved out by placing the pounded rock in cold distilled water and adding hydrochloric acid, drop by drop, as long as effervescence continued. *a.* The portion dissolved. *b.* The residue. *C.* The composition of the undissolved portion.

XII. Another thin calcareous bed, from the same place.

XIII. Grey ash, west of Coal Hill.

XIV. Calcareous lava from a boss north-east of Bronsill Castle.

B. Another fragment of the same rock.

a. The portion soluble in cold dilute hydrochloric acid. *b.* The residue. *C.* The composition of the undissolved portion.

XV. Calcareous lava, south of the British Camp, Herefordshire Beacon, and south-east of the cave. *a.* Portion dissolved by cold dilute hydrochloric acid. *b.* The residue. *C.* Composition of the undissolved portion. G=2·701.

As the two rocks last mentioned contain crevices and vesicular cavities, which were filled by calc-spar, the proportion of carbonates varies in different fragments of the same rock. In one of the small bosses under Bronsill Castle, carbonate of lime filled a cavity formed by the decomposition of a crystal of augite; and in other cavities it was associated with zeolite, which may have been formed by the decomposition of labradorite. In such cases the calc-spar is clearly the result of infiltration and decomposition. But in those now under consideration, XIV., XV., and in the calcareous lava in the valley of the White-leaved Oak, III., IV., the carbonate of lime was disseminated through the entire substance of the rock, and was more abundant in the hard unaltered parts of it than where it was decomposed.

The atomic proportion of the silica to the bases was also found to be nearly the same in the rocks containing the carbonates as in other rocks in the vicinity from which they were absent. It would therefore appear that the presence of the carbonate of lime cannot there be altogether the result of decomposition or infiltration. Dr. Holl has observed that these calcareous rocks do not represent the mass, but occur as beds, usually at the top or bottom of the lava beds. They would therefore have been formed at the commencement, or at the close, of the period of volcanic activity, when its force was least energetic, and the temperature probably lowest. Now the thermal waters of spent volcanoes are often found to be charged with carbonate of lime. The observations of Scacchi on the emanation-products of Vesuvius have also shown that eruptions of lava are accompanied by other substances than its ordinary constituents. Carbonate of lime, as is well known, retains its carbonic acid, even with access of atmospheric air, at a dull-red heat, and at a far higher temperature when fused with the carbonate or sulphate of soda, or with chloride of calcium. The emanation of carbonate of lime with volcanic matter towards the close of an eruption is therefore probable; and as the lava-flows in the black shales proceeded from numerous outbursts of limited extent and duration, the intimate dissemination of carbonate of lime in some portions of the rock at the period of its eruption may thus be accounted for.

Of the thin beds interstratified with the shales, one only, IX., has the composition of volcanic ash. The others, X., XIII., have that of the shales with which they are associated, with the occasional addition of carbonates, XI., XII. These, together with the associated beds of shale, were probably derived from the decomposition of lavas of the Black-shale period.

II. *Eruptive Rocks of the Hollybush Sandstone.* Holl, *l. c.* pp. 87, 88. Phillips, *l. c.* 52, 53.

The appearance of many of these rocks is such as to justify the term "felspathic traps" by which Professor Phillips has designated them. But in those which I have examined I have never found the atomic proportion of the silica to the bases to exceed 2 : 1.

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper.	Oxide of Manganese.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
XVI.	58·07	19·14	5·90	......	0·25	1·95	1·00	1·96	11·73
XVII.	54·01	17·45	8·05	......	......	2·36	3·53	2·95	11·65
XVIII.	57·64	17·34	7·71	0·20	0·15	2·42	0·60	3·60	10·34
XIX.	52·12	18·48	8·91	0·25	0·20	2·52	6·24	4·50	6·78
XX.	56·03	18·51	6·14	0·40	......	2·39	2·69	2·45	11·39

XVI. Light-coloured felspathic rock, west of Ragged Stone Hill.

XVII. From the same place, of a darker colour.

XVIII. Similar rock, of a light colour, from the north side of a small quarry, near an oak tree, S.S.E. of Fowlett's Farm; decomposed.

XIX. From a "dyke" in the Hollybush Sandstone at the south-west base of Midsummer Hill: dark-coloured.

XX. From the same; light-coloured, magnetic.

Both these specimens have the appearance of porphyritic lava. Hornblende, imperfectly crystallized, occurs more abundantly in XX. There are also a few minute red crystals resembling orthoclase. There is some magnetic oxide of iron disseminated through both rocks; but in the darker portion the greater part of the free oxide of iron is the protoxide: in the lighter portion, which is of a reddish colour, the magnetic oxide predominates.

A mass of felstone on the north side of the east cone of Ragged Stone Hill has the same constitution as these rocks; but it differs in its physical characters and mode of occurrence. It was probably formed by a mechanical deposition of the products of volcanic action. With the analysis of this rock I give one of a fragment from the summit of Ben Nevis, which in composition closely corresponds with it and with the eruptive rocks of the Hollybush period.

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper.	Oxide of Manganese.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
XXI.	59·45	20·50	3·02	trace	0·25	3·54	1·15	1·18	10·91
XXII.	58·70	21·19	3·80	0·17	......	2·97	1·09	1·61	10·47

XXI. Felstone, from the north side of the summit of the east cone of Ragged Stone Hill. G=2·614.

XXII. Dark-coloured rock, weathering white, from the summit of Ben Nevis.

The Hollybush Sandstone includes some thin beds, apparently formed by the deposition of felspathic ash. One of these may be observed on the east side of the quarry, at the south-west base of Midsummer Hill, east of the eruptive rock, XIX. XX. It is, in part, of the structure of sandstone, and in part felspathic, with traces of epidote. These thin beds differ from those forming larger masses of a later date, in being composed of a rock which is nearly a trisilicate. Its composition is similar to that of portions of a lava-bed near Castle Morton Common, and to that of some grey sandstone on the hill overlooking Little Malvern.

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper.	Oxide of Manganese.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
XXIII.	64·20	16·41	6·45	0·30	......	1·32	......	4·18	7·14
XXIV.	67·78	16·29	1·21	......	......	1·32	......	2·04	11·36
XXV.	67·99	17·96	2·30	0·40	......	2·11	trace	1·31	7·93
XXVI.	65·43	19·71	3·77	......	......	1·23	1·13	2·70	6·03

XXIII. Fine-grained greyish rock, of the structure of sandstone with occasional thin lines of epidote, from a band in the Hollybush Sandstone, on the east side of the eruptive rock, quarried on the south-west side of Midsummer Hill: passing into felspar.

XXIV. Felspathic portion of the same rock.

XXV. Lava-bed, west of Castle Morton Common. Matrix of a bluish colour; cavities filled with epidote. G=2·617. This rock, in its external characters, resembles the amygdaloidal greenstone of Caer Caradoc, and that from the top of Lawley, Staffordshire,

XXVI. Greyish sandstone. From the hill overlooking Little Malvern.

III. *Shales.*

Shales and schists do not properly belong to the subject of this paper; but some of them approximate so nearly in composition to the beds of volcanic ash with which they are associated that it is necessary to notice them. I therefore give here the result of the analysis of the different kinds of shale found in the south and south-west part of the chain.

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper.	Oxide of Manganese.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
XXVII.	46·75	27·54	9·16	......	......	1·73	3·18	4·35	7·29
XXVIII.	50·50	24·40	9·40	0·20	......	1·45	3·34	4·96	5·75
XXIX.	49·37	21·47	13·39	......	0·30	0·75	1·00	6·66	7·06
XXX.	52·67	20·94	7·55	......	......	1.82	1·81	7·34	7·87
XXXI.	62·65	17·86	3·73	......	......	1·56	0·97	CO_2 3·61, HO 4·26	5·36
XXXII.	64·37	18·62	2·07	......	......	1·7	0·77	3·84	8·86
XXXIII.	45·82	16·39	16·20	......	0·45	1·46	7·81	6·19	5·68
XXXIV. *a.*	......	1·72		......	......	0·77	0·11	13·33	
b.	49·33	21·24	8·70	......	......	1·45	3·35		
c.	53·97	23·24	9·51	......	......	1·58	3·66	......	8·04
XXXV.	43·61	19·34	17·02	Trace	0·15	2·31	7·10	5·51	4·96

XXVII. Yellow shale, east of Coal Hill.

XXVIII. From the upper part of the bed of shale numbered 3 in Dr. Holl's section across the northern extremity of Coal Hill, *loc. cit.* p. 89.

XXIX. From the lower part of the same bed.

XXX. Blue shale immediately above the lava boss, V. VI. VII., south of the Eastnor Road, interstratified with black shales. The divisional surfaces in the plane of the bedding are stained by hydrated peroxide of iron.

XXXI. Black shale from the field near Fowlett's Farm. G=2·455.

XXXII. Part of the same beds, in contact with lava, VIII., by which it has become bleached. G=2·448.

XXXIII. Smooth metamorphic schist, in thin beds, with steatitic surface, interposed with rock at the north side of the quarry to the south of the West Ragged Stone.

XXXIV. Metamorphic shale from beds near the entrance of the same quarry. *a.* Carbonates removed by diluted cold hydrochloric acid; *b.* The undissolved residue; *C.* Composition of the residue.

XXXV. Irregular metamorphic schistose rock from the south slope of the West Ragged Stone.

Of these, XXVII. to XXX. have less silica and more alumina than clay-slates of primary strata, and they differ more in structure than in composition from the beds of volcanic ash with which they are interstratified.

The black shales, XXXI.and XXXII., have a composition nearly resembling that of the thin bands of trachytic ash in the Hollybush sandstone, XXIII. and XXIV., and of the lava-beds west of Castle Morton Common, XXV. Their structure only is different, being such as would result from the deposition of their particles in a minute state of subdivision in still water containing organic matter. The others, XXXIII. to XXXV., resemble the lavas erupted after the deposition of the Black Shales, and were probably derived from the mechanical deposition of volcanic matters ejected during the eruptions.

IV. *Bedded Traps, Lavas, and Felstones of the Herefordshire Beacon, South and South-east of the British Camp.* Holl, *loc. cit.* pp. 92, 93; Phillips, *loc. cit.* pp. 30, 31.

1. Trappean rocks, mechanically deposited, form the mass in which the cave is excavated, and occur in various parts of the east buttress.

2. Rocks of similar characters, but higher specific gravity, are found over trap-dykes near the footpath south of the cave, and on the east of the ridge on which it stands; they contain much lime, and in parts have the yellowish-green colour of massive epidote. They appear to be older than those last-mentioned, some of which, towards the east, contain included fragments of them.

3. Red rock, containing a few small quadrangular crystals of felspar, occasional fragments of rock resembling altered shale, and epidote, apparently formed by the mixture of volcanic ash with water, and subsequently modified in structure by intrusive rocks with which it is in contact.

4. Beds of bluish trisilicated lava, containing epidote in cavities, as in XXV.

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper.	Oxide of Manganese.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
XXXVI.	48·61	14·14	13·39	Trace.	0·40	7·94	6·16	3·47	5·89
XXXVII.	49·37	15·80	10·82	Trace.	Trace.	11·00	6·40	4·00	2·59
XXXVIII.	50·37	15·83	9·30	0·70	....	14·63	4·02	1·65	3·50
XXXIX.	58·61	17·01	13·99	Trace.	....	4·47	2·87	2·19	0·86

XXXVI. Bedded trappean rock, cave. G=2·826–2·852.

XXXVII. Bedded rock, south of the cave, near the footpath; contains a few grains of olivine, and a little quartz in cavities. Parts of this rock resemble the matrix of the lava of the Capo di Bove, near Rome. In its chemical composition it nearly corresponds with that which Bunsen gives for the "Normal augite" of Iceland. Notwithstanding its occurrence in regular beds, its mineralogical character and its chemical composition make it probable that it has *flowed* over the surface. G=2·923.

XXXVIII. Bedded trappean rock, east of the ridge north of the cave. It contains a few minute angular fragments of silica. G=3·101.

XXXIX. Over Castle Morton Common. Red rock, including a few fragments of altered shale, minute quadrangular crystals of felspar, and epidote, near a trap-dyke. Its chemical composition is similar to that of some recent lava from Efrahvols, Iceland, analyzed by Genth.

5. Sandstones more or less altered, consisting of trappean ash, intimately mixed with grains of quartz and felspar derived from the disintegration of older rocks. These may be well observed on the north of the ridge on which the cave is situated, where they are associated with beds of trappean ash (XXXVIII.), of which they are partly composed, and into which they appear to pass. In other places the quartzose and trappean fragments are more or less segregated; so that in the same specimen one analysis will show nearly all to be silica, a second nearly all trap, and a third a uniform mixture of the two. Sometimes the quartz grains are so distinct as to give the altered rock the appearance of quartzite, but are, notwithstanding, intimately mixed with the basic elements of the trap.

	Silica.	Alumina.	Oxide of Iron	Oxide of Manganese.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
XL.	70·36	13·07	4·76	0·15	5·18	1·96	2·30	2·22

XL. Altered sandstone. Near the ridge north of the cave; not far from XXXVIII. G=2·637.

6. To the eastward of the trappean sandstones, commencing from fifty to a hundred yards below them, are the compact-bedded felstones of the large eastern buttress, the "fine-grained felspathic trap" of Professor Phillips. The chemical composition of all these rocks, so far as I have ascertained it, corresponds with that of the "felstones" contemporaneous with the "Cambro-Silurian" rocks of Wicklow, Wexford, Waterford, Kerry, and Caernarvon, as determined by Professor Haughton; but they have less alkali, and proportionally more lime. They also resemble those rocks in some of their physical characters, and in their association with beds of "greenstone ash." Lower down, towards the east, near the base of the large buttress, the rock is a petrosilex, of which the composi-

tion, excepting as regards the relative proportions of lime and alkali, resembles that which Bunsen has assigned to the "normal trachyte" of Iceland. Some trap in contact with it (LXXVI. *infrà*) was quite unaltered; and the two rocks were easily separated from each other, leaving smooth even surfaces. The felstone must therefore have been indurated before the eruption of the trap. But some dark rock, having the external character of altered shale, appeared to have become partly combined with the felstone. Its constitution, near the place of contact, was intermediate between the felstone and trap. The two rocks must have been together in a plastic state, and subsequently metamorphosed; or the petrosilex must have been in a state of fusion when brought into contact with the other rock. There is, however, no evidence in favour of the conclusion that the petrosiliceous rock was intrusive.

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper.	Oxide of Manganese.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
XLI.	75·07	14·27	1·29	....	0·20	5·34	0·42	1·53	1·88
XLII.	64·80	15·60	5·65	0·10	0·20	5·32	2·18	3·06	3·09
XLIII.	77·33	12·30	1·33	....	....	5·39	0·91	1·45	1·29
XLIV.	76·77	8·75	4·75	....	0·25	6·35	....	1·03	2·10
XLV.	78·92	8·18	4·08	....	....	5·05	0·48	1·19	2·10
XLVI.	75·48	13·40	1·63	0·30	0·16	2·90	0·87	5·03	0·23

XLI. Felstone or petrosilex, nearly white, from the large east buttress, near the base.

XLII. Rock resembling metamorphic shale, containing a little red felspar of no distinct crystallization, in contact with XLI. In composition it differs from the shales in the vicinity in containing a larger proportion of alkaline earths. The fragment analyzed contained one per cent. of hydrofluoric acid.

XLIII. Felstone from the same place, resembling XLI., but of a pink colour. G=2·695.

XLIV. Felstone, near the ridge south of the British camp.

XLV. Porcellanite, north-east of the cave. G=2·7304.

XLVI. Greyish rock, associated with, and passing into felstone: of similar composition, excepting that it contains more water.

Dr. Holl ascribes the altered condition of these rocks to the intrusion of the trap-dykes by which they are extensively invaded*. There is certainly an apparent transition from shale to felstone or porcellanite, similar to that which Mr. J. Geikie† has noticed in the gradual changes which the Lower Silurian greywackes and shales of Carrick undergo during their passage into crystalline and pseudo-igneous rocks.

* *Loc. cit.* p. 93.

† Quart. Journ. Geol. Soc. vol. xxii. p. 513, &c.

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
XLVII.	62·01	15·79	9·37	0·37	1·19	1·79	4·26	5·22
XLVIII.	65·60	19·17	5·11	0·20	1·86	1·68	3·64	2·74
XLIX.	64·23	16·70	5·53	....	2·07	1·03	3·41	7·03
L.	75·07	12·92	4·26	0·25	2·14	1·02	1·90	2·44

XLVII. Shale from the east side of the lane between the Herefordshire Beacon and the offstanding hill overlooking Little Malvern, near the east base of the large buttress. G=2·690.

XLVIII. Black shale from the low ridge east of the Herefordshire Beacon, near the keeper's lodge. The Black Shales of this district are distinguished from the Black Shales near the Hollybush Sandstone by their higher specific gravity, caused by a larger proportion of metallic oxides and alkaline earths. G = 2·644—2·649.

XLIX. Altered shale near the top of the narrow ridge forming a slight curve over the keeper's lodge. G = 2·632—2·658.

L. Felstone, near XLIX. G=2·643.

The result of the above analyses leaves no reason to doubt that the metamorphic rock XLIX. has been formed by the alteration of a shale similar to those in its vicinity. If the felstone (L.) had a similar origin, its silicification must have been caused, not by the direct action of an eruptive rock, but through a chemical change produced by mineral waters, introducing silica and removing a portion of the alkali.

V. *Felstones North of the Herefordshire Beacon.*

Highly metamorphosed sandstones, frequently with alternating beds of shale, and occasionally associated with conglomerates, occur at intervals, from the Camp Hill to the End Hill; of these I propose to consider the composition, probable age, and correlation to other rocks, in a future communication.

Felstones of a somewhat similar character to those of the Herefordshire Beacon are found, sometimes in rather large masses, east of Wind's Point. And in the large quarry west of the Wych Hill, I found some rock of nearly the same composition, of the colour of fine white brick, regularly bedded with a dark-greenish rock, like the bedded traps of the Herefordshire Beacon, passing into the metamorphic diorite.

	Silica.	Alumina.	Oxide of Iron.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
LI.	74·58	13·52	1·78	2·16	....	0·92	7·04
LII.	75·34	13·09	1·69	1·53	....	3·16	5·19
LIII.	49·23	20·74	11·66	12·07	2·38	2·58	1·34

LI. Pink felstone, forming tabular beds, east of Wind's Point.

LII. Light-reddish-white rock, becoming grey when the oxide of iron was reduced in the furnace, bedded with cryptocrystalline trappean rock and metamorphic diorite, west of the Wych Hill.

LIII. Dark-green trappean rock, with no distinct crystallization, bedded with the rock last described.

VI. *Quartzo-Felspathic Veins.*

These have been described by Professor Phillips under the designation of "crystallized felsparite" (*op. cit.* pp. 42, 43).

These rocks are of two distinct types, characterized by the atomic amount of the silica. In some the ratio of the oxygen of the silica to that of the bases is 5 : 1, their constitution thus resembling that of the series of felstones above described. In others this ratio is 4 : 1.

In the large quarry west of the Wych Hill, a loose mass, resembling decomposed granite, was extensively penetrated by veins, some of which crossed each other like veins in mud-cracks. In the plane to which they were perpendicular was a thin layer, which, on being removed, separated into small fragments, of which the sides closely fitted each other. Their upper surfaces were smooth, and coated with peroxide of iron; underneath they were rough and irregular. In one of these (LIV.), analyzed entire, the ratio of the silica to the bases was 5 : 1. In the veins of this type, the quartz is often segregated in rather large masses. In those in which the ratio is 4 : 1 the quartz is more commonly found as in granite (LV.), or in a fine granular mixture of quartz and felspar (LVI.).

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper.	Oxide of Manganese.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
LIV.	76·71	13·74	0·92	Trace.	....	2·03	0·27	0·96	5·37
LV.	71·23	17·10	1·52	....	0·17	1·85	0·30	1·07	6·76
LVI.	71·22	14·82	1·02	0·58	0·40	1·51	....	1·67	8·78

LIV. Quartzo-felspathic rock west of Wych Hill.

LV. Fine-grained vein in granite, west of St. Anne's Well, chiefly quartz and orthoclase (Holl, *loc. cit.* p. 81).

LVI. Vein composed of grains of orthoclase and quartz, with a few plates of potash-mica, in a fine-grained mixture of quartz, mica, and felspar on the south side of the large quarry at North Malvern. G=2·602.

In LV. and LVI. the atomic proportion of the silica to the bases is as 4 : 1.

VII. *Trisilicated Felspathic Veins.*

These were well exposed in the excavation of the railway-tunnel. Many of the rocks there met with were altered sedimentary deposits. These were penetrated, for a distance of 160 yards, by a hard greenstone rock, similar to the trap-dykes found in the South Hill and elsewhere; and at no great distance from it were masses of felspar, in parts highly crystallized. The composition of the mass of this rock was nearly that of a trisilicate, becoming in places more basic. In the more crystallized portions there was some brilliant black mica, which I found by analysis to be lepidomelane.

VIII. *Felspathico-Hornblendic Rocks.*

These rocks, in which hornblende predominates, have been described by Professor Phillips* as "mottled syenite," and by Dr. Holl† as "diorite." They occur in all the hills, excepting the Ragged Stone. Their origin is probably similar to that of the bedded traps, lavas, and volcanic ash-beds south and south-west of the chain; and, like them, they appear to be partly intrusive and partly sedimentary; but being of much earlier age, and having undergone more extensive metamorphosis, resulting in a more complete crystallization, their mineralogical character is different. They are often distinctly stratified; granular beds alternate with others of larger crystalline structure; the "diorite" passes, abruptly or gradually, into a subcrystalline rock; and lines, marking the bedding, may be traced continuously from one to the other. The hornblende and felspar are sometimes extensively segregated, and in other places they form a confused aggregation of indistinct crystals. Quartz is an occasional constituent. They are associated with other rocks, of metamorphic character, in connexion with which they will have to be further considered.

The following analyses show the composition of these rocks, and its resemblance to that of the trap-dykes and lava-beds throughout the chain:—

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper.	Oxide of Manganese.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
LVII.	44·22	20·66	10·80	Trace.	Trace.	11·32	7·17	1·80	4·03
LVIII.	45·67	20·17	11·28	....	....	10·86	5·43	1·55	5·04
LIX.	56·61	21·72	5·26	....	0·15	4·74	3·63	1·55	6·34
LX.	44·76	16·60	8·43	....	0·20	9·92	8·56	2·68	8·85
LXI.	46·10	22·67	6·36	0·70	....	13·63	6·59	2·07	1·88

LVII. Fine-grained bed in diorite, on the east slope of the North Hill. Small crystals of hornblende, white uncrystallized felspar disseminated, and a little pyrites. G=2·990.

LVIII. Another bed interstratified with the last-mentioned, more largely crystallized. Hornblende and white felspar.

LIX. Diorite, south of the large quarry at North Malvern, resembling, in its external characters, the Labrador hornblende-rock found about fifty miles north of Cuff Harbour. Black hornblende, quartz, and pink and pinkish white felspar, of which the cleavage resembles orthoclase, but the chemical constitution is more nearly that of andesine. G=2·894. About three-fourths of the portion analyzed consisted of felspar.

* *Op. cit.* p. 41. † *Op. cit.* p. 83.

LX. Diorite from Swinyard Hill, containing hornblende, white felspar, and silvery mica. The more micaceous and felspathic portion of the rock was analyzed. G=2·933–3·076.

LXI. Diorite, Key's End Hill, containing greenish hornblende, red felspar, and a little silvery mica.

IX. *Intrusive Traps.*

The trap-dykes have been fully described in Dr. Holl's paper, and their position has been most accurately marked on the map which accompanies it. The following Table shows their chemical composition, together with that of some other rocks, XCV.–XCVII., which may probably be regarded as contemporaneous with them, from Wales and from the Charnwood-Forest district, and the more recent traps forming small dykes erupted, after the deposition of the Old Red Sandstone, at Brock Hill and Bartestree, XCIII., XCIV. The series commences with those at the south end of the Malvern chain:—

	Silica.	Alumina.	Oxide of Iron.	Oxide of Copper.	Oxide of Manganese.	Lime.	Magnesia.	Loss on Ignition.	Alkalies and Loss.
LXII.	50·26	15·69	13·93	Trace.	Trace.	5·91	3·53	2·77	7·91
LXIII.	50·62	17·68	14·46	....	....	2·20	4·21	2·47	8·36
LXIV.	44·33	19·37	12·42	....	....	12·04	6·03	4·34	1·47
LXV.	52·94	15·34	14·10	....	....	6·37	3·20	1·32	6·73
LXVI.	45·26	15·39	17·89	....	....	9·22	6·85	2·83	2·56
LXVII.	44·59	22·54	7·37	....	0·20	11·44	6·97	3·28	3·61
LXVIII.	46·32	12·75	17·38	....	0·40	10·55	5·71	1·60	5·29
LXIX.	41·90	16·45	12·60	....	....	6·83	8·95	5·41	7·86
LXX.	48·48	14·23	15·00	....	0·20	7·52	4·89	1·76	7·92
LXXI.	46·95	13·44	19·18	....	....	6·81	5·49	1·43	6·70
LXXII.	46·96	16·12	12·89	0·75	....	9·66	8·13	2·80	2·69
LXXIII.	44·54	13·88	13·70	....	0·80	16·12	5·30	3·21	2·45
LXXIV.	54·86	18·12	11·64	....	0·70	4·02	2·84	1·71	6·11
LXXV.	47·68	19·71	9·11	....	0·40	6·65	7·49	2·72	6·24
LXXVI.	41·34	19·65	15·13	Trace.	Trace.	10·35	6·09	4·70	2·74
LXXVII.	46·94	14·26	14·11	0·20	....	13·82	6·23	2·43	2·01
LXXVIII.	48·45	29·13	5·25	0·40	0·20	4·34	1·64	3·48	7·11
LXXIX.	48·16	17·59	9·67	....	....	9·35	5·81	2·37	7·05
LXXX.	54·05	20·98	12·24	....	....	1·87	3·75	....	7·11
LXXXI.	47·33	15·67	15·01	Trace.	0·25	9·10	5·31	2·26	5·07
LXXXII.	51·70	16·96	12·67	....	Trace.	6·51	4·13	1·73	6·30
LXXXIII.	60·73	22·55	2·60	Trace.	0·30	6·01	0·56	1·40	5·85
LXXXIV.	48·94	16·67	15·46	Trace.	....	9·07	4·61	2·52	2·73
LXXXV.	50·02	18·53	12·03	....	....	4·15	4·90	4·58	5·79
LXXXVI.	47·32	16·55	16·56	....	0·10	8·48	4·71	2·87	3·41
LXXXVII.	53·28	16·61	14·06	....	0·30	4·05	3·57	2·56	5·57
LXXXVIII.	44·83	18·39	13·74	0·40	....	7·76	5·39	2·82	6·67
LXXXIX.	51·47	16·79	14·82	Trace.	Trace.	6·65	3·56	1·43	5·28
XC.	47·77	16·22	14·94	....	....	8·05	3·52	1·65	7·85
XCI.	51·52	15·04	13·15	....	0·70	6·11	3·83	1·83	7·82
XCII.	51·55	15·99	13·98	....	....	7·45	4·30	1·12	5·61
XCIII. *a.*	....	2·73	1·09	....	....	2·46	0·71	4·81	....
,, *b.*	45·03	13·32	11·30	....	0·75	9·25	5·46	....	3·09
,, *c.*	51·05	15·10	12·81	....	0·85	10·50	6·20	....	3·49
XCIV.	45·46	16·63	13·17	....	0·90	5·83	7·11	5·21	5·69
XCV.	46·71	13·55	16·76	0·50	....	12·04	3·61	1·65	5·18
XCVI.	54·39	18·39	10·30	0·60	....	7·15	3·92	3·46	1·79
XCVII.	51·23	18·10	4·41	0·70	....	5·72	3·13	5·21	11·50

LXII. Trap near the summit of the West Peak of the Ragged Stone, dark bluish-grey uncrystallized epidote in the interstices. G=2·862.

LXIII. Trap from the same place, higher up, consisting of hornblende imperfectly crystallized, and some brown felspar of no distinct cleavage.

LXIV. Trap from a small dyke near the south end of Midsummer Hill, greyish black, cryptocrystalline, contains pyrites. G=2·9368.

LXV. Trap from a large dyke, Midsummer Hill. A confused mixture of hornblende and a reddish felspar indistinctly crystallized. G=2·834.

LXVI. Trap from a dyke crossing Swinyard Hill, greenish black, imperfectly crystallized; hornblende, felspar, and pyrites. G=2·979–3·198.

LXVII. Trap from a dyke north of the Cave, Herefordshire Beacon, from the east slope of the ridge, thirty or forty yards down into the ravine dividing the eastern buttresses of the Beacon from east to west. Hornblende; felspar partly of a waxy and partly of a vitreous lustre, allied to Labradorite; traces of epidote and hæmatite. G=2·855.

LXVIII. From a mass of trap immediately south of the cave, on the west side of the ridge. The fragment analyzed was taken from the part of it which is in the wood; it contains hornblende, labradorite, glassy felspar, and garnet. Some parts of this mass of trap contain, in addition to the above, hypersthene, some free quartz and massive felspar, which, when freed from the protoxide of iron by which it is stained, is greyish white. G=2·952. The specific gravity of a portion taken higher up, near the footpath, =2·912.

LXIX. From trap immediately below the cave, to the west of it; the specimen is from the narrow footpath passing under it. Soft, greenish black, no distinct crystallization, contains a little hæmatite.

LXX. From the east slope of the buttresses of the Herefordshire Beacon, south of the deep ravine which divides the buttresses from east to west, and overlooking a farmhouse at the extreme end of Castle Morton Common. Hornblende, and brown and red felspar of no distinct cleavage.

LXXI. From the same place. Both these specimens were taken from a large irregular mass of crystalline rock, which in parts contains epidote, massive and crystallized. The intrusive character of the entire mass is doubtful. Some parts of the rock resemble the "diorites" of the North Hill. It is possible that other substances may have become included in the eruptive rock, and metamorphosed with it. This specimen contains hornblende, labradorite, a little glassy felspar, epidote, and hæmatite. G=2·827–2·931, increased by the local addition of epidote to 3·043–3·058, and in one spot to 3·292.

LXXII. Greenish-black trap from a linear dyke on the east side of a hill, near a tree, and north of the ravine above mentioned. G=2·849–2·864.

LXXIII. Greyish-black trap, containing small crystals of hornblende. From a small dyke, of which only a width of a few feet is exposed on the ridge running east and west, about fifty yards west of the trap-mass next mentioned.

LXXIV. From an irregular mass, a quarter of a mile from the cave, and to the north-east of it. It contains hornblende, yellowish red orthoclase, and felspar with the iridescent appearance of labradorite. G=2·935.

LXXV. Trap near the base of the large east buttress. Uncrystallized, separates into rhomboidal fragments with smooth surfaces, which are stained red in places by anhydrous peroxide of iron. G=2·816.

LXXVI. From the same place, in immediate contact with bedded petrosiliceous rock. No distinct crystals. G=2·956.

LXXVII. Trap south of the ravine below Wind's Point, north-east of the keeper's lodge. Greenish black; hornblende, greenish felspar, and a little hæmatite. G=2·939.

LXXVIII. Felspathic portion of the rock last mentioned. Dull green to greenish yellow, waxy or greasy lustre, softer than felspar, contains water, analogous to labradorite. A green mineral of a similar character is common in the trap-dykes throughout the chain, especially in those of the Herefordshire Beacon. The labradorite in basalt has a similar character. It could not be entirely separated from the augitic parts of the rock.

LXXIX. Smooth amygdaloidal trap or lava, containing epidote in vesicular cavities, from the offstanding hill overlooking Little Malvern.

LXXX. Another rock from the same place, and of similar character, except that the vesicular cavities were filled with carbonate of lime, which was removed by diluted acid before the analysis of the rock.

LXXXI. Trap from the round eminence, midway between the Wych Cutting and the Worcestershire Beacon. A confused mixture of hornblende and felspar, the former predominating, and iron pyrites. G=2·994, diminishing near the border to 2·905.

LXXXII. Crystalline trap from a dyke crossing the summit of the Worcestershire Beacon in a north-western and south-eastern direction. Hornblende and yellowish brown felspar. G=2·949.

LXXXIII. Felspathic portion of the trap last mentioned, separated by pounding and washing the rock. Its entire substance was penetrated by the hornblende, with which it was so intimately combined that separation from it, even in the smallest fragments, was extremely difficult. This felspar is partly massive and partly crystallized. The angles were too small for measurement; but the cleavage resembles that of orthoclase. The chemical composition of the portion analyzed does not correspond with the theoretical formula of orthoclase, and is nearer that of andesine.

LXXXIV. Trap from the north-west base of the Worcestershire Beacon, south of the small stream, part of the same mass as LXXXII. Not distinctly crystallized; hornblende and a little white felspar and pyrites. G=2·981.

LXXXV. Fragment from the border of the same rock, light, porous, variegated, no crystallization. This border-rock has evidently been altered. Parts of it are stained red by peroxide of iron separated from the mass, occasionally forming plates of hæmatite, which, being soluble in hydrochloric acid, are probably not due to igneous action. They may have been produced, by double decomposition, from chloride of iron and water, the hydrogen of the water combining with the chlorine, and its oxygen with the protoxide of iron, causing its peroxidation. In the harder portions of the dyke, a few yards further into the mass than LXXXIV., the oxide of iron has been reduced, and separated as pyrites.

LXXXVI. From a trap-dyke at the south-west base of Summer Hill. Greyish black, imperfectly crystallized, contains pyrites. G=2·873. Near the border, with lines of epidote, G=2·861; and with peroxide of iron, G=2·887.

LXXXVII. Near the border of a trap-dyke penetrating the rock on the south side of the large quarry at West Malvern. Parts of it are of a red colour, caused by anhydrous peroxide of iron; the rest is grey, reddish grey, and blackish grey; it contains felspar of a reddish colour, not distinctly crystallized. G=2·789–2·821.

LXXXVIII. From the middle trap-dyke in the terminal hill between North and West Malvern. Hornblende, some felspar of a pearly lustre, and a little glassy felspar, not distinctly crystallized. G=2·955. In small veins, G=2·903.

LXXXIX. Crystalline trap from the east side of North Hill. Hornblende and yellowish felspar of no distinct cleavage.

XC. Greyish black trap from the south slope of the North Hill, not far from the border of a dyke. G=2·989. In the more crystalline parts of the same dyke, nearer the centre, G=2·913.

XCI. From the more central portion of the large trap-mass overlooking Holly Mount. Hornblende crystals, of which a few are acicular, and brownish uncrystallized felspar. G=2·912.

XCII. Part of the same mass, nearer the border. Greyish black; no distinct crystallization. G=2·942. At an intermediate portion of the same mass, G=2·932.

XCIII. Dyke at Bartestree, altering the Old Red Sandstone, described by Professor Phillips, *loc. cit.* p. 180. G=2·776.

a. Portion soluble in cold distilled water slightly acidulated with hydrochloric acid.

b. The undissolved residue.

C. Composition of the undissolved portion.

XCIV. Dyke altering the Old Red Sandstone, Brock Hill, Shelsey Beauchamp. Phillips, *loc. cit.* p. 156. Hornblende was the predominant mineral in the specimen analyzed.

XCV. Trap from a dyke near Glynrhonwy, containing white felspar, hornblende, and pyrites.

XCVI. Trap traversing Mount Sorel granite. Greyish black; uncrystallized; contains pyrites.

XCVII. Red felspathic trap, three quarters of a mile south of

Quorndon; fine-grained, slightly vesicular, with a little carbonate of lime disseminated, and in cavities.

For the five last named, as well as for many characteristic specimens of the Malvern dykes, I am indebted to Dr. Holl.

General Conclusions.

1. In the intrusive trap-rocks, the ratio of the oxygen of the silica to that of all the bases taken together varies progressively from 5:4 to nearly 2:1. The middle term, representing the mean composition of the trap-rocks, is 3:2, which is the proportion assigned by Bunsen to "augitic" rock of normal composition. It should, however, be observed that the bases are not entirely combined with the silica, but are, in various degrees in different rocks, united with other acids, or deposited as free oxides in the capillary interstices of the rock. This is easily proved by digesting the pounded rock in diluted acetic acid, which dissolves out a portion of the bases without decomposing the silicates. There are also sulphates, bisulphurets, fluorides, arseniates, and carbonates. Sulphate of baryta occurs in cavities and fissures, and as a cementing substance; it has clearly been precipitated from a state of solution, and, being itself insoluble, it must have been formed by the decomposition of carbonate or silicate of baryta by soluble sulphates. Bisulphurets abound, generally as pyrites; arseniates south-west of the Midsummer Hill and in the Ragged Stone; fluorides in the trap-dykes and lava-beds, most abundantly in those of recent formation, as the bosses in the field near Fowlett's farm. Carbonates are constituents of some of the rocks at the south end of the chain. Protoxide, peroxide, and magnetic oxide of iron are disseminated throughout the substance of the intrusive rocks in various proportions. The proportion of the oxygen of the silica to that of the bases *actually combined with it*, is therefore much nearer that of a bisilicate than it would appear to be from the above analyses.

2. The relative proportions of the several bases vary considerably in different rocks, and often characterize particular localities. Magnesia abounds in the lava-beds and dykes, and in the volcanic ash of the Hollybush-sandstone and Black-shale periods, in one or two dykes of the Herefordshire Beacon, and in the Brock Hill dyke. The other traps, including the Bartestree dyke, though of the same age as that at Brock Hill, have more lime than magnesia. Lime and iron both abound in some of the dykes of the Herefordshire Beacon, and at Glynrhonwy; lime only in others—in the dyke at the south end of Midsummer Hill, and at Bartestree; alkalies in the Ragged Stone and at Quorndon, and in some of the Herefordshire Beacon. I have determined the alkalies as difference, but I ascertained, from separate experiments, that there was more potash than soda in the eruptive rocks associated with the Hollybush Sandstones, and that in most of the other rocks examined for the determination of the relative amounts of the two alkalies, soda was the most abundant.

3. The chemical composition of the eruptive rocks does not vary

according to their age. Many of the "diorites," which are the oldest, are more basic than some of the volcanic beds, which are the most recent, some of the Lower Cambrian than others of the Upper Cambrian period. There is as much variety in the atomic amount of the silica in rocks of the same age and place, as in rocks of different ages or from distant localities, and as much resemblance between some of the trap-dykes and the products of ancient and modern eruptions of Hecla and Vesuvius as that which they bear to contemporaneous dykes in their vicinity.

4. The atomic proportion of the silica to the bases appears to be *highest* in the *largest* masses of trap, such as those of the North Hill (XCI., XCII., LXXXIX., XC.), the Worcestershire Beacon (LXXXII., LXXXIV.), the large irregular mass in the east buttress of the Herefordshire Beacon (LXXIV.), and the great dyke of Midsummer Hill (LXV.),—and lowest in the smallest masses, as shown in some of the dykes of the Herefordshire Beacon (LXXIII., LXXVI., LXIX.) and in the dyke traversing Swinyard Hill (LXVI.). But this law, though very general, is not invariable; for in the trap of the middle terminal Hill (LXXXVIII.), which is rather a large mass, the oxygen quotient is about 0·7, and the specific gravity 0·955.

5. In the same masses of trap there is an appreciable increase in the silica towards their centres, as may be seen by comparing the central portion of the trap in the large dyke over Hollymount (XCI.), which is nearly a bisilicate, with the outer portion (XCII.), and similarly, in the North Hill, LXXXIX. with XC., and, in the Worcestershire Beacon, LXXXII. with LXXXIV. It must, however, be observed that at the *extreme* border of a dyke, if there be not sufficient pressure exerted by the contiguous rocks to make it dense and impervious to water, soluble bases have been removed, and the relative amount of silica thereby increased (LXXXV., LXXXVII.).

The increase of the silica towards the central parts is not the effect of a liquation in the fluid mass; for its atomic proportion would then be as much below the average in the exterior portions as it is above it in the interior; whereas no parts of the larger masses contain more base than is usually found throughout the trap-dykes of the chain.

From these facts I infer that the *primary source* of all the trap-rocks in the Malvern Hills was nearly a bisilicate, which, during the various processes by which it has been brought to the surface, has become united more or less with other substances, assimilating metallic oxides, lime, magnesia, or alkalies, according as one or others might be locally prevalent, just as, in modern times, the lava of Vesuvius takes up soda, and that of Etna lime. When these basic elements have been deposited in the rock as free oxides, or have become united with other acids than the silicic, they may be separated more or less completely from the silicate, as shown in Analyses XIV., XV., LXXX., XCIII. When they have become united in various proportions with the silica, they have caused a diminution in the atomic amount of the silicate of the erupted rock. In none of the traps which I have examined has all the base been saturated by the silica; but this has not been owing to an insufficient quantity of the acid; for in the "diorites," in which the silica is in the same atomic proportion as in the traps, the combination of the bases with the silica is complete. In the smaller dykes, the extraneous elements have formed a larger proportion of the erupted rock than in the larger masses; and in these last the original bisilicate has been most alloyed in that part of the molten rock which must have come first to the surface. As other portions rose in a plastic state and formed successive layers, forcing the earlier portions out, by distention, from the centre, the central portions have become less and less affected by the assimilation of foreign matters; and so they approximate nearer to the composition of the bisilicated mass from which I have supposed them to have been previously derived.

6. In all the rocks of the Malvern chain, known or supposed to be products of eruptive action, the atomic proportion of the silica to the bases varies according to a common law. In the traps and augitic lavas, the ratio of the oxygen of the silica to that of all the bases chemically combined with it is never greater than 2 : 1, nor less than 3 : 2. In those which I have described as trachytic rocks, this ratio is never more than 3 : 1, nor less than 5 : 2. In the granitic veins it is not more than 4 : 1, nor less than 7 : 2; and in some quartzo-felspathic and petrosiliceous rocks it is not greater than 5 : 1, nor less than 9 : 2. The eruptive rocks may thus be primarily referred to four sources, in which *silica* was combined with bases according to a regular arithmetical progression, which may be expressed by the numbers 2, 3, 4, 5, other elementary substances, acid and basic, being united according to their several elective affinities. But when such of these as were decomposable by heat were exposed to a high temperature in foci from which they were eventually ejected, many bases were necessarily separated by the evolution of their acids in a gaseous form. And as silicic acid will combine with bases in a great variety of proportions, and its power of forming such combinations was increased by the same circumstances under which that of other acids was destroyed, the silica appropriated to itself a larger proportion of base than that with which it was at first united. But the extent of this alteration was in all cases limited; and its maximum amount may be expressed arithmetically by the proportions 3, 5, 7, 9 to 2. And enough of the original silicate still remains, especially in the central parts of the largest masses, to enable us to refer them to one or other of the four well-defined classes into which they are naturally divided, and to show that they were formed by the combination of the silica with bases according to the usual law of multiple proportions, its quantities in different compounds bearing a very simple relation to each other—a combination which could only have taken place with such regularity where the various elements were in such a state of atomic division, and possessed such perfect freedom of motion, and such complete exemption from all disturbing forces, that the action of chemical affinity was entirely unrestrained..

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8. *On the* Relative Distribution *of* Fossils *throughout the* North Devon Series. By Townsend M. Hall, Esq., F.G.S.

Contents.

1. Introduction.

Almost all observers since the time of Messrs. Weaver and Williams, in 1837 and 1838, have shown that the slates, shales, and sandstones which constitute a large portion of the north of Devon differ so much in their lithological and mineralogical structure as to render it necessary to subdivide them into several successive zones or groups. In the 'Palæozoic Fossils of Cornwall, Devon, and West Somerset,' Prof. Phillips pointed out, by means of a synoptical table, the relative occurrence of fossils throughout these different subdivisions of the North Devon series, which he named the Lynton, Combe Martin, and Pilton groups respectively, each of these three fossiliferous beds being separated from each other by a considerable thickness of grits and shales, which have hitherto proved destitute of organic remains. More than a quarter of a century, however, has now elapsed since Prof. Phillips's work was published; and since that date not only have many new fossil-localities been observed, but so great a change has taken place in the system of nomenclature as to render it at present anything but easy for the geologist to identify the names of some of the species, or to ascertain in which group they occur. Thus the *Leptæna caperata* of Phillips was placed a few years later in the genus *Strophalosia*, and the name of the species has since been altered into *productoides*, so that in *Strophalosia productoides* of the present day no trace whatever of the original name can now be recognized. Again, many fossils, especially the Brachiopoda, which, from imperfect material, were supposed to constitute new species, and to require, therefore, a distinctive name, have lately been considerably reduced in number; and so great a diminution has been effected by Mr. Davidson, that *Spirifera disjuncta* is now made to include the following North Devon varieties, to which separate names had formerly been applied:—*S. Barumensis*, *S. calcarata*, *S. distans*, *S. extensa*, *S. gigantea*, *S. grandæva* (?), *S. pratensis*, *S. Verneuilii*, and several others. In the other classes of fossils the same reduction of species may eventually be made. Several of the so-called species of *Cucullæa* are probably synonyms; and some of the crinoidal stems which abound in the North Devon rocks are so doubtful as to render their specific determination a matter of extreme difficulty.

In order to insure as much accuracy as possible in the determination of my type specimens, I availed myself last autumn of the kind assistance of Robert Etheridge, Esq., F.G.S., Palæontologist to the Geological Survey, when, during the course of a visit to North Devon, he examined my collection, and verified the greater number of the species which I had obtained during the last ten or twelve years. The Brachiopoda had previously been examined by Mr. Davidson, who figured several of the most remarkable in his Devonian Monograph. I am further indebted to Mr. Etheridge for his kindness in adding to my list the name of the author by whom each species was originally named.

2. Subdivision of the North Devon Rocks.

The series of slates and sandstones to which the present paper will be confined is bounded on the north by the Bristol Channel, and on the south by the great trough of Carboniferous grits, which extends far into the middle of the county. The beds of slate and shale which divide this true Carboniferous deposit from the Devonian can scarcely yet be assigned with certainty to either of these formations; and to avoid, therefore, the confusion which would arise by classing these intermediate beds with either of the other well-defined rocks, I shall still continue to use the term "North Devonian," which I have before applied* to the entire series which lies north of the town of Barnstaple.

From the Foreland on the north to Barnstaple on the south the rocks have an almost uniform dip to the south, usually at a high angle; and in such a wide series, presenting to all appearance an unbroken succession, it is especially important to be able to show that throughout the whole of this area there exists a marked difference in the distribution of species, both as regards variety of genera and abundance of individuals, thus justifying the conclusions which had been formed by previous observers, who had based their subdivisions of the North Devon system rather on the lithological structure of the beds than on the evidence of the fossils contained in them.

The accompanying sketch map is intended to show the relative position and extent of the North Devon beds.

In ascending order there are:—

1st. The unfossiliferous grits of the Foreland, which rise out of the Bristol Channel, and to all appearance form the lowest member of the series.

2nd. Lynton beds, consisting of hard grits, shales, and sandstones, intersected with occasional bands of calcareous and ferruginous matter. These beds contain a few species of fossils, principally *Orthis arcuata*†, Spirifers, and Crinoids, all of which, from the extreme hardness of the stone, can only be obtained in the shape of impressions and imperfect casts. At Woodabay and Lynton the best sections may be seen.

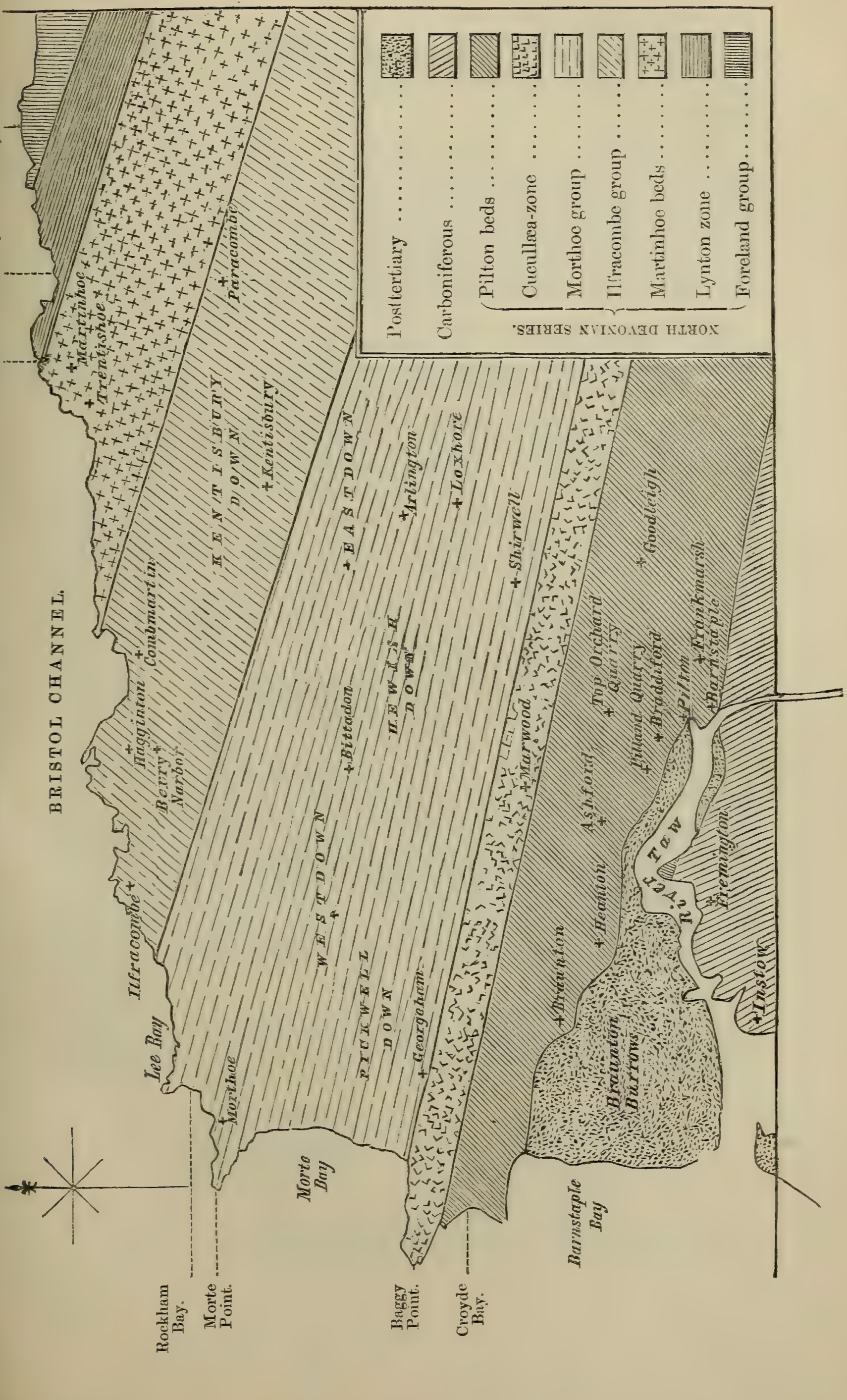
3rd. Martinhoe bed. Unfossiliferous grits and shales.

4th. Ilfracombe group. A series of silvery slates and shales, containing several thick bands of limestone, which, on being either polished or exposed to the action of the air, show the outlines of

* Geology of North Devon, p. 7.

† This species probably includes also the *Orthis longisulcata* of Phillips.

Sketch Map of the Fossiliferous Deposits of North Devon.



numerous fossils. The limestone bands are worked extensively at Combe Martin, Haggington, and near the town of Ilfracombe, where two species of *Cyathophyllum* are common, and several species of Brachiopoda are also found in a most imperfect state of preservation.

5th. Morthoe group. This wide group has hitherto yielded no trace of any fossil. Its northern or lower portion consists of slates which do not materially differ from those of the Ilfracombe group, except that the characteristic limestone bands are wanting. The upper beds of the group are composed of micaceous sandstones and conglomerates, nearly all of which are stained a deep-red colour, from the iron-ore with which this southern portion of the series abounds.

6th. Cucullæa-zone. This bed formed the lower part of the Pilton group of Prof. Phillips, and has been called by both Messrs. Salter * and Jukes † the "Marwood" bed. This local designation is not, however, altogether an advantageous one, and in some cases it is productive of confusion between this group and that which succeeds it, since in the extensive parish of Marwood numerous quarries are worked in the slates of the Pilton beds; and hence it follows that many of the fossils found *at* Marwood do not occur in what Messrs. Salter and Jukes call the Marwood beds ‡. As these sandstones are in some places a perfect congeries of shells of the genus *Cucullæa*, it may perhaps be better to follow the example of some of the German geologists, who frequently name a bed after its predominant or characteristic fossil §.

The following are the best fossil-localities in the Cucullæa-bed:—(1) Baggy Point, where the width of the bed is well seen, as the Promontory of Baggy is due to the extreme hardness of the sandstone, the component particles of which are united in places with a ferruginous cement, and which has therefore greater power to resist the action of the waves than the soft slates lying on either side of it. A thin vein of greenish or olive-coloured shale is situated on the south side of the sandstone, and separates it from the slates of the Pilton group. (2) Sloly Quarry, where there are several beds of olive shale, full of two small species of *Lingula*. They are intercalated with the sandstone, and are not confined to its southern boundary as appears to be the case at Baggy Point. In this quarry the sand-

* Quart. Journ. Geol. Soc. vol. xix. p. 479. † *Ibid.* vol. xxii. p. 347.

‡ Mr. Davidson, in his monograph of Devonian Brachiopoda, mentions the occurrence of the following species at Marwood (as these specimens were from my Collection, I take this opportunity of saying that, although they were found at Marwood, they did not occur in the Cucullæa-sandstone, but in the Pilton slates):—

Chonetes Hardrensis.	Orthis interlineata.
Productus prælongus.	Productus scabriculus.
Rhynchonella laticosta.	Rhynchonella pleurodon.
Spirifera Urii.	Strophomena analoga.
Terebratula sacculus.	

§ A recent British example of this system of nomenclature may also be found in the "*Avicula-contorta*" zone of the Rhætic formation.

stone contains *Cucullæa* in abundance, and the shales yield large numbers of plant-stems.

7th. Pilton beds. Slates of a purplish or greyish tint. Several rolls and contortions, which materially diminish their apparent thickness, may be observed near Braunton, at Pilton, and near Goodleigh Church.

Throughout nearly every part this bed contains fossils in abundance, especially Brachiopods, crinoidal stems, and a small crustacean (*Phacops latifrons*). Thin intermittent bands of limestone are common, traversing the slate; they also are highly fossiliferous, but decompose rapidly on exposure to the action of the weather.

The following quarries, situated in the Pilton beds, are amongst the best localities for fossils:—

Parish of Pilton {
- Top Orchard.
- Pilland.
- Frankmarsh.
- Bradiford (ceased to be worked).

Goodleigh (ceased to be worked).
Croyde Bay*.
Braunton.

3. Table of the Distribution of Species throughout the various Fossiliferous Groups.

In the following Table I have endeavoured, by selecting those quarries situated at some distance from each other, but which are worked in the same group, to show the relative distribution of certain species. The occurrence of each fossil which has come under my own personal observation is marked with an asterisk, thus (*), whilst those which I have inserted upon the authority of other writers are distinguished by a small cross (†).

* Croyde Bay, which is close to Baggy Point, is situated in the slates of Pilton, and lies south of the Cucullæa-bed. Before these two groups were divided, these localities were looked upon as almost synonymous; and hence we find that in the 'Palæozoic Fossils' several species are described as occurring at Baggy which were found in the slates and limestones of the Pilton groups in the adjoining cliffs of Croyde Bay. As most of these fossils are expressly stated by Prof. Phillips to have been found in limestone, I have put them in my list as occurring at Croyde, since they clearly could not have been found amongst the sandstones of the Cucullæa-bed, which form, as has been before mentioned, the Point of Baggy.

Table showing the Relative Distribution of Species throughout the Four Fossiliferous Groups of North Devon‡.

	Pilton beds.								Cuculæa-bds.			Ilfracombe group.			Lynton beds.	
	Pilton.	Pilland quarry.	Frankmarsh quarry.	Bradiford.	Goodleigh.	Top Orchard quarry.	Croyde.	Braunton.	Baggy Point.	Marwood.	Sloly quarry.	Ilfracombe.	Haggington.	Combe Martin.	Woodabay.	Lynton.
Subkingdom CŒLENTERATA.																
Class ACTINOZOA.																
Amplexus tortuosus, *Phillips*	...	...	*													
Chætetes tumidus, *Phillips*	...	...	...	...	...	...	...	†								
Cyathophyllum cæspitosum, *Goldfuss*	...	...	...	...	...	...	...	...	...	...	...	†	*	†		
—— obtortum, *Lonsdale*	...	...	...	...	...	...	...	...	...	...	...	*	*			
—— turbinatum, *Goldfuss*	*															
Favosites fibrosa, *Lonsdale*	...	...	...	...	...	...	...	...	...	...	...	†	...	†		
—— polymorpha, *Blainville*	...	...	...	...	*	...	...	*	...	...	...	†	†	†	...	†
Fistulipora cribrosa, *Goldfuss*	†															
Petraia celtica, *Lonsdale*	...	...	*	*	...	*	...	*								
—— pluriradialis, *Phillips*	†	...	...	...	...	...	...	...	...	...	...	...	...	...	...	†
Pleurodictyum problematicum, *Goldf.*	...	...	...	...	...	...	...	†								
Stromatopora concentrica, *Lonsdale*	...	...	...	...	...	...	...	...	...	...	...	...	...	†		
Subkingdom MOLLUSCA.																
Province I. MOLLUSCOIDA.																
Class I. POLYZOA.																
Ceriopora, sp. ?	...	...	...	...	...	...	...	...	...	...	...	*				
—— gracilis, *Phillips*	†	...	...	...	...	...	†	†								
—— similis, *Phillips*	...	...	*	*												
Fenestella antiqua, *Goldfuss*	*	*	*	*	*	*	*	*	...	...	...	...	*	...	†	†
—— arthritica, *Phillips*	...	...	...	...	...	...	...	...	...	...	...	...	†			
—— plebeia, *M'Coy*	...	...	...	..	...	...	...	†								
—— prisca, *Goldfuss*	...	...	*													
Glauconome bipinnata, *Phillips*	*	*	...	*	*	*	*	*								
Polypora laxa, *Phillips*	...	...	...	...	...	...	†									
Class II. BRACHIOPODA.																
Athyris concentrica, *Von Buch*	*	...	*	*	*	*	*	*	...	...	...	†	...	...	...	†
—— decussata, *Sowerby*	†	...	...	...	...	...	†									
—— indentata, *Sowerby*	†?															
—— oblonga, *Sowerby*	†?															
—— planosulcata, *Phillips*	...	...	...	...	...	...	...	†								
Atrypa desquamata, *Sowerby*	...	...	...	..	*	...	...	*								
—— reticularis, *Linnæus*	...	...	...	...	...	...	...	...	...	...	...	...	†			
Calceola sandalina, *Linnæus*	...	...	...	...	...	*										
Chonetes Hardrensis, *Phillips*	*	...	...	*	*	*	*	*	..	...	...	...	...	...	...	†
Cyrtina heteroclita, *Defrance*	...	...	...	...	...	...	...	...	...	...	..	...	†			
Discina nitida, *Phillips*	...	...	*	...	...	...	*	...	...	...	†?					
Lingula squamiformis, *Phillips*	...	...	...	..	...	...	...	...	...	...	*					

‡ Seven or eight of the species included in this list, like *Orthis calcar* or *Spirifera rudis*, are so doubtful that a note of interrogation is appended to their names.

TABLE (*continued*).

	Pilton beds.								Cuculæa-bds.			Ilfracombe group.			Lynton beds.	
	Pilton.	Pilland quarry.	Frankmarsh quarry.	Bradiford.	Goodleigh.	Top Orchard quarry.	Croyde.	Braunton.	Baggy Point.	Marwood.	Sloly quarry.	Ilfracombe.	Haggington.	Combe Martin.	Woodabay.	Lynton.
Lingula circularis, *Hall*	...	...	...	...	...	...	...	...	...	...	*					
Merista plebeia, *Sowerby*	...	...	...	...	...	...	...	...	...	...	*	...	†			
Meristella tumida, *Dalman*	...	...	...	...	...	...	*									
Orthis arcuata, *Phillips*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*
—— calcar, *Phillips* (=Streptorhynchus crenistria?)	†															
—— granulosa, *Phillips*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	†	
—— interlineata, *Sowerby*	*	*	*	*	*	*	*	*	...	...	...	...	†			
—— striatula, *Schlotheim*	...	...	...	...	...	...	...	...	...	...	...	...	†			
Productus longispinus, *Davidson*	...	...	...	...	...	*										
—— prælongus, *Sowerby*	...	...	...	...	*	*	*	*								
—— scabriculus, *Martin*	*	...	...	...	...	*										
Rensselæria stringiceps, *Roemer*	...	...	...	...	...	...	...	...	...	...	...	...	*			
Rhynchonella cuboides, *Sowerby*	...	...	...	...	...	...	...	†								
—— laticosta, *Phillips*	...	...	...	...	...	...	*	†?								
—— pleurodon, *Phillips*	*	...	...	*	*	*	*	*								
—— pugnus, *Martin*	*	...	...	*	*											
—— ——, var. anisodonta, *Phillips*	*	...	...	*	*											
—— subdentata, or reniformis, *Sowerby*	†	...	...	...	...	...	...	†								
Spirifera canalifera (?), *Valenciennes*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	†
—— curvata, *Schlotheim*	...	...	...	...	...	*	...	...	...	...	...	†				
—— cuspidata (?), *Martin*	...	...	...	...	...	...	...	†								
—— disjuncta, *Sowerby*	*	*	*	*	*	*	*	*	...	...	...	†				
—— ——, var. Barumensis, *Salter*	...	...	...	...	*	*	*	*								
—— ——, var. calcarata, *Sowerby*	*	...	...	*	*	*	*	*								
—— ——, var. grandæva, *Phillips*	...	...	...	...	*											
—— hysterica (?), *Schlotheim*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	†
—— lævicosta, *Valenciennes*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	†	†
—— rudis (?), *Phillips*	...	...	...	...	...	...	†									
—— speciosa, *Schlotheim*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	†
—— striata (?), *Martin*	...	...	...	...	...	...	†	†								
—— Urii, *Fleming*	*	*	*	*	*	*	*	*								
Spiriferina cristata, *Schlotheim*	†															
Streptorhynchus crenistria, *Phillips*	*	*	...	*	*	*	*	*	...	...	...	†	...	...	...	†
Stringocephalus Burtini, *Defrance*	...	...	...	...	...	...	...	...	...	...	...	†	*	†		
Strophalosia productoides, *Murch.*	*	...	*	*	*	*	*	*								
Strophomena rhomboidalis, *Wahlenberg*, var. analoga, *Phillips*	*	...	...	*	*	*	*	*	...	...	...	...	*			
—— ——, var. rugosa, *Dalman*	...	...	...	*	*											
Terebratula elongata (?), *Schlotheim*	...	...	...	...	...	...	...	†?								
—— sacculus, *Martin*	*	...	*	...	...	...	*									
Province II. LAMELLIBRANCHIATA.																
Class I. CONCHIFERA.																
Avicula cancellata, *Phillips*	...	...	...	...	...	*	†	*								
—— Damnoniensis, *Sowerby*	...	...	...	...	...	...	*	†	...	*						

TABLE (*continued*).

	Pilton beds.								Cuculæa-bds.			Ilfracombe group.			Lynton beds.	
	Pilton.	Pilland quarry.	Frankmarsh quarry.	Bradiford.	Goodleigh.	Top Orchard quarry.	Croyde.	Braunton.	Baggy Point.	Marwood.	Sloly quarry.	Ilfracombe.	Haggington.	Combe Martin.	Woodabay.	Lynton.
Avicula rudis, *Phillips*	*					*										
Aviculopecten, sp.?											*					
—— nexilis, *Sowerby*	†							†								
—— polytrichus, *Phillips*					*	*		†								
—— tessellatus, *Phillips*								†								
—— transversus, *Sowerby*	*	*			*	*	†									
Clidophorus ovatus, *Sowerby*	†															
Ctenodonta latissima, *Phillips*	†															
—— lineata, *Phillips*		*					*									
Cucullæa amygdalina, *Phillips*									*	*	*					
—— angusta, *Sowerby*									*	*						
—— depressa, *Phillips*										†						
—— Hardingii, *Sowerby*									*	†	*					
—— trapezium, *Sowerby*									*	*						
—— unilateralis, *M'Coy*										*	*					
Curtonotus elegans, *Salter*	†							†								
—— rectus							†									
Cypricardia (Schizodus) deltoidea, *Phill.*										*						
—— impressa, *Sowerby*							†									
—— Phillipsii, *D'Orbigny*							†									
Modiolopsis, sp.?			*			*		†								
Myalina, sp.?														*		
Nucula, sp.?											*					
—— plicata, *Phillips*							†									
Pterinea spinosa, *Phillips*															†	
—— subradiata					*											
Pullastra antiqua, *Sowerby*	†						†?									
Sanguinolites complanatus, *Phillips*	*		*	*			*									
—— liratus, *Phillips*	†						*									
—— mimus											*					
Province III. ODONTOPHORA.																
Class I. GASTEROPODA.																
Acroculia vetusta, *Sowerby*						*		†								
Euomphalus serpens, *Phillips*			*		*			*								
Loxonema, sp.?						*										
——, sp.?												*				
—— rugifera, *Phillips*								†								
Macrocheilus, sp.?							†									
Natica, sp.													*			
——, sp.									*		*					
—— meridionalis, *Phillips*									†?							
Pleurotomaria, sp.								†								
—— aspera, *Sowerby*	†														†	†
—— cancellata, *Phillips*	†															
—— expansa, *Phillips*							†		†							
—— gracilis, *Phillips*							†		†							

TABLE (*continued.*)

	Pilton beds.								Cuculæa-bds.			Ilfracombe group.			Lynton beds.	
	Pilton.	Pilland quarry.	Frankmarsh quarry.	Bradiford.	Goodleigh.	Top Orchard quarry.	Croyde.	Braunton.	Baggy Point.	Marwood.	Sloly quarry.	Ilfracombe.	Haggington.	Combe Martin.	Woodabay.	Lynton.
Order NUCLEOBRANCHIATA.																
Bellerophon bisulcatus, *Römer*	...	...	...	...	...	...	†									
—— subglobatus, *M'Coy*	†	...	...	...	...	...	...	...	...	†	...	...	...	...	†	
—— Urii, *Fleming*	†	...	...	...	...	*	†									
Porcellia Symondsii	...	...	...	...	...	...	...	†								
Class II. PTEROPODA.																
Conularia quadrisulcata	...	...	*													
Class III. CEPHALOPODA.																
Cyrtoceras, sp.	...	*	...	*												
Goniatites vinctus, *Sowerby*	†															
Orthoceras cinctum, *Sowerby*	...	...	...	...	..	*										
—— cylindricum, *Sowerby*	†															
—— imbricatum, *Wahlenberg*	...	...	...	...	...	*	...	...	†	†						
—— lineolatum, *Phillips*	...	...	...	...	...	...	†									
—— Ludense, *Sowerby*	...	...	...	...	...	...	...	...	...	†	...	...	...	...	†	
—— tentaculare, *Phillips*	...	...	...	...	...	*	...	...	*							
—— undulatum, *Sowerby*	...	...	...	...	...	...	...	†								
Subkingdom ANNULOSA.																
Province I. ANNULOIDA.																
Class ECHINODERMATA.																
Actinocrinus polydactylus, *Miller*	...	...	...	...	...	...	...	†								
—— tenuistriatus, *Phillips*	*	...	...	...	...	*	*	*	...	...	...	...	...	...	...	†
Adelocrinus hystrix, *Phillips*	...	*	...	...	...	*	...	†								
Cyathocrinus ellipticus, *Phillips*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	†?
—— macrodactylus, *Phillips*	*	...	...	...	...	*	...	*								
—— pinnatus, *Goldfuss*	...	*	...	*	...	*	...	*								
—— variabilis, *Phillips*	*	*	*	*	*	*	*	*	...	...	...	†	...	...	...	†
Palæaster, sp.	...	...	...	...	...	...	...	†								
Poteriocrinus, sp.	*	...	*	...	...	...	...	*								
—— fusiformis, *Roem.*	*	...														
Protaster, sp.	...		...	...	..	...	*	†								
Rhodocrinus, sp.	...	...	...	...	...	...	...	†								
Province II. ANNULATA.																
Class ANNELIDA.																
Cornulites, sp.	...	...	...	...	...	*										
Tentaculites, sp.	...	...	...	...	...	...	...	...	...	...	...	*	*			
Province III. ARTICULATA.																
Class CRUSTACEA.																
Phacops granulatus, *Münster*	...	...	...	...	...	...	...	†								
—— latifrons, *Bronn*	*	...	*	*	*	*	*	*	...	...	...	...	...	...	...	†

TABLE (*continued*).

	Pilton beds.								Cucullæa-bds.			Ilfracombe group.			Lynton beds.	
	Pilton.	Pilland quarry.	Frankmarsh quarry.	Bradiford.	Goodleigh.	Top Orchard quarry.	Croyde.	Braunton.	Baggy Point.	Marwood.	Sloly quarry.	Ilfracombe.	Haggington.	Combe Martin.	Woodabay.	Lynton.
Subkingdom VERTEBRATA.																
Province I. ICHTHYOPSIDA.																
Class PISCES.																
Holoptychius (scales of)	...	...	...	...	...	...	† ?									
PLANTÆ.																
Adiantites Hibernicus, *Forbes*	...	...	...	...	...	...	...	...	...	...	*					
Calamites, sp.	...	...	*													
Bornia (Calamites) transitionis, *Göppert*	...	...	...	...	...	...	...	...	...	...	†					
Knorria, sp.	...	...	...	...	...	...	...	...	...	*	*					
Lepidodendron (Knorria) dichotomum, *Haughton*	...	...	...	...	...	...	...	...	...	†	†					
Sagenaria (Knorria) Veltheimiana, *Sternberg*	...	...	...	...	...	...	...	†	...	...	†					
Sigillaria, sp.	...	...	...	...	...	*										
Sphenopteris, sp.	...	...	...	...	...	...	...	...	...	...	*					
Sternbergia, sp.	...	...	...	...	...	...	*	†								
Doubtful species	...	...	*	...	*	*	*	*	*	*	*					

Summary.

	Genera.	Species.
Actinozoa	8	12
Polyzoa	4	9
Brachiopoda	20	45 and 6 varieties.
Conchifera	13	32
Gasteropoda	6	14
Nucleobranchiata	2	4
Pteropoda	1	1
Cephalopoda	3	9
Echinodermata	7	12
Annelida	2	2
Crustacea	1	2
Pisces	1	1
Plantæ	10	10 or more
Total	78	153

4. NOTE ON THE SPECIES OF LINGULA FROM SLOLY QUARRY.

The small *Lingula* which is found in such abundance at Sloly Quarry was named by Mr. Salter *L. mola**, and in the Catalogue of

* Quart. Journ. Geol. Soc. vol. xix. p. 480.

Fossils in the Museum of Practical Geology it is called *L. hybrida.* Mr. Davidson, in his Monograph of the Devonian Brachiopoda, refers it to the Carboniferous species *L. squamiformis,* and remarks that "it is difficult to obtain specimens preserving their natural shape, almost every example being deformed or put out of shape from the effects of pressure or cleavage." *Lingula squamiformis* is described as "longitudinally oblong, one-third or less longer than wide; valves slightly convex, with their external surface covered with numerous fine concentric striæ or lines of growth. Usual dimensions 9 lines in length by 5 in width." Taking this as the specific character of the shell, we find at Sloly that, besides *Lingula squamiformis,* there is also another *Lingula,* which must be either a new species or, at least, a well-defined variety. A comparison of a great number of specimens shows that the breadth of this shell is equal to its length, or nearly so. Dimensions 5 lines in length by 5 in width; valves convex, and generally marked with two lines of growth. Numerous fine intermediate striæ cover the surface of the valves, and give them a peculiar laminated appearance. Should this *Lingula* prove to be a new species, the name *L. circularis* might be appropriate, since it differs so materially from the other *Lingulæ* in having a form which is nearly orbicular. I should perhaps add that the difference in shape from *L. squamiformis* could scarcely be due to distortion, effected by either cleavage or pressure; and I have observed that when several individuals of these two species occur on the same slab of slate, they in every case have retained their independent and characteristic form.

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9. *On the* Geology *of the* Princess Islands *in the* Sea *of* Marmora. By W. R. Swan, Esq.

(Communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., F.G.S., &c.)

[The publication of this paper is unavoidably deferred.)

(Abstract.)

Mr. Swan points out the existence of a considerable mass of Devonian strata, partly fossiliferous, in several of these islands, of an age different from that of the beds of the Bosphorus, which latter he has shown in a former paper to belong to the lowest of the Devonian series of the Rhine. The presence of the remains of fish in the above strata, and of an ancient coral-reef in one of these islands (Andirovitho), is also noticed.

The rocks which form the remaining portions of these islands are (1) Trachytic, of younger age than the Devonian strata, and (2) Trappean, more recent than the Trachytic. The quartz-rocks, of which some of the islands are largely, and others entirely composed, are altered sandstones of Devonian age.

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10. *The* Sulphur-springs *of* Northern Formosa.

By Cuthbert Collingwood, M.B., F.LS.

[Communicated by Dr. J. D. Hooker, F.R.S., F.G.S.]

I lately had an opportunity afforded me, by a cruise in H.M.S 'Serpent,' Commander Bullock, of visiting the remarkable sulphur-springs in the neighbourhood of Tamsuy, in the north-east part of the island of Formosa. These springs are situated among the hills about equidistant from Tamsuy (or Hoowei) and Mangka, the capital of the Tamsuy district, and are highly interesting from a geological point of view, indicating as they do the existence of volcanic action near the surface in these regions—a circumstance which we might have been led to expect from the frequent occurrence of earthquakes.

The sulphur-springs which I am about to describe are not the only springs of the kind in those parts; others are indicated at no great distance. The road to them runs through a beautiful and highly cultivated district. Besides numerous paddy-fields situated upon the hillsides, and ingeniously irrigated by a series of platforms, down which the water flows from one to the other after the manner of the cascades of St. Cloud, a remarkable feature is an immense pineapple-plantation of many acres in extent; so that the verdure of these hills leaves one unprepared for the fact of subterranean heat finding a vent in such close proximity.

About halfway up the ascent we cross a stream having the character of a mountain-torrent, the stones at the bottom of which are covered with a deep-green deposit, very copious in the quieter and more sheltered spots; and upon dipping one's hand into this stream, the temperature is found to be too high to allow it to remain there. At this point it was about 130°; but higher up it could be seen steaming, notwithstanding the tropical heat of the day.

This stream does not appear to flow directly from the sulphur-springs above, but probably from some subterranean source connected with them. The channel leading down directly from the springs is quite dry, though it bears evidences of having been, comparatively recently, the theatre of similar exhalations. The rocks over the opposite side of this ravine are lofty, and crop out boldly, striking south-east, and dipping down to the north-east in the direction of the springs. At this spot they have a bleached appearance, visible from a distance, precisely similar to that exhibited at the active springs. They bear, however, at this present moment, no other sign of their past activity; but, on a near approach to them, a very perceptible odour of sulphuretted hydrogen is smelt, and the rocks themselves appear to have their surface disintegrated by the action of the steam.

A short distance above this spot we reach a *cul-de-sac* in the hills, bounded on the right by bold bare rocks, having the lithological characters of a coarse calcareous grit, and dipping about 15° to the north-east. This is the spot occupied by the present active sulphur-springs, and is of small extent, embracing not more than two acres of ground, whose desolation forms a very striking contrast to the verdure on nearly three sides of it. This spot is perfectly barren, and is filled up with low hillocks of friable rocks, loose stones, and débris, having the character of a moraine; it is interspersed at irregular intervals with shallow pits or depressions containing mud and sand, and sometimes foul muddy water. From cracks and fissures in these depressions arose clouds of steam; and yellow patches of sulphur were visible from a distance.

At the time of my visit, in the middle of June 1866, there were seven or eight springs in a more or less active condition, from which clouds of superheated steam arose, either by a small round hole or narrow fissure, or by several such apertures. The rushing steam produced a loud noise, like that accompanying the blowing off of steam from a boiler; and above the fissures was a quantity of sublimated sulphur, adhering to the rock in acicular crystals, forming, about the most active spring, a bright-yellow patch which was visible from a considerable distance. It was no easy matter to reach the sublimed sulphur; for, on a close approach to the spot, a jet of hot steam made it necessary to withdraw, and warned us that a nearer approach was dangerous. I managed however, with the aid of a stick, to procure some from the crevices, on and around which it was deposited. Most of the springs were dry; but one rose through muddy water, which bubbled up in a series of rapid explosions, carrying the boiling water, sand, and mud 5 or 6 feet high, and splashing it all around.

It is evident that the degree of activity of these springs is very variable, and that at the time of my visit they were in a comparatively quiescent state. The jets of steam were isolated, and a comparatively small portion of the two acres at which I estimated the area of grey barrenness was in an active condition. Numerous pits, which had evidently at some period sent forth their jets of steam, were perfectly quiet: and stones coated with sulphur scattered among them showed their occasional activity. Moreover the edge of the level, where it began to descend down the ravine before mentioned, was covered with a thick crust, which had evidently been at one time in a semifluid state, and had slowly flowed, a viscous mass, over the edge, and now had the appearance of dried asphalt. This was doubtless the remains of mud through which the sulphur rose, such as we saw in some comparatively small pools, but which at one time had been in sufficient quantity to rise above the general depression and run over the edge into the ravine.

The sulphur appeared in all cases to be deposited in a perfectly pure sublimed form; nor was there any smell to be detected in the active springs themselves. The steam is laden with the element in a dissolved condition, and deposits it in pure crystals upon any substance with which it comes in contact. The effects produced upon the calcareous rocks were in all cases due to the disintegrating and bleaching power of steam; and the smell of sulphuretted hydrogen was most perceptible in a spot where the rocks had been disintegrated, but where there was no sign of present activity.

It has been supposed that the locality is very fatal to animal life, from the presence of sulphurous vapours—that it is a sort of Avernus, destroying birds and insects which pass in its neighbourhood; but I cannot endorse this view. I myself observed birds and insects flying over it with ease and impunity, nor was any noxious smell perceptible. Any ill effects could be produced only by the direct action of the *steam*, with which the *sulphur* could have little or nothing to do; and if any corroboration of this were required, it need only be mentioned that the patch occupied by the sulphur-springs is immediately surrounded by the brightest verdure, and a stream of clear water runs along its edge and alone separates it from paddy-fields in the most green and healthy condition.

At the present time no attempt is made to obtain sulphur from this prolific source. Although it can be obtained at the rate of 45 cents per picul of 133 lbs. (about 2*s*. per cwt.), the Chinese government stupidly and obstinately forbid its being worked. Still sulphur has been largely obtained from these springs on the sly, or by means of a bribe, and it yet remains for European enterprise to open up so important and probably almost inexhaustible a source of this valuable material.

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11. *On the* Geology *of* Benghazi, Barbary; *and an* Account *of the* Subsidences *in its* Vicinity. By G. B. Stacey, Esq.

[Communicated by the President.]

The town of Benghazi is built on a sandy foundation with a superstratum of clay. It is protected from the sea by a reef of sandstone rocks, now only 2 or 3 feet above the level of the water.

Inside the reef, the water reaches nearly to the clay cliffs, on which, during the winter gales, it has a very destructive effect.

Fifty years since, according to the testimony of natives, horse-races were held inside the reef, where now the water is in some places 5 feet deep; and, according to a European inhabitant, only a small strip of water existed there twenty-five years ago.

On the reef, remains of buildings are to be seen under water; and at Juliana Point the sea has made a breach, forming an island of the point, between which and the mainland the water is very shallow.

Hamilton, in his 'Travels in North Africa,' mentions that the land has sunk, and supposes a sudden catastrophe; but, from the above and other evidence, I imagine that the land is sinking regularly, and comparatively quickly.

Small hills of sandstone exist to the north-east and south-east of the town, and are quarried for the stones of which the town is built.

The fundamental rock of the country is a Tertiary limestone, in which several interesting subsidences have occurred, some of which (the "Gardens of the Hesperides" of Beechey) are cultivated; others, more extensive, are filled with brackish water, and contain a large eel and another fish of small size.

The following is a brief description of a few of the lakes which I have examined.

"Howa Bugedah" is about one-third of a mile in circumference, W.S.W. slope to water; rocks perpendicular E.S.E. to S.W. Greatest height of sides about 30 feet. Depth of water round the edges 11 feet N., 10 feet S., 15 feet E., from 13 to 14 feet W.; small cave on the south-east side.

"Howa Mumlood," 150 yards to the eastward of the above, is about half a mile in circumference; N.E. slope to water; sides perpendicular N.E. to S.E., about 30 feet high; depth of water 6 feet N., 9 feet W. On the south-east the rocks are much rent and slipped towards the water, leaving small chasms.

"Howa Mingernat," about 200 yards further east, is about one mile in circumference. The sides have more of a slope inwards, and are much more weathered than the others. On the south-east side is a small bay, the water of which is milk-coloured, being probably shallow and charged with carbonate of lime. The rocks slope downwards on the N.N.E. side, where it joins by a shallow channel another lake, bearing the same name. Sides perpendicular, cracked, and fallen in on the E. and N.E. About a quarter of a mile in circumference.

"Howa Buhowsh," about 300 yards north-west of the latter, has an island in the middle, separated from the north-west side by only shallow water. On the south-east side the rocks are much split and detached. Small caves in the fissures.

In "Howa Mumlood" on the N.N.W. side, a thin layer of coarse sandstone contains angular pieces of a black foreign rock, small pieces of bone, and a flint with a polished under surface, appearing as if it had been ground to a point. These materials were apparently washed in through a fissure, as the layer is not continuous.

Besides the above, many smaller subsidences have occurred; in fact, the face of the country may be said to be dotted with them.

The causes of these subsidences may probably be explained by examining a series of caverns containing fresh water and called "the Lethe," of which the accompanying section may give a sufficiently correct idea.

Section of "the Lethe" Caverns.

The slope in this case leads by a low entrance into a cavern, which leads by a narrow passage into another, where a huge block projects from the water. This leads again into another cave by a low entrance, and this may lead to others; but the rocks were so near the water that I was unable to proceed further with the boat. Stalactites hang from the roof.

The caves are probably reservoirs of the rain-water which runs down the declivity in winter; this being out of the influence of the sun, but little evaporation would take place.

In the above case, we must suppose a cavern to have existed at x; the roof having fallen in has left a series of caverns exposed.

If we imagine this to have occurred on a larger scale, we have, I think, the true cause of the larger subsidences, all of which have, at one part or another, a slope to the water similar to the above.

The whole country must be cavernous; and the brackishness of the water of the lakes may be due to a connexion with the sea.

"Howa Bullowsh" may have been formed by two subsidences.

Of the fossils collected, I have only been able to identify *Echinodermata*, 3 sp., *Ostrea*, 2 sp., *Coral*, 2 sp., a *Pecten*, a *worm* in the form of a Helix, and, on the surface, *Cardium edule*.

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12. *Report on the* Existence *of a large* Coal-field *in the* Province *of* St. Catherine's, Brazil. By Edward Thornton, Esq.

[Communicated by the Rt. Hon. the Secretary of State for Foreign Affairs.]

The Tubaraõ basin is situated in the southern extremity of the province of Sta. Caterina, lat. 28½° S., long. 5½° to 6° W. of Rio de Janeiro, and 48° 14′ to 48° 44′ W. of Greenwich, distant about forty-five miles north-west of the seaport of Laguna, and intersected by the river Tubaraõ and its tributaries, which stream is navigated by small vessels for about twenty-five miles.

The existence of coal in this district has for some years been an established fact; and the Belgian traveller, Van de Lede, in 1842, visited and reported upon the small seams which were exposed to view on the route from Laguna to Lages; but from 1861 to 1863 a practical exploration was carried out by the Viscount Barbacena (who engaged Mr. James Johnson, an experienced Lancashire coal-viewer, and the engineers Messrs. Borell and Klap), which resulted in his purchase of a tract of land containing the best seams, and his acquisition of a concession of mineral rights in the valley of the Tubaraõ from the Imperial Government, dependent upon the formation of a railway and the opening of the mines.

The exploration, by driving several levels and sinking pits over an area of about twelve miles, proved the existence of a series of Coal-beds at nine different levels, underlying a sandstone formation, in almost horizontal strata of different qualities, and of thickness varying from 1½ to 10 feet, all more elevated than the waters of the adjacent streams.

The longest adit was driven 78 feet through coal, which proved similar to that exposed in two other outcrops three miles distant from each other, showing, under a solid roof of grey sandstone,—

	ft.	in.
Top Coal		8
Black Bass		3½
Coal		4
Strong Schist	1	7
Coal		1½

	ft.	in.
Dark Schist	0	8½
Main Coal-seam	8	0
Grey Schist full of vegetable impressions	1	4
Coal, very good	1	2
Warren earth		11

making 10 feet 3 inches of Coal of good quality, the main seam being extremely hard and, like Cannel Coal, igniting readily; it is also of great heat-producing capacity, but leaves more ash than the best English coals.

An analysis of samples from two seams, made by Professor Thomas Richardson in London, exhibited the following results:—

	Sample No. 1.	No. 2.
Fixed Carbon	37·67	35·42
Gaseous matter	18·33	21·10
Ash	44·00	43·48

The calorific power as follows:—

No. 1.	No. 2.
9·07	8·82.

These figures give the number of pounds of water which 1 lb. of coal can evaporate from the boiling-point. The best English steam-coals evaporate as much as 12·50 lbs.

To the immediate fruition of so valuable a property the present obstacle is the want of means of transport, which by survey has been ascertained to be obtainable by a tramway of thirty-seven miles from the centre of the Coal-field to a navigable part of the river Tubaraõ, where ships of 600 tons burden might take cargoes.

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13. *On the* Sources *of the* Materials *composing the* White Clays *of the* Lower Tertiaries. By George Maw, Esq., F.G.S., F.L.S., &c.

In examining some light-coloured deposits that occur between the Boulder-clay drift and the Carboniferous Limestone of North Wales, an account of which has recently appeared in the Geological Magazine*, I was led to the conclusion that some of the beds of very white and pure clays occurring in "pockets" in the limestone could not have been derived from the mere mechanical degradation of any previously existing materials; and an analysis showed that they consist of silica and alumina in nearly similar proportions to the silica and alumina in the limestone, and, therefore, that they were probably left behind after its calcareous matter had been removed by watery dissolution.

The Tertiary formations of Hampshire, Dorsetshire, the Isle of Wight and Devonshire, contain vast deposits of similar white clays; and I beg to lay before the Society a few facts bearing on the probability of their having had an analogous origin by the dissolution of the calcareous portion of the chalk.

* Vol. iv. pp. 241 and 299.

The white clays of North Wales are contained in pockets in the limestone, and could have had no other origin than by the gradual dissolution of the latter, the cavities being complete *culs de sac* to which a mere mechanical abrading power could gain no approach; and the fact that vast quantities of redeposited lime, as tufa, occur in the neighbourhood of the pockets proves an extensive removal of the limestone by watery dissolution. That a similar process has been going on with the chalk (distinct from the mere mechanical effects of rain-wash) is a fact that all geological observers have been made familiar with, both from the surface of the chalk being pitted with sand-galls and sand-pipes, and the frequent occurrence of tufa in the chalk districts; such deposits, however, represent but a very small proportion of the carbonate of lime that has been removed by solution, as the greater part would be carried to the sea before it could be redeposited; and, as has been shown by Mr. Sorby, lime in solution can be absorbed and redeposited into the substance of the chalk itself.

All chalk contains both silica and alumina, which could not be removed in solution; and I beg to submit the following analyses of chalk and white Tertiary clays, in proof that the clays may have been composed from the insoluble matter in the chalk.

Many of the Tertiary white clays of Devonshire and Dorsetshire are almost chemically pure silicate of alumina, or impalpable silica; and it seems impossible to account for their accumulation, almost entirely free from foreign admixture, as the result of the mere mechanical degradation of previously existing beds.

However effective the separating-power of water may be in sorting and dividing coarse from fine matter, its mechanical operation could not isolate silicate of alumina from other materials of similar specific gravity.

Another point to be noticed is the peculiarly fine state of subdivision of the white Tertiary clays, an impalpable condition which distinguishes them from nearly all other argillaceous deposits.

Many of the Coal-measure clays are extremely fine and pure; but their state of subdivision (for they invariably contain some proportion of coarse particles) clearly indicates a detrital origin. The bulk of the matter composing the white Tertiary clays, however, is quite impalpable, though sandy particles may be occasionally associated with them.

In testing the state of division of the Bovey Tracey and Wareham clays, I found that, after mixing them with water to the consistency of cream, and passing them through fine silk lawn, containing 10,000 perforations to the square inch, no appreciable quantity of coarse matter remained behind from most of the examples, not even to the weight of a grain out of several pounds of clay. I can state, from the result of a number of experiments on clays and marls of various ages and formations, that such a state of subdivision is peculiar to these Tertiary clays.

Mr. Sorby has demonstrated that from 90 to 95 per cent. of the mass of the chalk consists of the cases of Foraminifera and comminuted shells; and I would submit whether (if the Tertiary clays have been derived from the chalk) the state of impalpable subdivision of the silica and alumina may not result from their having been wrapped up in organic association with the carbonate of lime composing these shells.

A comparison between the following analyses of chalk indiscriminately collected from various sources, and the composition of the white Tertiary clays of Devon and Dorset, will, I think, strongly support the probability of the derivation of the clays from the chalk.

	a.	*b.*
Finely divided silica soluble in caustic potash	0·26	16·710
Insoluble siliceous matter (fine clay)	...	6·090
Oxides of iron and alumina	2·86	0·780
Lime	52·33	40·757
Magnesia	0·31	0·825
Potash and soda	Traces.	Traces.
Phosphoric acid	Traces.	0·242
Sulphuric acid	Traces.	1·546
Carbonic acid and loss	44·24	33·050
	100·00	100·000

a. Analysis of Chalk from Gloucestershire, by Dr. Voelcker.
b. Analysis of Chalk-marl or "Malm" from Wiltshire, by Dr. Voelcker.

The following analyses are taken from the article by Prof. Thomas Way and Mr. J. M. Payne "On the Chemical and Agricultural Characters of the Chalk Formation," published in the 12th volume of the Journal of the Royal Agricultural Society of England, 1851.

	c.		*d.*	
Soluble in dilute acids:—				
Silicic acid (silica)	2·16		2·11	
Carbonic acid	29·96		36·73	
Sulphuric acid	0·21		0·06	
Phosphoric acid	0·21		0·05	
Chlorine	0·08		0·04	
Lime	41·52		49·16	
Magnesia	0·30		1·18	
Potash	0·26		0·11	
Soda	1·64		1·36	
Protoxide and peroxide of iron	2·20		1·74	
Alumina	0·11	78·65	0·20	92·74
Insoluble in acids:—				
Lime	1·71		0·22	
Magnesia	Trace.		Trace.	
Potash	0·32		0·15	
Soda	0·07		0·05	
Alumina and a little oxide of iron	2·57		1·42	
Silicic acid and sand	16·68	21·35	5·42	7·26
		100·00		100·00

c. Analysis of the Grey Marl or "Malm" (No. 7) by Prof. Way.
d. Analysis of Chalk-marl (No. 8) by Prof. Way.

	e.	*f.*	*g.*	*h.*
Clay and sand insoluble in acids	2·04	0·66*	1·46*	0·87*
Silicic acid soluble in acids	A trace.			
Carbonic acid	42·14	42·98	41·48	42·57
Sulphuric acid	0·31	A trace.		0·09
Phosphoric acid	0·07	0·08	0·04	0·08
Chlorine	—	—	—	0·08
Lime	54·37	55·24	55·72	55·18
Magnesia	0·25	0·10	0·06	0·30
Potash	0·08	0·06	0·17	0·22
Soda	0·19	0·14	0·02	0·21
Oxide of iron and alumina	0·55	0·74	1·05	0·40
	100·00	100·00	100·00	100·00

e. Analysis of Lower Chalk (No. 9), by Prof. Way.
f. Analysis of lower portion of Chalk with Flints, North Hants (No. 10), by Prof. Way.
g. Analysis of the Upper (soft, white, or free) Chalk, Odiham, North Hants (No. 11), by Prof. Way.
h. Second Analysis of the Upper (soft, white, or free) Chalk, Odiham, North Hants (No. 12), about half a mile north of where (*g*) was obtained, by Prof. Way.

The seven following analyses of white clays from the Tertiary beds of Devon and Dorset are given for comparison with the insoluble constituents of the chalks and chalk-marls which would be left after the removal of the carbonate of lime and other more or ess soluble matter by watery dissolution.

	i.	
Soluble in hydrochloric acid:—		
Moisture and water of combination	9·09	
Oxide of iron	0·50	
Alumina	18·05	
Lime	0·18	
Magnesia	0·14	27·96
Insoluble in hydrochloric acid:—		
Alumina	18·87	
Lime	0·25	
Magnesia	0·18	
Silica	51·88	
Alkalies and loss	0·86	72·04
		100·00

i. Analysis of White Pipe-clay from Newton Abbot, Bovey Tracey Lignite-deposit, by Dr. Voelcker.

For the following analyses I am indebted to Mr. Charles D. Blake, of Newton Abbot:—

	j.	*k.*	*l.*	*m.*
Silica	67·5	47·0	60·0	63·0
Alumina	29·0	48·0	34·0	32·0
Oxide of iron	1·0	1·5	2·5	3·0
Magnesia	1·5	2·0	—	1·0
Potash	—	—	2·0	—
Water and waste	1·0	1·5	1·5	1·0
	100·0	100·0	100·0	100·0

j. Analysis of "China Ball Clay," Bovey Tracey Lignite-deposit, from the clay-works of Messrs. Watts, Blake, Bearne & Co. of Newton Abbot.

* Sand and siliceous matter.

k. Analysis of "Blue Clay," Bovey Tracey Lignite-deposit, from the clay-works of Messrs. Watts, Blake, Bearne & Co., Newton Abbot.
l. Analysis of "Blue Clay," Dorsetshire, Lower Bagshot.
m. Analysis of "Brown Clay," Dorsetshire, Lower Bagshot.

The following are taken from the Catalogue of Rock Specimens in the Museum of Practical Geology (3rd edit. p. 167):—

	n.	*o.*
Silica	65·49	72·23
Alumina	21·28	23·25
Oxides of iron	1·26	2·54
Alkalies and alkaline earths	7·25	1·78
Sulphate of lime	4·72	
Loss	—	0·20
	100·00	100·00

n. Analysis of "White Pipe-clay" (Lower Bagshot), Branksea Island, Dorsetshire, by Prof. Way.
o. Analysis of "Black Clay" (Lower Bagshot), Branksea Island, Dorsetshire, by Prof. Way.

Mr. Charles D. Blake, of Newton Abbot, referring to the clays of the Bovey Tracey lignite-deposit, says:—"Speaking generally, I may state that our mines produce clays containing silica and alumina in every proportion, between 95 per cent. of silica (maximum) down to 50 per cent. of silica (minimum), and from 50 per cent. of alumina (maximum), down to 4 per cent. of alumina (minimum); also that some of our clays are nearly pure silicates of alumina, containing no free silica, whereas others contain as much as 70 per cent. of free silica.

These variations in the composition of both the white Tertiary clays, as well as of the chalks, would render a comparison between individual examples of little value; but by comparing, as follows, the average composition of a number of clays, with the average proportion of silica and alumina contained in the series of chalk examples before described, a fair means of comparison may be arrived at.

(*p*) *Average composition of clays i, j, k, l, m, n, and o*:—

Silica	61·01
Alumina	32·06
Oxide of iron	1·76
Magnesia	0·76
Lime, sulphuric acid, alkalies, loss, water, &c.	4·41
	100·00

Let us now see how far this composition agrees with that of the insoluble residue that would remain after the carbonate of lime and other soluble constituents of the chalk have been deducted as removable by water charged with carbonic acid. Nearly the whole of the silica and alumina, the peroxide of iron, and part of the magnesia would remain behind, and a portion of the magnesia would be removed with the carbonate of lime: as the soluble and insoluble forms of the iron and magnesia are not distinguished in the analyses, the whole of them are included in the following average composition of the insoluble matter in the chalk.

The whole of the eight analyses (namely, five of chalk and three of chalk-marl) give the following result:—

(*q*)	Alumina and iron	21·13
	Magnesia	4·63
	Silica	74·24
		100·00

and taking the five specimens of chalk by themselves, omitting the three chalk-marls,

(*r*)	Alumina and iron	53·75
	Magnesia	8·95
	Silica	37·30
		100·00

As the iron and alumina are not given separately in all the analyses, it has been necessary to state them together in these averages; but it must be borne in mind that a part of the iron and magnesia must be deducted (as being soluble in carbonic-acid water) in comparing them with the composition of the clays; when this is done it will be found that there is a remarkable resemblance. The average of the five chalks and three chalk-marls gives somewhat more silica than the average of the clays, and the five chalks taken separately somewhat less.

It must be observed that the chalk-marls contain a great proportion of silica, which affects the general average rather disproportionately, as the three examples of chalk-marls to the five of chalk would be greater than the actual mass of the marl in comparison with the actual mass of the chalk. The whole series of eight analyses averaged with the analyses of the five chalks taken separately (which would represent the marl in proportion to the chalk as 3 to 10) would be a fairer comparison. This mode of estimating gives—

(*s*)	Iron and alumina	37·44
	Magnesia	6·79
	Silica	55·77
		100·00

which, after deducting a portion of the iron and magnesia as soluble, gives a result closely corresponding with the average composition of the clays (*p*)—namely, in round numbers, 60 per cent. of silica, 30 per cent. of alumina, with a little iron, magnesia, &c. When it is considered how extremely the individual examples of both clays and chalks vary, so close a correspondence, on an average of a small number indiscriminately selected, is remarkable.

The supposed Derivation of the White Tertiary Clays from Granite.—Messrs. Pengelly and Heer, at p. 9 of their Memoir "On the Lignite-formation of Bovey Tracey," published in the Philosophical Transactions, make reference to the probable derivation of the deposit from the degradation of the Dartmoor granite. This inference seems to be due more to the geographical proximity of the granite to the clays of the Lignite-formation than to any more certain evidence.

The present areal outline of the deposit, and the surface-contour of the country, may perhaps give the Lignite-formation a more local aspect than it really possesses; and the occurrence of beds of similar physical character and age, far removed from the source of granitic materials, would seem to throw doubt on the suggested local origin from the granite of Dartmoor.

Furthermore the present geographical limits of the deposit may have scarcely any relation to its original extension. It is intersected by considerable faults; and the beds are occasionally disposed at high angles, which have no relation to the present surface-contour; and it seems probable that they may be but a remnant of the original formation, which has been protected from denudation in the Bovey Valley.

At the time of the deposition of the white Tertiary clays the chalk must have more completely covered the older formations than at present, and shrouded them over from being sources of supply for the Tertiary deposits; and the geographical distribution of the white Tertiary clays, which are either superimposed on, or in close proximity to the chalk, suggests a derivation from it rather than from the granitic rocks; indeed nothing resembling the Tertiary clays in physical aspect occurs far removed from the chalk, except the white clays before referred to, forming isolated deposits on the Mountain-limestone; and these appear to be the result of local subaërial dissolution analogous to the process suggested for the derivation of the white Tertiary clays from the chalk.

Another point to be noticed is, that Kaolin (the result of the decomposition of felspar) is perfectly implastic, a feature opposed to the character of the white Tertiary clays, the chemical composition of which favours a derivation from the chalk rather than from the decomposition of the felspar of granite; and, furthermore, felspar would not provide the proportion of alumina to silica found in the clays*.

* The inference that might be drawn from this must, however, be received with some caution, as Kaolin, which has certainly been derived from felspathic rocks, almost invariably contains a larger proportion of alumina to silica than that existing in the felspar of the parent mineral. The loss of a part of the silica seems difficult to account for, as, on the decomposition of the felspar, both the silica and alumina would be expected to remain associated in a state of impalpable subdivision not capable of *mechanical* separation. It may, however, be explained on one of the two following hypotheses. (1) The silica may have been partly segregated into crystalline concretions, and removed in the separation of the granitic quartz from the fine Kaolin; or, which seems to be more probable, (2) it may have entered into a soluble combination with the alkali of the felspar, and in this condition have been washed out, leaving the alumina with a smaller proportion of silica than that associated with it as felspar.

In taking the average compositions of ten examples of felspar, I find that 66·2 per cent. consists of silica, 21 per cent. of alumina, and 12·8 of alkalies &c.; or, leaving out the alkalies, in 100 parts of the sum of the silica and alumina, 75·86 would be silica, and 24·14 alumina—in round numbers, 3 of silica to 1 of alumina. But in the plastic clays, taking 100 to represent the sum of the silica and alumina, 65·59 would be silica, and 34·41 alumina, or less than two parts of silica to one of alumina, a proportion that agrees very closely with that of the silica and alumina in the average composition of a number of examples of chalk.

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14. *On the* Structure *of the* Postglacial Deposits *of the* South-East *of* England*. By Searles V. Wood, Jun., Esq., F.G.S.

Some years ago I entered upon an examination of the Glacial and Postglacial deposits of the East of England, and began to map the general distribution of the beds upon the small Index Map of the Ordnance Survey (10 miles to the inch), and, simultaneously with that, during a regular geological survey, on the ordinary inch to the mile Ordnance sheets 1 and 2.

I was induced to select the latter sheets for this purpose, principally because they comprised that part of England where the most important members of the Glacial and Postglacial series approached nearest to each other, and therefore the part likely to throw the greatest light on their relative structure—and in some measure because my place of residence afforded facilities for the task.

This survey, when I had made some progress, led me to believe that the entire valley-system of the East of England originated in centres of arc-like or curvilinear disturbance, which immediately preceded the elevation of the bed of the sea from which was deposited the wide-spread deposit of Boulder-clay forming the latest of the Glacial beds of the South of England. My view is that, these disturbances having given an impress to the surface, the denudation accompanying and ensuing upon the elevation of the sea-bed, by wearing more deeply the impress thus imparted, made it more conspicuous in the parts where this denudation was most prolonged. I found also that the rectilinear upheaval along the Wealden line of disturbance appeared to have been a subsequent event to this curvilinear denudation, and that generally these rectilinear disturbances had occurred long after those which accompanied the first elevation of a part of the Glacial sea; so that, while a part of the valley-system was due solely to the action of the first of these agencies, the rest (and more especially the part of England lying south and south-west of London) had originated from the combined action of the two. I very briefly, and in some respects imperfectly, called atten-

* The portion of England to which these observations apply is that lying east of a line drawn from the south-western extremity of the Wash to the valley of the Severn, near Bristol, and thence south to the English Channel.

tion to this structure in a paper published in the Philosophical Magazine*.

The completion of this survey has not only confirmed me in this opinion, but has led also to some results bearing upon the geographical conditions under which the Thames gravel was accumulated, and upon those which succeeded its deposition. These results have removed from my mind much of the perplexity besetting the Postglacial structure of the portion of England embraced in this paper.

In order to place in an intelligible form the evidence upon which these results are founded, carefully prepared copies of both the small-scale examination mapping, and of the large-scale survey made on sheets 1 and 2 are necessary, as well as copious sections illustrative of both. These being beyond the scope of a communication to the Society, the only plan that has occurred to me by which the views at which I have arrived and the evidence upon which they are based could be recorded was to embody them in a manuscript memoir and essay, with maps of the surveys I had made, to offer it to the Library of the Geological Society, where it might be available for the examination of those who thought the subject worthy of an investigation, and to lay a brief epitome of the principal results before the Society. This course I have adopted.

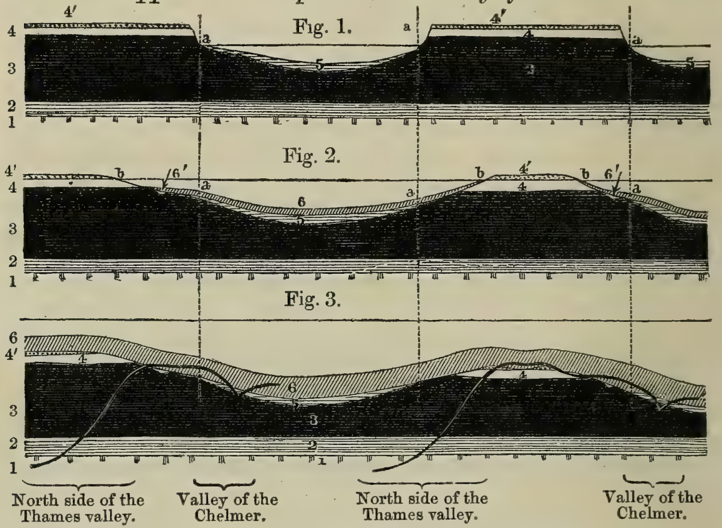
Sheet 1, thus coloured geologically, shows that the Boulder-clay of the Essex heights (which is the formation I have elsewhere had occasion to describe as the Upper Drift, but which it will be more convenient, by the way of contradistinction to the Postglacial series, to call the Upper Glacial) exhibits no trace whatever in this part of having formed their southern edge by original deposition, but the reverse. In all respects it presents the same pelagic features as it does along its northern margin, where it is cut off by denudation through central Lincolnshire, Huntingdon, Northampton, and Leicestershire—and along its south-western margin in Buckinghamshire, where it is similarly cut off by denudation. Even in the detached tracts occurring through South and Central Lincolnshire, and as far away as the small outliers north of Gainsborough, the material of the deposit is so identical with that on the brow of the Thames valley, that a basket of clay taken from either extremity of this area could not be distinguished, although these extremities are 140 miles apart. Therefore its abrupt termination on the northern brow of the Thames valley, with the Tertiary beds of this part *complete beneath it*, is to be ascribed to denudation only. The position of the Upper Glacial clay relatively to the Middle-drift formation (which, for a similar reason to that before given, it will be more distinctive to call the "Middle Glacial") is one of overlap; and this, as well as the position of both relatively to the valley of the Thames, will be best shown by the following diagrams illustrating the structure within Ordnance sheet No. 1.

Fig. 1 shows the period when the Middle Glacial sea had, after depositing its sediments, eaten its way by coast-erosion between either islands or promontories formed of the upper part of the Lon-

* 4th series, vol. xxvii. pp. 180–190.

don Clay capped by the Lower Bagshot sand and Bagshot pebble-beds, and when, in the indentations and inlets so eroded, a thickness considerably less than the mass of this formation further to the north, in Norfolk, Suffolk, and north Essex, had been accumulated.

Figs. 1–3.—*Diagram Sections showing the relations of the Middle and Upper Glacial deposits to the Valley of the Thames.*



1. Chalk.
2. Lower London Tertiaries.
3. London clay.
4. Lower Bagshot sand.
4′. Bagshot pebbles.
5. Middle Glacial beds.
6. Upper Glacial clay, occasional patches of shingly gravel. The horizontal lines indicate the sea-level of each successive stage.

Fig. 2 shows the commencement of the submergence which, with a total change in the sediment, introduced the Upper Glacial formation (or Boulder-clay). During this incipient submergence, and after the change of sediment had occurred, the coast-erosion carried the shore back from the points marked *a*, at which it stood at the close of the Middle Glacial formation, to the point marked *b*; the new deposit of Boulder-clay was spread over the interval, being underlain here and there only by a feeble bed of shingly gravel (6′), very distinguishable from the thick sands and gravels of the Middle Glacial period, and marked in figs. 2 and 3. Fig. 3 shows the stage when complete submergence had been effected, and a thickness of Upper Glacial clay spread over the entire area. As this deposit, where it has most escaped denudation, still retains a thickness of 160 feet, as in Cambridgeshire and Huntingdonshire, and presents so uniform a character of slow and steady accumulation by the outspread of water-borne clay-sediment, accompanied by the dropping of chalk-débris from ice, there is but little room to doubt its having spread over the counties of Surrey and Kent, as well as Essex, in great thickness, although, from its attenuation by denudation towards the north brow of the Thames valley, a much less thickness than 160 feet remains in that part.

Although these diagrams, in strictness, relate to the Glacial structure, it is essential to the realization of the Postglacial structure, which has resulted from the denudation commencing at the elevation of the Upper Glacial clay, that the position of this clay along the northern brow of the Thames valley should be clearly defined.

It is from this great deposit of Upper Glacial clay, the result of a wide-spread submergence, that the valley of the Thames is cut down at Grays to a depth (measured by the strata denuded in the process) of 600 feet. Owing to the upcast imparted to the beds during the denudation of this 600 feet, the brow occupied by the Glacial clay stands at a height of from 250 to 350 feet only above the Thames river. The manner in which the valley is, on its north side, cut down from the Glacial clay, is indicated by the strong lines in fig. 3; and actual sections drawn to the longitudinal scale of the Ordnance map will be found in the manuscript memoir before referred to, taken in various directions through Sheet 1, illustrative of all the features displayed by the above diagrams. While the northern side of the Thames is occupied by a slope which is cut down from the Glacial clay, in the manner shown by the strong lines, for a distance of 40 miles east of London (without reckoning sinuosities), we do not anywhere on the south side, or over the counties of Kent, Surrey, and Sussex*, encounter the faintest trace of the Glacial clay, although we have in that area all elevations from the sea-level up to 800 feet†.

The extensive deposit known as the Thames gravel occupies, but in a complex way, the trough thus cut down from the Glacial clay along that part of the Thames valley, east of London, which is west of Fobbing in Essex—a point 13 miles west of the Thames' mouth at Shoeburyness: and while in this part the gravel rests against the denuded surface represented by the strong lines of fig. 3, *on the north side of the river only*, that arm of it which stretches up the Lea valley for more than 15 miles has the Glacial clay *on both sides of it*, the trough containing the gravel being there cut in a simple way through the Glacial clay. The following diagram sections (figs. 4 and 5) illustrate the position of the Thames gravel in either case.

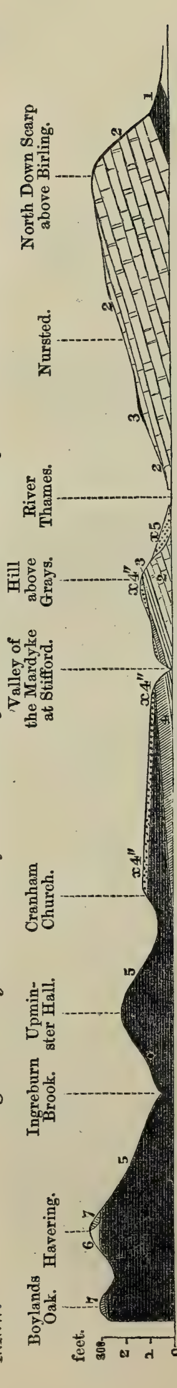
Numerous actual sections corroborative of these diagram sections throughout Sheet 1 will be found in the memoir referred to.

The position occupied by the Upper Glacial clay along the north side of the Thames appears to me due to the circumstance of its having formed the southern edge and emerged portion of the

* Nowhere over the south or south-east of England, indeed; but I have, in a paper in the Geological Magazine, called attention to the probability that a search over the highest Tertiary beds of Surrey and Hampshire might, perhaps, yield traces of it.

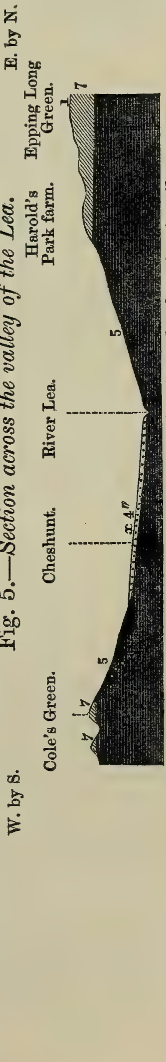
† It is important to observe that the depressions in which the Glacial beds are shown, in figs. 1, 2, and 3, to have been deposited have no relation to our present valleys, except that, where in a few instances (as in that of the Roding about Navestock) the present valleys happen to pass such a depression, they appear (but for a very short distance usually) to have the Glacial beds resting within their brows.

Fig. 4.—*Diagram Section from Havering across the Thames valley to the North Downs.*



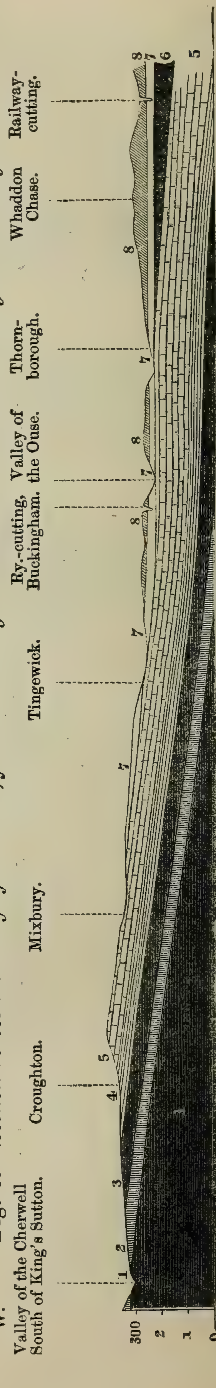
1. Gault and Upper Greensand. 2. Chalk. 3. Thanet sand. 4. Woolwich beds. 5. London clay. 6. Lower Bagshot sand. 7. Upper Glacial clay. *x* 4″. Thames gravel main sheet. *x* 5. Fluviatile or lower terrace brick-earth and gravel.—N.B. The levels north of the Thames are as near an approximation as the levels marked on the last issue of part of the Ordnance sheet permit. Those south of the Thames are only estimated. Length of section 18 miles.

Fig. 5.—*Section across the valley of the Lea.*



References the same as in fig. 4.—Length of section 7 miles.

Fig. 6.—*Section across the valley of the Ouse, from near King's Sutton to the Glacial beds beyond Buckingham.*



1. Lower Lias. 2. Middle Lias. 3. Upper Lias. 4. Stonesfield slate (of the Geological Survey). 5. Great Oolite (capped towards Buckingham by patches of the Cornbrash). 6. Oxford clay. 7. Middle Glacial beds. 8. Upper Glacial clay.—The altitudes are arrived at approximately from the few altitudes given at page 3 of the Memoir of the Geological Survey in explanation of Sheet 45.

Upper Glacial sea-bed, the detached portions, or outliers, of the deposit of that sea which occur on the west of the Lea valley having, at that time, formed islands detached from the mainland,—represented by the main mass of the upraised sea-bed. As the emergence and denudation proceeded, these islands became, with the outliers of the Bagshot Sand at Hampstead and Harrow (this sand, by reason of the structure shown in figs. 1–3, forming a common deposit with the Glacial clay for the first action of the denudation), the eminences of land up which stretched an inlet from the main sea that was afterwards occupied by the Thames gravel. We have, therefore, on the east of London, so far as this part of the structure extends, the simple case of an early Postglacial sea-margin, with the land breaking off into detached islands represented by outliers of the Glacial beds; and this feature becomes readily appreciable by the eye when the delineation of the Glacial beds in the Index Map accompanying the memoir is examined.

Precisely similar features are exhibited by the delineation of the south-western extremity of the Glacial beds in the counties of Buckingham and Northampton; and, in order to collate the features of this part with those exhibited in Essex, I annex a section drawn from the lip of the Glacial beds near Buckingham to the valley of the Cherwell* (fig. 6).

Here we have the denudation, which in this direction cuts off the Glacial beds, descending through successive deposits of Oolite and Lias, which rise up (like the Chalk and Lower Cretaceous beds in fig. 4) as the denudation descends through them. If a local geological map of this neighbourhood, given in the memoir, be examined, it is apparent that the denudation, which in fig. 6 is shown across the plateau-country, commenced in the Upper Glacial clay and descended westward along the valley of the Ouse to that of the Cherwell, forming both those valleys by the gradual westerly recession of the sea. The troughs through which the rivers Ouse and Cherwell run in these parts both expand, from the westerly direction of the denudation, in the opposite direction to the present course of those rivers, and are beautifully defined by the map-colours of the formations (from the Glacial beds to the Lower Lias) which have been exposed in their turn by the denudation in its descent. So entirely independent of the denudation of these troughs are the rivers which traverse them, that, in the case of the one now partly occupied by the upper waters of the Ouse, although its denudation is uniformly in a western direction, the present drainage through it runs in two contrary directions—one part east into the Ouse, and the other in the direction of the denudation. This latter part, however, by falling into the Cherwell eventually, like the rest of the drainage originating

* The Section of the valley at Buckingham, given in the Memoir of the Geological Survey in explanation of Sheet 45, appears to me to be quite at variance with the actual structure of it. So far from there being any evidence of the existence of an actual valley in this part prior to the Glacial period, the mode in which the valley of the Ouse is cut through the Glacial beds shows the valley to have been wholly formed since the deposition of the Glacial clay.

in the trough, runs to the sea in the opposite direction to that represented by the denudation of the trough in which it takes its rise. In this respect the Ouse and Cherwell resemble streams that, like the latter, are tributaries of the Thames, such as the Evenlode and the Darent; they also resemble the Tove, a tributary of the Ouse. All these rivers run through valleys whose denudation the Postglacial structure shows to have descended from the Glacial clay in the reverse direction to that followed by the courses of the streams themselves. The present levels of the different parts of these troughs have greatly changed, even *inter se*, since the time when the denudation formed them.

We have thus identical features exhibited by the earlier part of the Postglacial denudation along the southerly edge of the Glacial beds in Essex and along their south-westerly edge in Buckinghamshire.

Thus arises the presumption that the extensively denuded south and south-west portions of the area referred to in the head of this paper have acquired their present condition from a denudation which commenced with the elevation of the tracts now occupied by the Glacial beds, and which at the outset wholly destroyed them to the southward of their present limits, as well as extensively in a northerly direction.

As a general proposition, the denudation increases as we recede from the Glacial beds—whether it be in the southerly direction from the counties of Essex, Middlesex, Hertford, Bedford, Buckingham, and Northampton or in the northerly direction from the counties of Leicester, Northampton, Huntingdon, Cambridge and West Suffolk, and Norfolk, in which, with the exception of one or two small outliers, such as that near Grantham, and the central Lincolnshire tract, they are destroyed for a great distance towards York.

In the Index Map accompanying the memoir I have shaded in with great care and minuteness all the principal hill-contours from the sheets of the Ordnance Trigonometrical Survey, and marked upon it, in strong red lines, such of the arcs of denudation (to which I called attention in 1864) as affect the area now under consideration. These arcs may be seen to present a striking feature; and as they do not depend upon any authority less than that of the National Trigonometrical Survey from which they are reduced, they cannot be regarded as any fanciful emanation from me. All that I have done is to call attention to them, to place them in a form readily accessible to the eye, and to show the position occupied by the Glacial beds in reference to them. These arcs of denudation, by becoming more deeply scored out to the south and south-west, concur with the structure displayed by the Glacial beds to which I have been adverting, in indicating the augmentation of the Postglacial denudation in those directions. The arcs, which in all their repetitions preserve a remarkable concentricity, belong to two series—one having the centre a little east of Canterbury, and the other about Brookpoint in the Isle of Wight. Those of the first series in every outward repetition, except close to the centre in Kent, cut through the Glacial beds in some part of their sweep; and this the large-scale

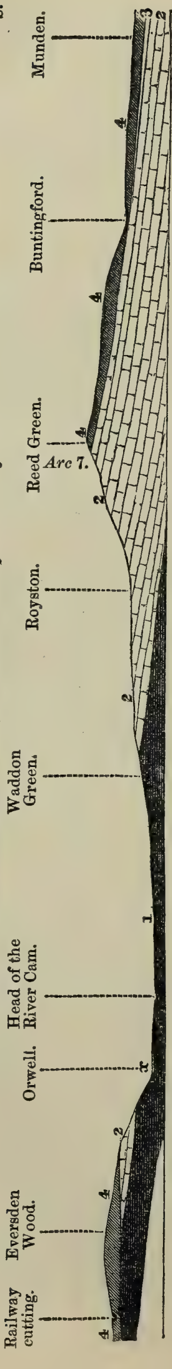
Survey-sheet, No. 1, by comprising parts of four out of the eight conspicuous arcs of the series, affords the means of minutely testing. The outermost (and consequently the largest), extending from Bath to Stamford, and taking in the western scarp of the Cotteswolds, only cuts through the Glacial beds near Market Harborough, the structure and delineation on the map of the Glacial beds south and west of that place showing their denudation in this direction. Those arcs which cut through the Glacial beds in Essex, and of which the large Survey-map affords easy means of testing, embrace the cross valleys indenting the northern scarp of the Weald, such as those through which the Medway and Darent flow in part of their courses, being the direction in which fig. 4 shows the denudation to increase from the lip of the Glacial beds in this part. It would be useless to attempt to describe these arcs further, as their delineation on the map must be seen and studied for their importance to be realized; but their structure, wherever they cut through the Glacial beds, shows them to have formed troughs occupied by arms of the Postglacial sea, which has deepened them by denudation. The general grouping of the Glacial beds in relation to them, and the south-westerly increment of denudation which those beds display, indicate, as it appears to me, that the progressive scarping of the arcs in this direction has been due to the prolongation of the denudation there.

Several sections, in illustration of the structure of these arcs in various parts, will be found in the memoir; but I will only trespass upon the Society with three—two of them illustrating the structure, in different parts, of the outermost arc but one of the Kentish series, which I select as being the most suitable to show the part played by denudation in their creation, and the third illustrating the structure of a part of one of the innermost arcs of the series (being one that traverses the surveyed Ordnance sheets accompanying the memoir).

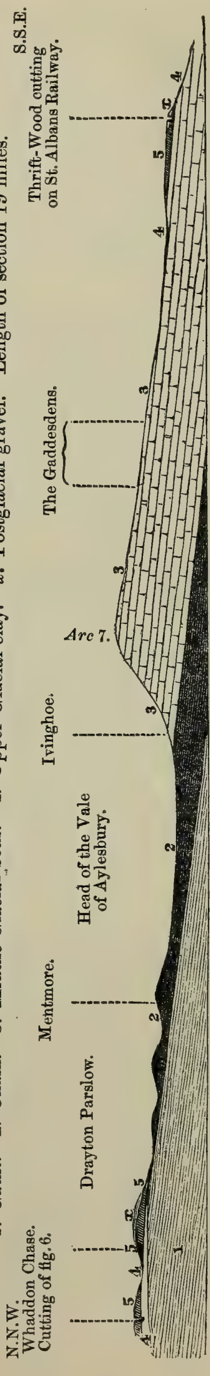
Fig. 7, which intersects the outermost but one of the Kentish series of arcs, does so at a part where the trough of denudation giving rise to the arc enters the body of the chalk, disconnecting itself from the outcrop of the Gault. It is evident that in this part, which is as well defined as any part of the arc, the structure giving rise to the arc-crest is one of denudation, and not in any way due to the outcrop of the base of the chalk; and it is equally evident that the scarp of the chalk which occurs above Royston is not due to atmospheric denudation, but to the erosion of a trough several miles wide, which is cut down *on both sides* from the Chalk and Upper Glacial clay into the Gault.

Fig. 8, on the other hand, exhibits the arc formed by the scarp of the chalk where no portion of that formation extends to the opposite side of the trough. Although the general lie of the beds seems antagonistic to an assumption that the elevation of the arc-crest is due to the Postglacial disturbances yet it is evident that there has been in this part an excessive denudation, first over the crest of the arc, and subsequently in the trough, which latter denudation has excavated the great vale of Aylesbury. Probably at the incidence of the Upper Glacial clay by general submergence the

Figs. 7 and 8.—*Sections illustrating the structure of Arc 7 of the Kentish series.*

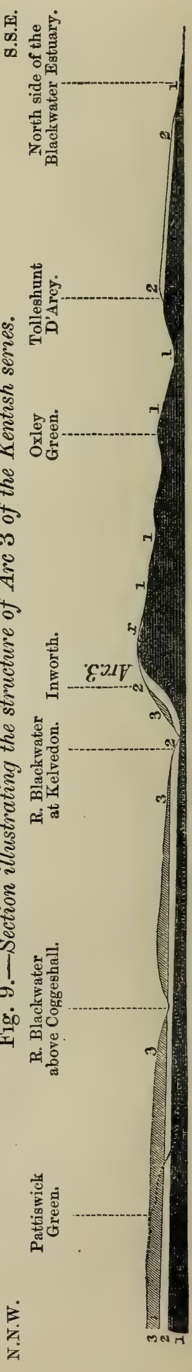


1. Gault. 2. Chalk. 3. Middle Glacial beds. 4. Upper Glacial clay. *x*. Postglacial gravel. Length of section 19 miles.



1. Various members of the Oolitic series. 2. Gault. 3. Chalk. 4. Middle Glacial beds. 5. Upper Glacial clay. *x*. Postglacial gravel. Length of section 27 miles.

Fig. 9.—*Section illustrating the structure of Arc 3 of the Kentish series.*



1. London clay 2. Middle Glacial beds. 3. Upper Glacial clay. *x*. (Probably) Post-glacial gravel. Length of section 12 miles.

edge of the chalk in this part formed lofty ground, which after submergence received this deposit on its summit at a higher level than the parts forming the extremities of the section, which at the outset of the Postglacial denudation were swept away; the denudation eroding the vale of Aylesbury succeeded to this.

The section, fig. 9, displays a structure that is constant along arc 3 for about six miles on the north side of the Chelmer, and again for three or four miles on the south side of that river, for which distances the Glacial clay lying on the western slope of the arc forms a narrow strip extending along the flank of the arc-crest. Were it not for this feature and the fact that, as the arc declines in altitude, the Middle Glacial series becomes continuous over the crest (the denudation of the crest being proportional to the extent of its elevation), I should be disposed to doubt that the hill was formed principally from the rolling character of the movements giving rise to the surface-impress, from which the arc-structure has arisen, as I conceive, by the denudation ensuing upon it.

The part traversed by this section, being a portion of the general tract of Glacial beds whose southern lip stretches along the heights of the north side of the Thames, is one which, having emerged at the earliest part of the Postglacial period, has been subjected to no denudation save that which it underwent in its elevation. The district traversed by the sections, figs. 7 & 8, on the other hand, not only underwent this denudation, but was, in the part formed by the vale of Aylesbury, subjected, as before observed, to a further denudation produced by the arm of the Postglacial sea which stretched up, and wore out, that vale. Now, if we suppose the part traversed by the next section, fig. 9, to have been subjected to this subsequent denudation, so as to have scored out the trough in the mode indicated by the dotted line, we seem to get a section identical in structure with fig. 8. I infer, in the cases of all these arcs, that there was an inequality of level at the commencement of the Glacial-clay period, but that this was exaggerated by the disturbances causing the arc-structure, and the line of it deeply defined by the Postglacial denudation. One thing seems clear to me from the general structure of the area—namely, that the arc-like or curvilinear form taken by the scarp is wholly due to the direction taken by the Postglacial denudation induced, as it seems, by the disturbances that put an end to the deposition of the Upper Glacial clay.

If the Index Map of the memoir be examined, it will be seen that the deeply denuded troughs intersected by Sections 7 and 8 are divided from each other by an isthmus at Hitchin, where the two principal tracts of Glacial beds approach close to each other, and where, by the cessation of the denudation, it is to be inferred that these two tracts were at a very early part of the Postglacial period joined to each other. Now both the trough intersected by Section 7, and that intersected by Section 8, rapidly expand as they recede from the Hitchin isthmus, each opening out into the main Postglacial sea—the former into that indicated by the extensively denuded tract before mentioned as extending from the northern lip of the Glacial beds through the counties of Leicester, Huntingdon, Cambridge, and west Suffolk and Norfolk, towards Yorkshire, and the latter into the Postglacial sea indicated by the denuded country stretching over the south of England.

Although the denudation of these troughs evidently succeeded that of the arc-crests, which took place during the first emergence of the tracts, it nevertheless appears to have occupied only the early part of the Postglacial period; for it is into the sea-margin formed by the arc shown in fig. 8, and at a point about 30 miles south-west of the place where this section intersects it, that the lower terrace or fluviatile portion of the great Postglacial deposit of Thames gravel had, as I regard the case, its western outlet; and the structure of this gravel indicates that it belongs to an early part of the Postglacial period.

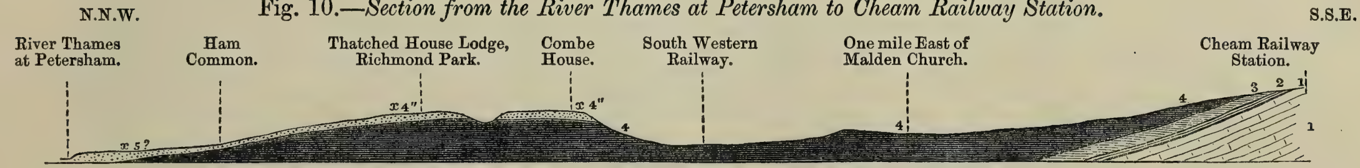
The position of this gravel (the most extensive of the Postglacial series) and that of its allied formations, the East Essex gravel and the gravel of the Canterbury heights, is difficult of explanation without the assistance of the map accompanying this memoir. The three gravels, I contend, are the deposits of a series of channels penetrating the southern margin of so much of the emerged land of the period as lay to the east of the arm of the Postglacial sea, which is represented by the trough shown in fig. 8. The largest of these channels, that occupied by the Thames gravel, opened out into the western sea around Reading *, between which place and Maidenhead it followed the narrow and tortuous course now occupied by the Thames river. From Maidenhead it expanded until it opened southwards to the sea then occupying the Chalk country of Surrey, at the part now represented by its high terrace of gravel on Richmond and Wimbledon hills, converting the Tertiary beds of northern Hampshire into an island. From Wimbledon the channel was again continued by London towards Gravesend, sending in its way a large arm up the Lea valley. East of Gravesend it was barred in from the East Essex gravel by a ridge of lofty land, now cut through by the Thames river, but which, prior to the introduction of that river, was continuous along the east of Essex and north of Kent as far as Rochester. Between Dartford Heath and this dividing ridge it again opened out to the sea occupying the Chalk country. The next channel, that occupied by the East Essex gravel, being divided in this way from the other, is marked by that gravel which ranges along the east side of Essex for upwards of 20 miles, crosses the Thames mouth at right angles, and occupies the western slope of the Medway valley between the Nore and Rochester, opening out to the sea of the Chalk country about the latter place. This sheet is cut through at right angles by the mouths of the rivers Thames, Crouch, and Blackwater. At each place where the Thames gravel opens

* The sea to which the main sheet of the Thames gravel opened seems to have been the latest part of that which denuded the arc-crest,—the sea denuding the trough being that into which the lower terrace of the Thames gravel (produced by the elevation and cutting down of the main gravel sheet) appears to have been discharged west of Reading.

out to the sea, represented by the Chalk country, and also where the East Essex gravel opens to it, the gravel is denuded from a lofty brow in the direction of the Chalk country, as I will show. One other channel (which not improbably may have been connected with that of the East Essex gravel through the area between Kent and Essex now occupied by the North Sea) occupied the London Clay and Lower Tertiary country lying north and east of Canterbury, opening to the sea over the Chalk country of Kent about this place. Of the deposits of these three channels, the Western or Thames channel, and the Eastern or Canterbury channel, have been the most broken up and denuded; the intermediate channel of the East Essex gravel has been but little disturbed except at its embouchure, where the gravel is cut down some 150 feet to the Chalk country. It would occupy too much space to show in any detail the mode in which this has taken place; but that of the break-up of the Thames sheet in the channel-mouth, between Dartford Heath and the East Essex dividing ridge, will be found to be copiously illustrated by sections in the memoir; and sections illustrative of the break-up and terrace-creation in the other channel-openings are given there also. I will therefore confine myself here to three simple sections in illustration of the structure at the channel-openings.

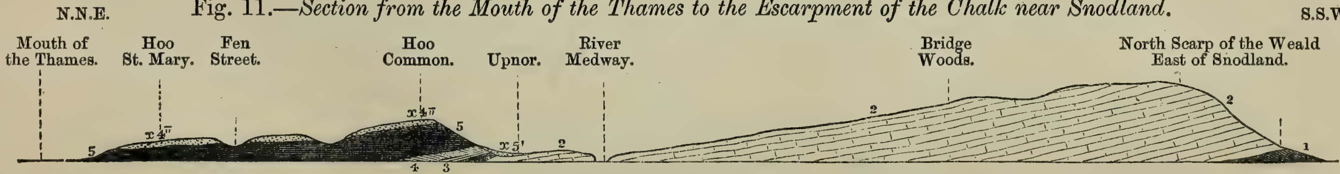
The first section, fig. 10, gives the denudation at the opening of the Thames gravel channel around Richmond and Wimbledon. In this section we have the gravel very sharply denuded towards the Chalk country, the Tertiary beds and the Chalk towards the Wealden area coming up with a considerable dip, which increases as the Chalk country is approached. This dip (of course immensely exaggerated in the compass of the section) indicates the sharp nature of the Wealden upthrow, which succeeded the denudation of the gravel, but which was preceded, as I have to show, by an intermediate period occupied by the formation, in the broken-up beds of the channel-troughs, of a series of fluviatile openings in which accumulated the gravels and brick-earths of the lower terraces, grouped in the surveyed sheets under the symbols $x5$ and $x\ 5'$. By varying the line of section a little, and carrying it from Wimbledon Hill to Croydon, we should see the denuded Tertiary beds that lie below the brow of gravel exactly in the same position as in fig. 10, but overspread by the flat sheet of the Wandle gravel, which, as shown on the Geological Survey Sheet No. 8, expands from the Thames towards the Chalk country like a broad river, terminating abruptly, as the chalk comes up, with a square end against that formation. This represents one of the fluviatile outlets into which the channel-openings shrank as the sea receded towards the Weald. In the neighbourhood of the section, however, we find no trace of any other gravel than that on the brow, and may therefore infer that the denudation exhibited by it represents simply the recession of the sea towards the Weald. This shows the London clay denuded with the gravel, consistently with the position assumed at the commencement of this paper—namely, that the upthrow and denudation of the Weald followed the deposition of the Thames gravel, which had

Fig. 10.—*Section from the River Thames at Petersham to Cheam Railway Station.*



1. Chalk. 2. Thanet sand. 3. Woolwich and Reading beds. 4. London clay. *x* 4″. Thames gravel (inlet sheet). *x* 5?. Gravel, the presumed equivalent of that shown under this symbol in Sheet 1, where that marked *x* 4″ forms a marked terrace above it. N.B. A patch of Lower Bagshot sand is supposed, by the Geological Survey, to exist under the gravel at the Thatched House Lodge. Length of section 8 miles.

Fig. 11.—*Section from the Mouth of the Thames to the Escarpment of the Chalk near Snodland.*



1. Gault. 2. Chalk. 3. Thanet sand. 4. Woolwich beds. 5. London clay. *x* 4‴. East Essex gravel. *x* 5′. Brick-earth. Length of section 12 miles.

followed the denudation of the Glacial clay which, with the London clay beneath it, had extended over the Wealden area.

The section previously given (fig. 5) illustrative of the position of the Glacial clay along the north side of the Thames may be made to serve, imperfectly, to show the denudation and upcast which followed the recession of the sea from this part towards the Weald, along the opening lying between Dartford Heath and the East Essex dividing ridge, as well as the formation of the fluviatile outlets (now represented by the Grays and Darent and Cray valley-deposits) that followed its recession. This embouchure of the channel is conspicuously marked by the denudation of the Tertiary beds in that part, and by the position which the remnants of the gravel occupy in reference to them, an arm of the chalk running up in this part into the centre of the eastern Thames area. It is only necessary to place my surveyed sheet, No. 1, in its order next to Sheet 6, already surveyed and published by the Geological Survey, to render this readily perceptible to the eye, an island, represented by Swanscomb Hill (round the flanks of which, at an elevation of about 100 feet, the gravel now clings, as it were), having occupied the centre of this embouchure.

The next section, fig. 11, gives the denudation at the embouchure of the East Essex channel by Rochester, and shows that gravel cut down from a lofty brow to the Chalk by the recession of the sea towards the Weald,—the London clay being cut off with it in the same way as it is with the Thames gravel in fig. 10, and consistently with the age claimed for this gravel—of priority to the Wealden upthrow and denudation.

The gravel of the Canterbury heights is denuded in a twofold direction—one towards the Chalk country of the Wealden scarp, and the other towards the Chalk country of the Isle of Thanet. The former presents no feature essentially different from that exhibited by figs. 10 and 11; and the denudation in the latter direction is well displayed in the coast-section east of Herne Bay, and may be seen in the section of the Lower Tertiary beds of that district given in Mr. Prestwich's Memoir on the Thanet Sands in the 8th volume of the Quarterly Journal of the Society (p. 264).

A section through the dividing ridge separating the Thames gravel trough from that of East Essex having been given by me in a communication to the Geological Magazine *, I do not think it necessary to give it here. The erosion of the valleys of the Thames mouth and Crouch river through this ridge, having taken place at a very recent date, is connected with another peculiar structure to which I have presently to allude; but first, as to the break-up of the Thames gravel in the body of its trough, and the formation of the fluviatile (or x 5) portion of it.

The valleys which are cut through the Thames gravel, and which have arisen from the denudation accompanying the rectilinear disturbances shattering that gravel and elevating the Chalk country,

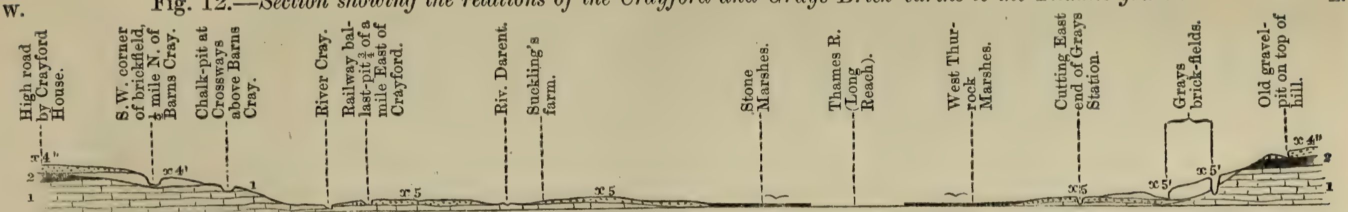
* Vol. iii. p. 348. In that section a small outlier of Bagshot Sand should have been shown on the top of Round Hill.

exhibit no connexion with the curvilinear or arc-disturbances before referred to, but associate themselves in more than one way with those upcasts of similar character which have accompanied the elevation of other Chalk districts, such as the Hog's Back and Portsdown Hill. There is, however, evidence, in the position occupied by the Thames gravel on the south of the Thames, that a line of rectilinear disturbance, although long subsequent to the formation of the original valleys in this part by the arc-disturbances and by denudation, preceded the introduction of that gravel and brought up the Lower Tertiary beds between Woolwich and Erith along a straight east-and-west line, against which the gravel-waters on their south shore rested. It seems to have been the oscillations to which these preliminary disturbances gave rise that, in the Thames-gravel channel at least, introduced the waters from which that formation was deposited, because we have evidence, in the presence of a fluviatile formation *beneath* the Thames gravel, much more limited in extent than the latter, that the trough had in this part been evacuated by the sea, and then reoccupied by it during a partial submergence which introduced the gravel-waters far above the northern edge of the previous fluviatile deposit. The underlying fluviatile deposit is a brick-earth, which has in some parts, with the gravel, been elevated into high terraces, and in other parts left, also with the gravel, but little disturbed. As Mr. Dawkins has asserted, in his late paper upon the Brick-earths of the Thames valley, that there is no distinction between this deposit and that of Grays, which belongs to the newer fluviatile series, or that occupying a lower terrace than the Thames gravel and formed after its break-up, I subjoin a section in proof of the contrary, the point involving the important question whether or not much of the Thames gravel was introduced over a Postglacial land-surface. On the south side of Dartford Heath this oldest brick-earth (x 4′) may be seen coming out inland from under the gravel, the two in superposition being exposed in the subway of Hulsewood House, while by Hill House, near the 101-feet altitude-mark on the west of Dartford, and upwards of 80 feet above the Cray and Darent gravels, I saw 12 feet of the deposit pierced to the chalk.

This oldest brick-earth (x 4′), by reason of its great and unequal thickness, descends at Erith nearly to the river, towards which it occupies the same apparent position as the Grays bed; but along the line of the section fig. 12 (as well as along other lines of section given in the memoir) it is cut down by a very sharp denudation, some 50 or 60 feet, to the gravels of the Cray and Darent and of the lower terrace, which have an extensive spread on either side of Grays, *and underlie the lower portion of the brick-earth of that place,* being worked in the fields after the brick-earth has been removed.

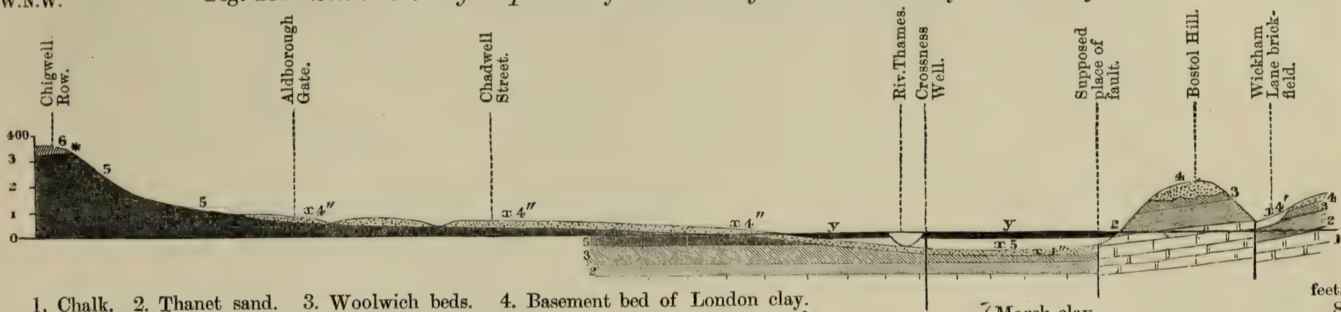
The organic remains yielded by the two brick-earths being apparently that upon which Mr. Dawkins has based his opinion (for he has given no *structural* sections in support of it), may not differ; but the physical evidence indicates their separation by an interval adequate to the deposition of a slowly formed gravel of far-travelled material 20 feet thick, and of a brick-earth (from 6 to 8 feet thick)

Fig. 12.—*Section showing the relations of the Crayford and Grays Brick-earths to the Thames gravel.*



1. Chalk. 2. Thanet sand. x 4′. Brick-earth beneath the gravel (x 4″). x 4″. Thames gravel of the main or inlet sheet. x 5. Gravel of the Cray and Darent valleys. x 5′. Grays brick-earth. (⁓⁓) Marsh-clay. The gravel (x 5) has been excavated below the brick-earth (x 5′) in part of the lower of the two brick-fields at Grays.

Fig. 13.—*Section showing the position of the Thames gravel between Stratford and Purfleet.*



1. Chalk. 2. Thanet sand. 3. Woolwich beds. 4. Basement bed of London clay. 5. London clay. 6. Upper Glacial clay. x 4′. Lower Brick-earth. x 4″. Thames gravel of the inlet sheet. x 5. Gravel, presumed to be the equivalent of the lower terrace of fluviatile gravels. y. Ancient forest yielding human skulls, covered by the Marsh-clay. At the spot marked * at Chigwell Row, a thin gravel occurs, which may be the bed of fig. 2, or one of the denudation gravels. Between Chadwell Street and the Marsh the gravel x 4″ is capped by patches of the upper Brick-earth, x 4‴.

Crossness Well gives		feet.
	Marsh-clay	8
	Forest and clay	13
	Subangular gravel	51
	Woolwich beds (identified by fossils)	30
	Thanet sand	42
	Chalk at...	144

into which it passes upwards (distinguished in the memoir as $x4'''$*), as well as to the break-up and denudation of both of these. The same underlying brick-earth ($x\,4'$) also distinctly passes under the main sheet of the gravel ($x\,4''$) at Ilford Station, forming a slight synclinal, of which the two brick-pits of that place are the extremities.

The disturbances that broke up and elevated the Thames gravel, although giving rise to terraces, present no feature indicative of the uniform elevation of a valley by the general rise of the country, such as has been described to us by Mr. Prestwich in the case of the Somme. The elevations, on the contrary, have been altogether dislocatory and partial, the gravel being elevated on one side of the principal rectilinear throw as much as 116 feet above the present sea-level, and thrown down to almost as great a depth below the Plumstead and Erith marshes. Moreover the chief portion of that arm of the gravel which extends up the Lea valley, and also that portion of the main mass lying between Stratford and Purfleet, have been thrown *exclusively on one side of the present valley*, owing to the unequal elevation. A previous section, fig. 5, affords an instance of this in the Lea valley; and the section last given, fig. 13, indicates the position occupied by the main mass of the gravel between Stratford and Purfleet, as well as the way in which it has been affected by the faulting of the Lower Tertiary deposits.

In the memoir I have endeavoured to show the process by which, as it appears to me, the gravel has been placed in this position, and the grounds upon which it seems probable that a part, at least, of the gravel beneath the Thames and Lea marshes may be the same as that of the lower terraces (or $x\,5$ series), although it occupies no terrace, nor possesses any feature to distinguish it. The position of the gravel on the west and north of Woolwich indicates that it has been affected by a part of the disturbances that have imparted so great a local elevation to the Tertiary beds of that district; and it is from this part that a cross line of dislocation appears to start northwards, which has thrown the gravel in one part of the Lea valley exclusively on the west side of the river, as shown in fig. 5, and elevated it to very considerable heights. The line of dislocation referred to passes at Tottenham out of the gravel altogether; so that, just there, the lower-terrace (or $x\,5$) deposits, instead of resting against elevated terraces capped by the main sheet (or $x\,4''$) gravel on both sides, have this on one side only, the opposite being formed by the London Clay of the original valley; but as the line of dislocation falls within the main sheet, that deposit forms terraces on either side of the lower or fluviatile series. So far as I am aware, that part of the Thames gravel of which portions have been elevated into high terraces, has not, either in that elevated position, or in the lower position in which the local character of the disturbances have left the greater part of it, yielded any organic remains whatever. It is from

* The symbols used here are those adopted in the memoir, a series of patchy gravels marking the denudation which, succeeding the Glacial clay, preceded the Thames gravel being grouped under the symbols $x\,1$, $x\,2$, and $x\,3$.

the fluviatile beds of the underlying brick-earth ($x\,4'$), or of the newer (or $x\,5$) series succeeding the principal or inlet gravel, that the molluscan and mammalian remains brought to notice from time to time have been obtained.

It would carry me beyond the compass of this paper to examine the way in which the beds of the series $x\,5$ have been followed by the denudation of the Weald; but all will, I think, admit that, if it be evident that both the marine (or $x\,4$) portion and the fluviatile ($x\,5$) portion of the Thames gravel had no connexion with the present river Thames, or with what is now the North Sea, but was discharged towards the Chalk country, then the excavation of the Weald valley, and the formation of the beds within it, must be of posterior date. In proof of that sequence I invite those who are sceptical upon the point to study the structure and position of the gravel *relatively to the trough containing it*, and to submit the mapping and structure of it shown in my memoir and survey to a rigorous and exhaustive examination, and to point out in what way the structure and position of the gravel can have any connexion with the river Thames or with its valley as it opens to the North Sea.

A section (fig. 14) drawn across the eastern embouchure of the Thames-gravel channel, the embouchure of the channel of the East Essex sheet, and that of the channel of the Canterbury-heights gravel, as the three originally opened to the sea of the south, together with the same section, as it now appears from the break-up and denudation, may assist in rendering the views discussed more intelligible*.

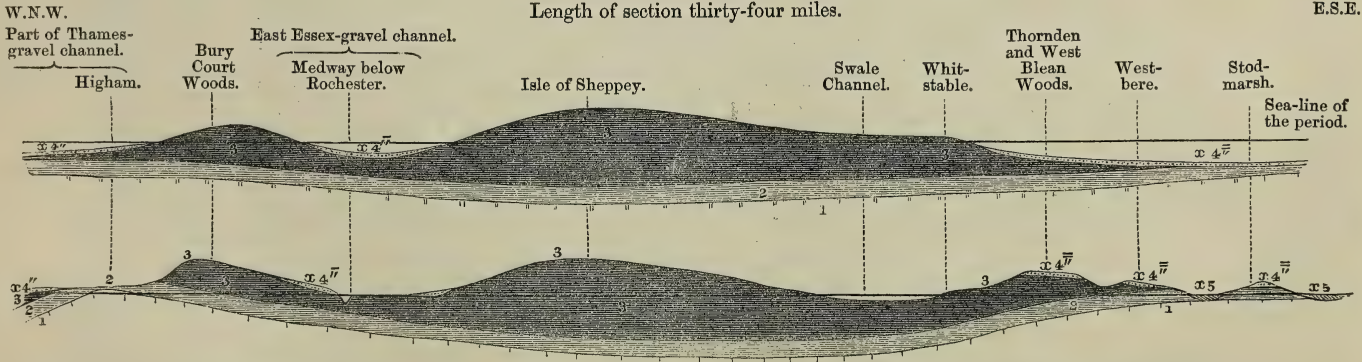
In the memoir I have endeavoured, by pursuing the denudation from stage to stage, and by connecting with it the various detached beds of Postglacial gravel occurring in the area, to trace the manner in which it has progressed subsequently to the break-up of the Thames gravel; and in doing so I have been led to the conclusion that the gravels in which the flint implements have, up to this time, been found, belong to a stage at least as much newer than the Thames beds as these are newer than the Glacial clay †, notwithstanding that these gravels, in Bedfordshire and west Norfolk, happen to occur in troughs cut down from the Glacial beds, and that to a small depth only, when compared with the trough containing the Thames beds. In the south of England, as, for instance, at Salisbury, these implement-gravels occupy that position which, in following the denudation from its commencement in the Upper Glacial clay through the Thames-gravel series into the Chalk country, indicates that they are divided from the latest part of the Glacial period by the interval occupied in the denudation of the Tertiary beds and the Chalk down to the Lower Cretaceous formations; for, although these

* I am indebted to Mr. Whitaker, of the Geological Survey (who has mapped the part of sheet 3 in which the eastern portion of this section occurs), for details made use of in that portion of it.

† Of course, I only refer to the implement-gravels *yet* made known; hereafter it may be discovered that man was coeval with some earlier gravel-period; but at present none of the beds belonging to the earlier part of the Postglacial period have yielded flint implements.

Fig. 14.—*Section from Higham to Stodmarsh across the Isle of Sheppey.*

The upper portion of this section represents the period when the three gravels of the $x\,4''$ series were contemporaneously accumulating. The lower portion represents the present state of things.



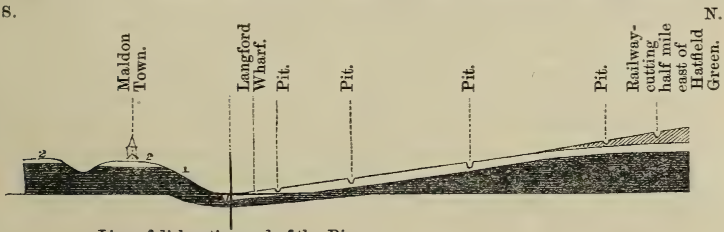
1. Chalk. 2. Thanet, Woolwich, and Oldhaven beds. 3. London clay. $x\,4''$. Thames gravel of the inlet sheet. $x\,4''$. East Essex gravel. $x\,\overline{\overline{4''}}$. Gravel of the Canterbury heights.—N.B. The Swale channel has probably undergone some denudation contemporaneously with the mouth of the Thames river.

gravels occur on the Chalk and other formations, it is only from fluviatile occupation of them,—the sea, the recession of which it is that I trace, having at this time ceased to occupy any portion of the Chalk country, and receded to the inlets represented by the bottom of the Weald valley in the south, by the Oolitic portions of the great valleys of denudation in western Wiltshire, and by the Lower Lias valleys of the eastern and western flanks of the Cotteswolds. It is to the gradual reversal of the country, produced by the continuous elevation which took place in the south and south-west (as the denudation proceeded in those directions), and which on the east coast brought part of the earliest emerged land, represented by the Glacial beds, again to the sea-level, that the apparently close relationship in position borne by the implement-gravels to these beds in Bedfordshire and west Suffolk is, as I contend, due. It is only necessary to observe, on the small-scale map of the memoir, the manner in which the Ouse valley between Buckingham and the entry of the river upon the Fen-country has been denuded through the Glacial beds, and in which it opens out at either extremity to the early Post-glacial sea, to perceive that the denudation of this valley is quite independent of the river which occupies it—although in places, as at Bedford, a small amount of denudation has been effected by the river when, during the implement-gravel accumulation, it stood at a higher level relatively to the country than it now does, and when changes of level, insignificant in comparison with those I have been tracing, took place. It will, I think, be found that the sequence of the gravels, as interpreted by their position relatively to the progress of the denudation, in the manner shown in the memoir, is quite in accordance with the evidence afforded by their organic remains, as far as this has yet been made known, and especially with the disappearance from this country of certain forms of mollusca, such as the *Corbicula fluviatilis*; and, from the late communication of Mr. Dawkins to the Society, this sequence appears to be equally in accordance with the evidence afforded by the mammalian remains; for, although I am compelled to dissent from the geological views of that gentleman inasmuch as he supposes the beds of the Thames valley to be synchronous with, or even older than the Upper Glacial clay), yet his analysis of the mammalian remains afforded by these beds, when compared with those yielded by the implement-gravels, affords evidence of an older facies. Being unaware of that fact until long after I had been led to an opinion of the newer age of the implement-gravels by the study of the denudation, I welcome this concurrence of testimony more than if, by being previously aware of it, I had been influenced by it in seeking the explanation of the Postglacial structure.

The extensive reversal of the drainage throughout the area is one of the principal features which the progress of the denudation exhibits; and the fact that this is traceable in the valleys of rivers that are affluents of the Thames, and in the western valley of the Ouse, becomes important on account of the special features exhibited by the former at its eastern extremity, to which I am about to allude, and of the position occupied by the implement-gravels in the latter, to which I have just referred. The case of the Thames river is, that east of London it has been introduced at a recent period over a Postglacial land-surface, represented by a forest which grew upon the gravels of the series x 4 and x 5. The forest-bed is a peat almost exclusively composed of the twigs and leaves of trees, in which the tree-trunks generally lie flat in immense numbers. At the base of the peat, however, I have observed stools in one or two instances rooted into the gravel. This was in the southern outfall sewer, about 20 feet below the level of the present high-water mark. There is clear evidence, in the universal occurrence of this bed under the marshes between the mouth of the Lea and Erith, that the entire bottom of the Thames valley in this part was occupied by the forest, so that the Thames could obtain no access to the North Sea but by passing over it: and this is what it has done; for the marsh-clay, which represents the deposit of the Thames before embankment, has covered the forest for a thickness of from 3 to 8 feet, and towards the upper valley of the Lea has overlapped it, so as to rest on the gravel near Tottenham, while the channel into which, by embankment, the river has been confined, cuts through it, so that the peat and the trees come out at low water on either bank. Nothing of the sort, however, occurs in the valley of the Thames-mouth, which, at a period apparently very closely coinciding with the introduction of the river, was cut through the dividing ridge of the Thames and East-Essex gravel-troughs. The Thames river thus occupies a position implying that relation only to the gravels associated with it which London itself bears—namely, one of introduction at a late period; and it can hardly be unreasonable therefore to associate its origin with that reversal which all the other features of the Postglacial period conspire, as I contend, to prove.

It will be found, on an examination of the region occupied by the valley of the Thames-mouth and its allied valley of the Crouch river, that a structure exists there which is very anomalous at first sight, but which, if the views I have put forward and endeavoured to substantiate in the memoir are well founded, is altogether in harmony with the other features displayed by the Thames river. We have in it the evidence of a very recent and local depression and elevation, by which the excavation of the valleys of the Crouch and Thames-mouth, and the redenudation of the south side of the valley of the Blackwater estuary, have been effected. The block of land thus locally depressed and elevated extends from the south side of the Blackwater mouth to the Medway; and I think also that the north coast of Kent has more or less partaken of the same movement. The *re*denudation of the south side of the Blackwater estuary-valley, and the excavation of the valleys of the Crouch and Thames-mouth, have been unaccompanied by even the feeblest trace of either gravel or brick-earth; and as there is not a valley, whose denudation we trace to any part of the Postglacial period, as old as, or older than, the implement-gravels, but yields some deposit of this sort, however insignificant, we are naturally led to assign the excavation of the Thames-mouth and allied valleys to a period so recent as to be posterior to all gravel or brick-earth accumulations. It is impossible to make the structure exhibited by this group of valleys intelligible without the assistance of the map and sections given in the memoir; but the following section at Maldon indicates that the Blackwater there occupies a line of Postglacial dislocation, on the south of which an elevation accompanied by denudation has taken place, from which the north side has escaped.

Fig. 15.—*Section across the valley of the Blackwater at Maldon.*



1. London Clay. 2. Middle Glacial Gravel. 3. Upper Glacial Clay.

This dislocation is so continuous along the estuary, that at its eastern extremity, at Bradwell, *the Postglacial or valley-formed East-Essex gravel is at a level as high as, and even higher than, the Glacial beds on the opposite side of the estuary*; albeit that this gravel is coeval with and intimately allied to that of the Thames, which, as I have shown, rests in a trough cut down (in one part at least) to a depth of 600 feet from the Glacial beds. Properly to apprehend this anomalous position it is indispensable that the grouping of the beds should be studied on the map.

In concluding this partial epitome of the structure examined in the manuscript memoir, I am anxious to call attention to two things: one is that the Postglacial structure of the area examined appears to me to be at variance with any general period of high- and low-level gravels, the extensive disturbances prevailing during the Postglacial denudation having, according to my views, placed the gravels at all elevations quite irrespective of their age. The other is that, if these views are well founded, the valleys within the area thus examined must have been wholly formed since the Upper Glacial clay*. Whatever may be the opinions of geologists as to the disputed beds of Lenham and Paddlesworth, few, I apprehend, would deny that the principal part of the denudation which has swept so much of the Tertiary strata off the south of England, be the period of it when it may, has been common also to the north of France. It is important therefore to ascertain what has been the point corresponding to the northern brow of the Thames valley from which the denudation of France has descended. Some time since †, I called attention to an identity which

* One or two exceptions only exist to this general proposition, and where preglacial depressions are recognizable as existing valleys. One of these is the long dry valley through which the railway runs from Welwyn to Hitchin.

† Ann. and Mag. of Nat. Hist., 1864, 3rd ser. vol. xiii. p. 185 *et seqq.*

appeared to me to subsist between the Loess of the Belgian Plateau and the Upper Glacial clay of England, and between the Sables de Campine (which the Loess *overlies and overlaps southwards*) and the Middle Glacial sands of England. Mr. Prestwich regards the Loess as the equivalent of the brick-earths of the Thames, of the Somme, and of the Seine *; and he observes that, although the valleys of Belgium are cut down from and through the Loess, this deposit is in places shut in by higher valleys. Now that feature, so far from being one of distinction, is one of identity, between it and the Upper Glacial clay; for although, strictly speaking, every valley in the neighbourhood of the Glacial clay is cut down from it, or through it, or into it, yet this clay has been extensively bedded against the sides of anterior depressions and erosions, of which the area of the Lower Bagshot sands of Essex, as illustrated in the diagrams figs. 1–3 affords an instance. My knowledge of the structure of the Loess is not derived from personal examination, but from the description of others, such as M. d'Archiac, and principally from a study of the admirable geological map † of Belgium of the late M. Dumont. To one familiar with geological mapping the latter appears to convey a more perfect idea of the structure than any description; and from it we see that a great denudation has descended from the brow which the Loess occupies on the north of the Meuse, in the same way as we see that the Postglacial denudation has descended from the brow occupied by the Glacial clay on the north of the Thames; but while this clay does not cross the Thames, the Loess has a few outliers on the south of the Meuse, just as occurs with the Glacial clay on the west of the Lea. As the Post-glacial denudation of England must to some extent be involved with that of France, these points of coincidence deserve, I think, to be noticed in this place.

NOTE.

In his paper, in the present volume of the Journal (p. 109), Mr. Dawkins states that the true Boulder-clay lies in the basin of the Roding, as well as in those of the Blackwater and Colne. As such a statement, going to the root of the whole question of the Glacial and Postglacial structure of the South-east of England, should be made only upon clear evidence, I applied to Mr. Dawkins to know where such evidence could be found. In reply, in the case of the Roding, he refers in proof to the Boulder-clay of Navestock. Now, if my Survey-map and the sections traversing this deposit be referred to, it will be seen that this valley happens at one part to traverse one of those depressions whose structure is illustrated in the diagrams figs. 1–3, which to one not familiar with the *whole* area would convey an illusory impression of the Boulder-clay resting within the brow of the valley.

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* Phil. Trans. 1864. According to my views the deposits of the Seine and Somme, like the gravels of Salisbury, belong to a much later part of the Post-glacial period than the beds of the Thames valley.

† From this map it would appear that, if we substitute the Loess for the Upper Glacial clay, and the Sables de Campine for the Middle Glacial, the diagrams figs. 1–3, would represent *as far as these beds are concerned*, their position on the north of the Meuse, and the way in which the valley now occupied by that river is cut down from them,—the subjacent deposits, as well as the structure they have acquired from the Post-glacial denudation, being of course quite different from anything in the Thames region.

Nothing, however, is clearer from the whole map than that the valley itself had no existence whatever at the period of the Glacial clay. In the case of the Blackwater, Mr. Dawkins refers me to the Boulder-clay of Ingatestone, Buttsbury, and Mountnessing. These places are *more than ten miles from the nearest edge of the Blackwater valley!* and they form the heights out of which the valley of the Wid, a tributary of the Chelmer, is cut. They are shown in my Survey-map to occur in a country affected by the structure shown in figs. 1–3. Had the Boulder-clay shown in the centre of the section fig. 9, however, been referred to, there would have been some colour for the assertion; but I trust that the structure shown in that section has been sufficiently explained to prove that the Glacial clay in the trough of arc 3 does not owe its position to any Preglacial existence of the Blackwater valley, which for a few miles of its course has incorporated into itself a part of arc 3, just as does the Roding, for some two miles, at Navestock incorporate a part of one of the depressions illustrated by figs. 1–3. In the case of the Colne valley, Mr. Dawkins tells me that the Boulder-clay "occupies a very large area in it, and can be seen in the valley near Colchester, immediately opposite Lexden." To this, all that I need say is, that I can find nothing of the sort there. The valley of the Colne (which is free from all complexity of structure) is, opposite Lexden, and near Colchester, occupied in its base by the London clay, the sides being formed by the Middle Glacial gravel, while the Boulder-clay occupies the more distant plateau-country, this valley being simply excavated in a plateau of Upper and Middle Glacial deposits.

Having for several years made it a special object to examine the structure of these valleys, I do not hesitate to affirm in the most unqualified manner that not only these three *river-valleys*, but every other in the south-east of England to which the Upper and Middle Glacial deposits occur sufficiently near to afford positive evidence upon the question, have been formed subsequently to the Upper Glacial clay. The exceptions alluded to in a previous note (page 415) refer not to *river-valleys*, but only to some dry depressions. But while that is so, it is of the utmost importance to bear in mind that there are Boulder-clays in the East of England of true valley or Postglacial origin, and deposited after the excavation of the valleys through the Upper Glacial clay. Of this, one instance affecting the Yare valley is given by Mr. Harmer, in the 23rd volume of the Journal; and he informs me that he has found the same thing in the valleys of the Gipping, in Suffolk, and Tese and Chet, in Norfolk; and I hope, in conjunction with another Fellow of the Society, shortly to lay before it evidence of a similar Postglacial or valley Boulder-clay spreading over hundreds of square miles and wrapping the denuded edges of the Upper Glacial clay like a cloth.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

Notes on the Geology *of the* Valleys *of the* Upper Part *of the* River Teign *and its Feeders.* By G. Wareing Ormerod, Esq., M.A., F.G.S.

(Read February 20, 1867*.)
[Abridged.]

A memoir on "The Bovey deposit," by J. H. Key, Esq., was read before the Geological Society of London, on November 20th, 1861†; and a memoir "On the Lignite and Clays of Bovey Tracey, Devonshire," by W. Pengelly, Esq., was read before the Royal Society November 21st, 1861‡. The district noticed in the following pages consists of the portions of the valleys of the River Teign and its feeders, that lie north of that described in these papers.

The Teign is formed for the most part by the North and South Teigns, the Walla Brook, Easter Brook, and Bovey River.

The South Teign rises near Fernworthy, about 1400 feet above the sea level §, and joins the North Teign at Leigh Bridge.

The North Teign rises on Dartmoor, about 1600 feet above the sea-level, near the upper end of a valley that is crossed at its western extremity by the East Dart; and near the Tolmen, 1192 feet above the sea, it receives the Walla Brook, which brings the drainage of an extensive granitic district to the north. Both these streams, near and at their junction, run in artificial courses, walled at the side with blocks of granite, and cut through a rising bank, the diversion having probably been made by tin-streamers to drain the broad level that occupies a hollow of the hills at this point. From this place the North Teign runs in a narrow gorge to a level in an opening of the hills at Gidley Park, where it receives the Blackatton Water, which brings the drainage of a district containing, in the distant part near Throwleigh, the edge of the Carboniferous beds; but no

* For the other communications read at this Evening-meeting see p. 176.

† Quart. Journ. Geol. Soc. vol. xviii. p. 9.

‡ Phil. Trans. 1862, p. 1019.

§ The elevations, except when otherwise stated, are from barometrical measurements taken by myself, and must be regarded as merely approximate.

fragments from that formation have been noticed by me along its course.

The point of the hill between the North and South Teigns, at their junction at Leigh Bridge, faces up stream, and is covered by large masses of granite piled on each other; near this place, on a spur from the hill on the right of the Teign, is the Puckie Stone, a transported block of granite about 26 feet long, 8 feet 8 inches wide, varying in height from 8 to 10 feet, rounded at the ends and angles, and having on the top a rock-basin; it rests on other transported blocks, and is broken obliquely across the centre.

On the right, a short distance below Chagford, the Teign is joined by Week Brook, having Yellum on its left bank; Bughead is on the ridge between this and a parallel valley which extends from the Teign at Whiddon Park to the range, near Moreton Hampstead, that divides the watershed of the Teign and the Bovey Brook. The course of the Teign and the feeders that have been mentioned, with the exception of a small area on the upper part of one of the branches of Blackatton water, is entirely over granite; and the gravels found, both in these streams and in the tin-grounds, as well as the "contour" or surface gravels, and those considered to have been deposited before the reexcavation of these valleys, and here called "Old Gravel," down to the place where the Easter Brook joins the Teign near Dogamarsh Bridge, are composed of granite or granitoid rocks.

The upper part of the valley of the Easter Brook, and the summit of the greater part of the high ground to the left of that valley, are composed of Carboniferous rocks; and near Parford a vein of porphyry is seen; and the gravels in the streams and tin-grounds are of granite and Carboniferous rocks, a few fragments of porphyry occurring with them in the lower part of the valley. The "Old Gravel" is of granite or granitoid rock. After the junction of the Easter Brook and the Teign, fragments of Carboniferous rocks are mixed with those of granite, both in the river-gravel and in the tin-grounds. The next parallel and adjacent valley to the north, that of the Silkhouse Brook and Drewsteignton, is in Carboniferous there found. The Teign leaves the granite for the Carboniferous strata at a gorge between Hunt's Tor and Whiddon Park, and runs over that formation by Finglebridge (where it receives the Silkhouse Brook), Clifford Bridge, and Dunsford Bridge to Chudleigh Bridge, near which place it enters on the Miocene beds of the Bovey Clay.

The Bovey Brook flows over the granite until it enters on the Carboniferous rocks near Letford Bridge, where it receives the Wray Brook, which also down to that place has flowed over the granite; near Bovey Tracey the joint stream enters on the Bovey Clay.

The granite of the Dartmoor district is stated by Sir Henry De la Beche * to be of more recent date than the Carboniferous rocks; and Mr. Vicary and Mr. Pengelly have shown the existence of pebbles of granite in the New Red Sandstone at North Tawton, Sampford

* Report on the Geology of Cornwall, Devon, &c., p. 116.

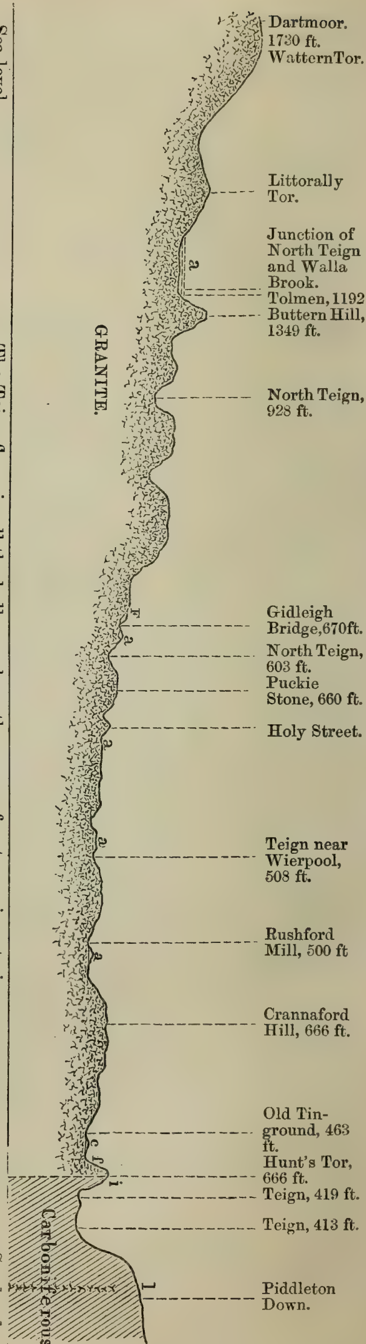


Fig. 1.—*Section from Dartmoor to Piddleton Down.*

The Teign flows in all the hollows where the name of a stream is not given.

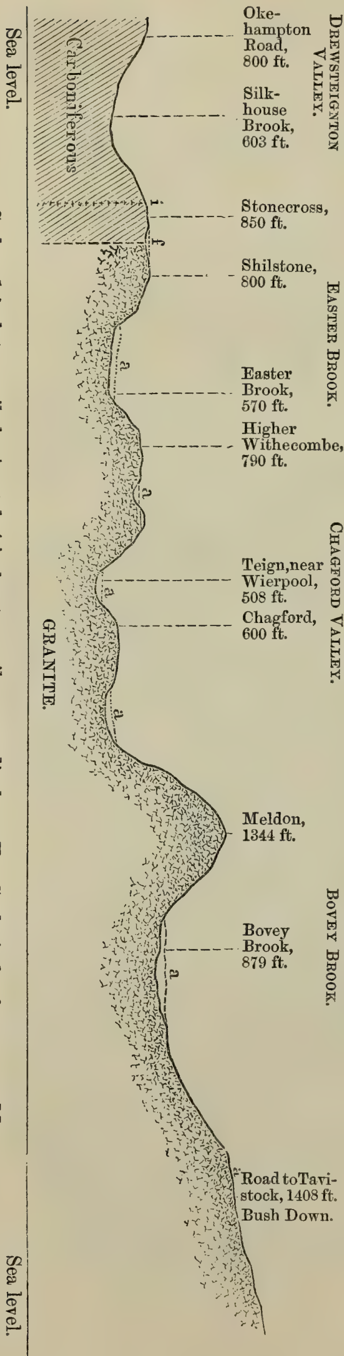
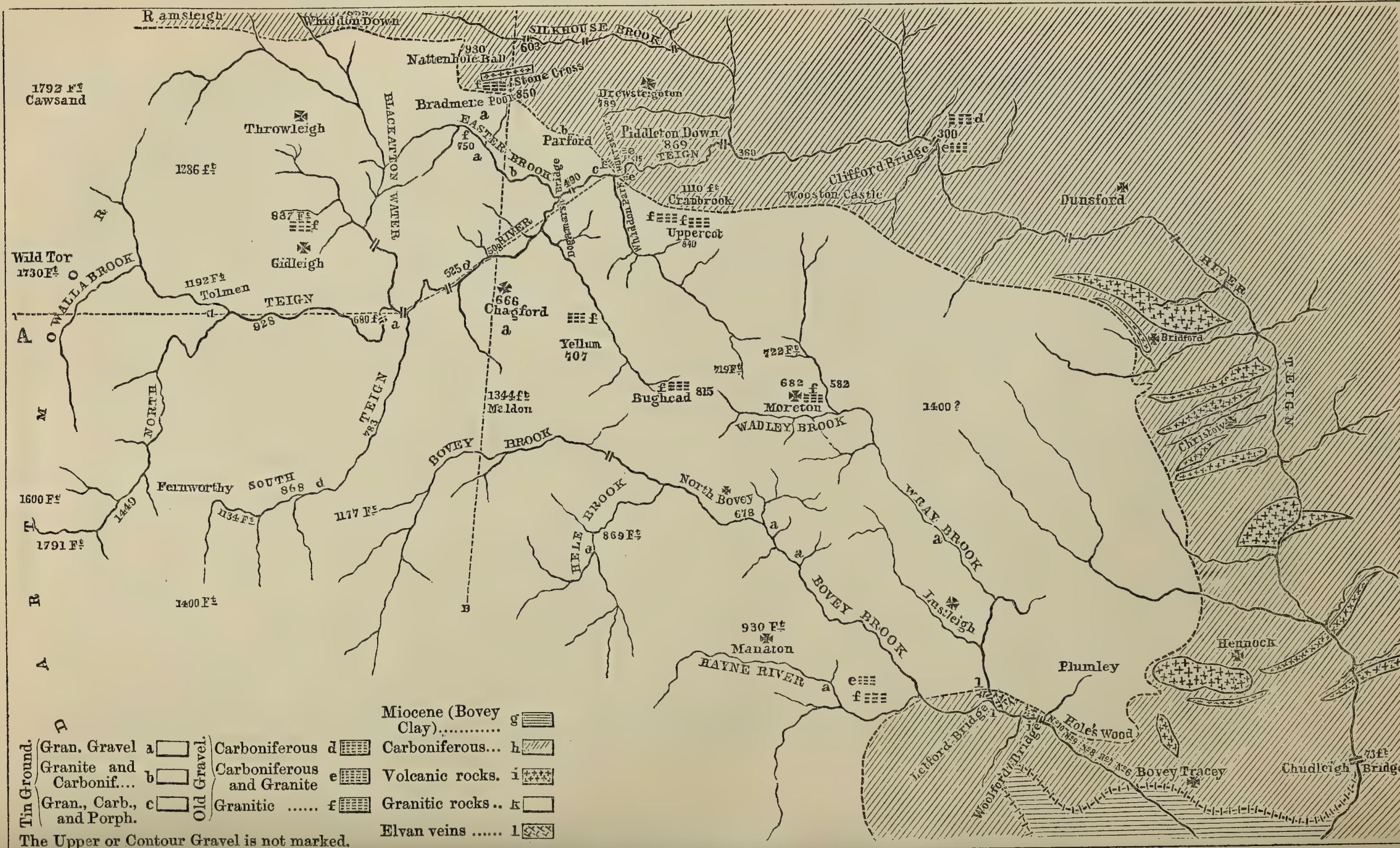


Fig. 2.—*Section from the Drewsteignton Valley to Bush Down.*

Scale.—1 inch to a mile horizontal, 4 inches to a mile perpendicular. For Geological references see Map.

Fig. 3.—*Sketch-map of the valleys of the upper portion of the River Teign and its feeders.*



Courtenay, and Haldon*. The granite in the district to which this paper relates is for the most part coarse and large-grained, and contains a great proportion of schorl, which occurs both disseminated in the rock and in distinct nodules and veins. The schorl varies very much in character, and rubellite has been found near Chagford. The examination of fifty-three veins near Chagford showed that thirty-nine ranged in directions from between N. and E. by N. to between S. and W. by S. No mines are worked on the granite near Chagford; but several lodes of tin are known to exist there. Veins of porphyry can be seen by the side of the road from Sandy Park to Parford, and near the stack-yard at Forder near Whiddon Park.

The Carboniferous beds lying to the north of the Dartmoor granite are broken up by frequent dislocations, and are occasionally contorted; the amount of dip is very variable, the direction being northerly. The minerals gradually cease as we proceed in an easterly direction; thus, of the principal minerals there found, it is believed that "lead" and "bismuth" do not exist to the east of Ivy Tor; "copper," "garnet," and "actinolite" not to the east of Manor Mine at Ramsleigh, and axinite not to the east of a dyke of "felspathic trap" near Stone Cross, to the west of Drewsteignton. A vein of manganese was worked to the south of this dyke; and is also found near the village of Drewsteignton. With these exceptions, none of the above minerals are known to the east of the dyke, until lead and manganese are again met with in the close vicinity of greenstone dykes, near Christow. Beds of limestone have been worked for many years at South Tawton and Drewsteignton. The only fossil animal remains found are those of the *Posidonia*, which are met with at South Tawton and Drewsteignton. At Drewsteignton and Dunsford, Calamites and a few other vegetable remains occur. Quartz, felspar, lime, and baryta are found in many various forms along the whole north edge of Dartmoor. The portion of the Carboniferous beds lying to the north of the granite, to the east of Stone Cross, appears to be free from intruded trap dykes. Veins of granite or elvan occur occasionally in the Carboniferous beds; at the gorge of the Teign, by Hunt's Tor and Whiddon Park, they are numerous; and, since the communication of a paper thereon to this Society†, other veins have been found in the same vicinity. The newly discovered veins at Hunt's Tor are very extensive; and being at the summit of the Tor a natural horizontal section is seen; in the 18-feet-wide vein at Sharpy Tor a vertical section is exposed; and these two places afford good situations for study. The veins just noticed vary in thickness from a hair's breadth to 18 feet; the elvan or granite in the thin veins is highly crystalline and compact; the felspar crystals in the central part of the wide veins are large, and diminish in size towards the sides; distinct crystals of schorl occasionally occur, forming small dotted lines in the elvan near the side of the vein, and sometimes crystals of schorl project nearly an inch

* Report of Devon Association for 1862, p. 52.

† Quart. Journ. Geol. Soc. vol. xv. p. 191.

in length into the vein at right angles to the side. Fragments from the adjoining Carboniferous beds are imbedded in the elvan; these are sometimes not quite detached from the native rock, and for the most part retain the angles; in the larger veins the edges are occasionally rounded, as if the mass had undergone attrition; but the rock does not appear to have undergone any change. Continuous partings occasionally pass through both the elvan vein and the adjacent rock, and such a parting has been found filled with a thin vein of schorl. The elvan veins occasionally cut the quartz veins of the Carboniferous beds.

No traces of undoubted glacial action have been seen in this district. In examining the gravels a frequent cause of error exists in the great similarity between the disintegrated, or partially decayed portions of granite rock *in situ,* and the slightly moved angular fragments that form the contour or surface-gravel; and as a general rule no bed can be regarded as a "granite gravel" which does not contain fragments that have been evidently rolled or transported. Again, the rounded form of blocks of granite is no evidence of their having been transported, as the gradual decay of the rock not unfrequently exposes its spheroidal structure, and a rounded mass is seen which at first sight has the appearance of a rolled block. As the gravels lying at the bottom of the valleys near Dartmoor have, it is believed, been all disturbed in the process of streaming for tin, no deductions have been drawn from them. In the gravels that will be noticed, no animal and, with the exception of the trunks of trees found in one instance in the "contour gravel," no vegetable remains have been found.

Certain small detached patches of gravel, composed of fragments of transported rocks, occur on the Carboniferous beds and granite; these have been regarded as the remains of beds deposited before the reexcavation of the valleys, and are here called the "Old Gravels." Proceeding down the valley of the Teign, these "Old Gravels" may be noticed at the following places:—By the road-side above Gidley Castle, about 900 feet above the sea-level, angular and rolled blocks, of various descriptions of granite and granitoid rocks, are exposed in a cutting, and are partly formed into a conglomerate by a bed of clay. Near the bridge in Gidley Park, on the hill-side on the left bank of the river, about 680 feet above the sea-level, there is a deposit formed of fine granite or granitoid gravel mixed with rolled and angular fragments of transported granite and elvan, the deposit being occasionally in laminæ, and the bed exposed about 25 feet in thickness. Beds of gravel are seen in the section in the river-bank near this place; but it is uncertain whether these are part of the last-named bed. On the left or western side of the valley of the Week Brook, near Yellum (Elm of the Ordnance Survey), about 700 feet above the sea-level, a bed of "Old Gravel" composed of rolled and angular blocks of various kinds of granite, quartz rocks, angular vein-stuff, and schorl is seen; and near Bughead (815 feet above the sea-level) similar transported fragments, overlying a bed of disintegrated granite *in situ*, existed in a cutting by the side of the highway; and similar gravels were exposed in the neighbourhood near Slancombe. On the hill east of Whiddon Park, in a field north-west of Uppercot Farm, and by the side of the highway east of the same, about 840 feet above the sea-level, there are deposits of angular and rolled fragments of granite, schorl, and black siliceous vein-stuff; and on the opposite side of the Teign, against the western side of Hunt's Tor, there are considerable deposits of the same character containing large blocks of granite. The subjacent rock at all the above localities is granite.

On the northern side of the valley of Easter Brook, between Shilstone Farm (by Bradmere Pool) and the Drewsteignton and Okehampton Road, about 850 feet above the sea-level, the "Old Gravels" are seen in a bed, about five feet in thickness, overlying the Carboniferous rocks and probably also the adjoining granite. They consist of fragments of rolled and angular granitic and schorlaceous rocks; near the surface a very few fragments of transported Carboniferous rocks occur; and it is questionable whether the last are part of the "Old" or of the "contour" gravel: probably they are of the later deposit. At a quarry near Sandsgate (about 750 feet above the sea-level) half a mile south-west of Bradmere Pool, a gravel, probably the "Old Gravel," is deposited on the surface of the granite rock, partly in fine laminæ, which dip at an angle of about 5° N.N.W., showing the direction in which the granite has been elevated since the deposition of the gravel. Near this spot and in the adjoining Rushford Woods, and skirting the Teign to the gorge at Hunt's Tor, many boulders occur, mostly of granite, but occasionally of Carboniferous rock; of these the largest is a granite block in Rushford wood, about 30 feet long, 16 feet high, and of irregular width, weighing about 200 tons.

Bradmere Pool (70 feet deep) is the site of an old tin-stream work, flooded by the closing of the adit about seventy years ago; and other tin-grounds have been worked in its vicinity. The gravel in the tin-grounds on the upper part of the Easter Brook consists of fragments of Carboniferous and granitic rocks; and in the lower part fragments of porphyritic rocks also occur.

At Hunt's Tor, about 660 feet above the sea, and 200 above the Teign, the Old granitic Gravels are exposed on the westerly side, and extend nearly to the summit of the Tor, and consist, it is believed, entirely of granitic rock; fragments of porphyritic and Carboniferous rocks, similar to those found in the contour-gravels and in tin-grounds near Parford, to the west, have not been detected there. The eastern side of Hunt's Tor is granite, save where it joins Piddleton Down, where it is formed of Carboniferous rocks traversed by elvan veins; and the slope on this side is almost entirely covered by fragments of Carboniferous rocks. The width of the gorge from the summit of Hunt's Tor to the point in Whiddon Park, nearly on the same level, where the granite and Carboniferous rocks are in contact, is about 290 yards. On the side of the hills sloping down to the left bank of the Teign, between Hunt's Tor and the turn to Clifford Bridge, granite is not seen, either as gravel or as transported blocks, save where such lie near the injected veins from which they are derived. To the right of the Teign, the line of boundary between the granite and the Carboniferous rocks passes to the south of Cranbrook Farm and a short distance to the south of the boundary as marked on the Geological-Survey map. A few remains of "Old Gravel" and numerous transported blocks of granite are seen on the side of the hill forming the eastern side of the valley, extending from Whiddon Park towards Moreton; and blocks of granite lie on the high ground to the east of the summit in Whiddon Park and Moreton Woods, and are scattered on the slope towards the Teign, being more numerous at the top of the hill than near the river; and these blocks on the hill-side soon cease entirely. To the east of Cranbrook Castle (1110 feet above the sea-level) near Cranbrook Farm, and near Wooston Castle, large transported blocks of granite and Carboniferous rock overlie the Carboniferous beds; between Wooston Castle and Clifford Bridge the transported blocks are of Carboniferous rock. Near the cross roads on the left bank above Clifford Bridge, on the road to Fulford, and by the side of the road to Dunsford, gravel again occurs, at the first place formed entirely of small fragments of Carboniferous rock, mostly angular, and occasionally cemented together by oxide of iron in which small fragments of mica exist—at the second place formed of angular fragments of Carboniferous rock of rather large size, and a single block of hard granite (not elvan), which was 14 inches long and 5 inches thick, and had been much rolled. These beds are from about 20 to 50 feet above the Teign (which is there about 300 feet above the sea-level), and probably belong to the "Old Gravel." As the present gravel of the bed of the Teign contains near this spot a proportion of about fifteen fragments of granite to eighty-five of Carboniferous rock, it is evident that these gravels are not derived from that source. Between Clifford Bridge and Uppercot quarry, near Chudleigh, I have not found traces of gravels overlying the Carboniferous rocks; and in that quarry there is a deposit composed of chalk-flints, rolled quartz, Greensand, iron from the Greensand, rolled black siliceous pebbles, and small black specks which appear to be particles of schorl; at Waddon Barton quarry, in the same vicinity, a similar gravel is mentioned by Sir H. De la Beche*, and at Rydon quarry, near Kingsteignton, gravel composed of similar rocks is found deposited against the face of an ancient cliff or escarpment. Near Chudleigh Bridge the Miocene beds of the Bovey Clay commence.

Along the Wray Brook and Bovey River the hills are for the most part so covered with herbage and wood that sections are not often obtainable. A cutting in the "Sentry" at Moreton Hampstead, about 80 feet from the Wray Brook (660 feet above the sea-level), gives a section of fine gravel with felspar, schorl, and quartz in thin laminæ lying nearly horizontally; this is probably "Old Gravel," though the point is not certain. Along the upper part of the Bovey Brook and its feeders no "Old Gravel" has been noticed. On the left bank of the Hayne River, about a mile to the south-east of Manaton, at the foot of the Riddy Hill, granite is seen *in situ*, and

* Report, p. 410.

this is overlain by "Old Gravel" consisting of sand, rolled granite in balls, angular fragments of many varieties of granite, rolled schorl, fragments of veins of schorl, and coarse granitoid rocks, but containing no Carboniferous rock, nor elvan of the character that will be mentioned hereafter. Overlying this bed and near the top of the hill there is a gravel composed for the most part of angular fragments of Carboniferous rock, and a smaller proportion of a hard light elvan: no granite of any description was found in this upper gravel; but rolled blocks of granite, some of large size, lie over it, and cover the hill-side. The construction of the Newton and Moreton Hampstead Railway has exposed many sections; these are through granite as far as Rudge, near Lustleigh, where the Carboniferous beds crop out, traversed by veins of a light-coloured speckled elvan; and similar veins occur lower down at Knowle. An elvan similar to this is found in the gravels that will be noticed as occurring to the south of this point, but I have not seen it to the north. The first point on the Carboniferous rocks at which the gravels are noticed is Yeo cutting; this is through hard Carboniferous rock crossed by a dyke of greenstone, and the beds are overlain by a gravel composed of elvan and small fragments of granite and Carboniferous rocks. Yeo Bridge cutting is through the Carboniferous beds, which are overlain by a similar gravel 4 feet in thickness, covered by a bed about 25 feet in thickness formed of soil, small angular fragments of Carboniferous rock, and a very small proportion of granite, but not containing any fragments of elvan. The Hole's Wood cuttings, Nos. 10, 9, and 7, are very similar. In No. 9 the cutting is through the Carboniferous rocks, which are overlain by gravel composed for the most part of angular fragments of Carboniferous rocks; a considerable part of the remainder consists of fragments of light-coloured elvan, and a small portion of rolled granite. In these three cuttings large masses of the elvan, rounded at the angles, lie at the base of the gravel on the Carboniferous rock: one block, in cutting No. 7, measured 4 ft. 8 in. long, 3 ft. wide, and 4 ft. thick; and on this point these three cuttings differ from the Yeo sections. This gravel is covered by a contour-gravel composed mostly of fragments of angular Carboniferous rocks and granite. At No. 8 cutting the gravel is different from that at 7 and 9 cuttings; it lies upon the Carboniferous rocks, and is composed of a small proportion of elvan and Carboniferous rocks, both in small fragments, felspar in various stages of decay, down to kaolin, schorl, rolled quartz pebbles (occasionally of large size), black siliceous stones, and rolled stones formed of a conglomerate-breccia composed of angular and rolled quartz, schorl, felspar, and rolled and angular Carboniferous rock, all in small fragments. The contents of this breccia vary both in their size and relative proportion; they are occasionally cemented together by an ochreous matter, and lime has not been detected. This breccia has not been seen at any other place along the line, but has been found in detached blocks between the line and Plumley, near a spot at which occasionally large flints are dug up (Plumley is on the granite). At the northerly end of this cutting, facing up the valley towards the north-west, portions of the trunks of two trees were found in upright positions, buried in the superficial contour-gravel, which, similar in its nature to that at the last-named cuttings, rose about 2 feet above their tops and lay beneath them. The largest portion was 5 feet in length, and 6 feet 6 inches in girth; the wood was sound, and the bark was on in places; the log consisted of the lower part of the butt of the tree with the upper part of the roots, but the top had become worn or decayed so as to form a point. The cuttings noticed are carried through spurs projecting from the hill-side; and the lowest gravel at different cuttings (save that in cutting No. 8) is so similar that these outliers are doubtless the remaining portions of a once continuous bed; and the same contour-gravel seems to have been deposited over the whole of that hill-side. These lower gravels, except that in No. 8 cutting, have been regarded as "Old Gravels." To the south of No. 6 cutting, the Bovey Brook and the Railway enter upon the Miocene beds of the Bovey Clay.

Tin-streaming has been carried on along the valleys of the Bovey and its feeders; a miner's pick was found in granite-gravel (which previously had been regarded as undisturbed) 5 feet below the surface, when the contractors were excavating for the foundations of the viaduct at Steward's Hill, about three-quarters of a mile to the south of Moreton. At Wray Barton, near the same place, an iron hook (so soft when found that it could be cut by a knife) was dug up amongst granite-gravel. On the surface, along the district of the Bovey River and its feeders, though almost confined within the area of the granite, transported blocks of granite occur in great profusion.

The position of these gravels shows in some degree the direction of the currents at the time when their deposition took place. Thus in the valley of the Silkhouse Brook, in the Carboniferous rocks to the north of the hills forming the left side of the granitic valleys of the Easter Brook and the Teign, no traces of transported granite in any form occur; whilst in the eastern parts of the last-named valleys, to the south of that line of hills, both transported blocks of granite and Carboniferous rock appear; and at Stone Farm, near the summit of the ridge, the edges of the beds of shaly Carboniferous rock are deflected, or washed down, in a southerly direction. On the Carboniferous beds to the east of the granite, transported blocks of granite and Carboniferous rocks are found; and, as seen on the Newton and Moreton Hampstead Railway, fragments of granite lie on the Carboniferous beds, and the adjoining hill-side, having been transported in a southerly or south-easterly direction. To these examples of the existence of a general current in a south-easterly direction, the gravel formed of elvan and Carboniferous rock at Riddy Hill is one exception: the nearest Carboniferous rocks to that place in a northerly direction are at Hunt's Tor, distant about six miles; and had this gravel been derived thence, fragments would probably have been deposited in the intervening country; such, however, is not the case; and as the fragments are angular and the rock soft, it is probable that they were derived from the Carboniferous beds to the south-west, on the opposite side of the valley. The substitution, at No. 8

cutting, of gravel of a different character from that found in the adjoining cuttings, which had doubtless been there denuded, points to the existence of a temporary variation in the current.

The question as to the manner in which these valleys were formed will not be entered upon, save as to the portion of the valley of the Teign between Hunt's Tor and Clifford Bridge. The sides of the valley of the Teign and its tributaries above Hunt's Tor are for the most part studded thickly with the remains of beds of gravel of different ages, and with boulders which reach up to the summits of many of the hills; and this is the case on the westerly side of Hunt's Tor, and along the line of hills extending thence to the south by Whiddon Park. Granite boulders extend for about three miles along the high ground at the summit of the hills, to the right of the Teign, below Whiddon Park, overlying both the granite and Carboniferous rocks; they occur also on the hill-side, on the right of the valley only, for a short distance below Whiddon Park. On the left side no granite boulders occur; and no granitic or other gravel has been noticed on either side of the river between Whiddon Park and Hunt's Tor and the crook of the Teign near Clifford Bridge. At the last-named place gravels composed almost entirely of Carboniferous rock occur; and the gravels between that point and Chudleigh Bridge differ entirely from those above Hunt's Tor. Had the narrow valley of the Teign that now exists between Hunt's Tor and Clifford Bridge been open at the time when the gravels and boulders were deposited against the western side of that Tor, the current that transported them would doubtless have caused a continuation of the deposit for at least a short distance down the valley over the Carboniferous rocks, in a manner similar to that which has taken place near Bovey Tracey; but here, although there are many nooks where the gravel would probably have been preserved, there are not any traces of such a deposit having taken place; it is therefore suggested that the gorge between Hunt's Tor and Clifford Bridge was not then open, and that a disruption of the Carboniferous rocks has taken place since the gravels were deposited. A fault of 100 feet, mentioned by Mr. Pengelly as existing in the Lower Miocene beds at Bovey Tracey*, shows that down to a comparatively recent geological period disruptions have taken place in a neighbouring part of Devon.

The last point for consideration is the direction in which the stream or current would have passed from the hollow lying to the west of Hunt's Tor, if an opening had not existed between that Tor and Clifford Bridge. There probably has not been much alteration in the relative elevations of the different ranges of high ground that now form the boundaries of the valleys of the Teign and Bovey. The lowest hollow on the high ground that forms the southern boundary of the watershed of the Teign, between Dartmoor and the west end of the low ridge which divides that stream and Bovey Brook, near Moreton Hampstead, is at Bughead (815 feet above the sea-level); the lowest on the high ground that forms a similar boundary on the north and east to the easterly end of the same low ridge (not

* Phil. Trans. 1862, p. 1082.

including the present opening at Hunt's Tor) is 789 feet above the sea-level, and is on the Carboniferous rocks to the south-west of Drewsteignton, where no traces of granite boulders exist. The ground gradually falls from Dartmoor to this place, and then, rising rapidly, forms the hills at Piddleton (869 feet) to the east of Hunt's Tor, Cranbrook Castle (1110 feet), and the range extending by the east of Moreton to the Wray Brook. The height of the ridge dividing the watersheds near Moreton at the easterly end, as taken by the barometer, is 722 feet, and at the westerly end, as shown by the levels of the Chagford Extension Railway, is 719 feet above the sea-level; and until the opening of the gorge by Hunt's Tor, the overflow from the hollow, now Chagford Valley, would have passed down Wray Brook to Bovey Tracey. Mr. Pengelly remarks* that the clays and sands of the Bovey deposit were carried from Dartmoor by currents from between west and north-west; a stream passing in the way now suggested would be in accordance with that opinion. But had the valley been open between Hunt's Tor and Clifford Bridge a northerly stream would have flowed into the hollow now containing the Bovey beds; and Mr. Pengelly shows that such a current did not exist until the deposition of "The Head;" and between the true Bovey deposit and that bed a great chronological interval occurs.

* Phil. Trans. 1862, p. 1080.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

1. *On* Abnormal Conditions *of* Secondary Deposits *when connected with the* Somersetshire *and* South Wales Coal-Basin; *and on the age of the* Sutton *and* Southerndown Series. By Charles Moore, Esq., F.G.S.

(Read March 20, 1867.*)

[Plates XIV.–XVII.]

Contents.

* For the other communications read at this Evening-meeting see p. 197.

I. Introduction.

My attention has for some time been directed to the peculiar physical conditions under which many of the Secondary rocks have been deposited on the southern edge and in the interior of the Somersetshire Coal-basin, and to the remarkable evidences of unconformability everywhere present. My observations have also been extended into South Wales, where to a considerable extent the same phenomena prevail. Within the last two years I have on several occasions accompanied friends to the interesting coast-sections of Sutton and Southerndown, which have lately been the subject of a paper by Mr. Tawney, when I have pointed out that, instead of representing, as they are supposed by him to do, beds older than the Rhætic and probably on the horizon of the St. Cassian or Muschelkalk deposits, they are only abnormal conditions of the Liassic rocks which are so familiar to us in many parts of England and on the continent.

Elaborate physical descriptions of some parts of the districts I shall have to notice have already been given by Messrs. Buckland and Conybeare, in the Geological Transactions *, under the title of "Observations on the South-western Coal-district of England," and more recently by the late Sir Henry De la Beche, in a paper contained in the Memoirs of the Geological Survey, "On the Formation of the Rocks of South Wales and the South-west of England." I shall hereafter have to refer to some interesting points not discussed in these Memoirs.

* 2nd series, vol. i. part 2.

II. The Mendip Hills.

This range of hills, which gives so marked a physical character, and has helped so much to modify the geology of the county of Somerset, commences near Frome, and passes, almost uninterruptedly, thence to Weston-super-Mare on the Bristol Channel. The connexion of the Mendip Hills with rocks of the same age on the southern flanks of the South Wales Coal-basin may be traced by the exposures of Carboniferous Limestone in the islands of the Steep and Flat Holmes of the Bristol Channel, and of these again with small exposures of the same beds on the opposite coast. The continuity of the Mendip Hills with the latter is therefore pretty clearly indicated; and it is not improbable that their elevation may have been contemporaneous and due to the same physical cause. Although on the South Wales coast Secondary rocks prevail, there is probably but little doubt that they only lie unconformably upon the Carboniferous Limestone and the Old Red Sandstone not far beneath.

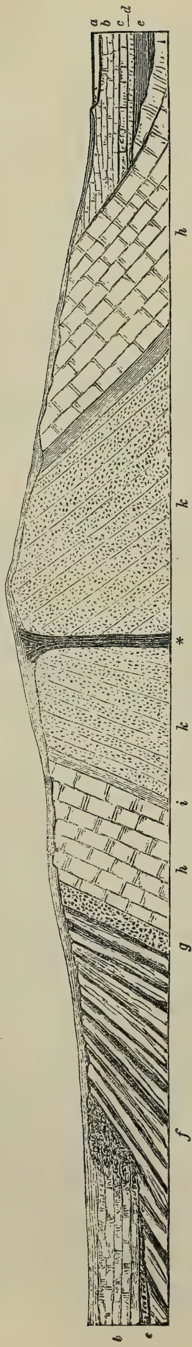
Measuring in a direct line from Oldford in a north-westerly direction to Weston-super-Mare, the length of the Mendips may be estimated at about thirty-five miles.

1. *Old Red Sandstone.*—Just north of the town of Frome, the Old Red Sandstone may be seen emerging from beneath the Inferior Oolite in a narrow strip nearly a mile in length, at Spring Garden, and having on its southern slope a thin band of Carboniferous Limestone. The Old Red Sandstone is next seen at Little Elm, whence it continues in the Mendips for some miles, and is the oldest stratified formation in this chain of hills. It has its largest development north-east of the town of Shepton Mallet, and again at North Hill and Blackdown; and in the Bristol district it is found on the Leigh and Weston Down.

2. *The Carboniferous Limestone.*—A mile west of the Carboniferous Limestone previously mentioned, this formation appears in several pretty combes, one leading from Frome by way of the Vallis to Elm and Mells, in the Murder Combe, and in a narrow wooded defile known as the Whatley Combe, in which are situated the ruins of Nunney Castle. Towards the southern end of this are the quarries of Holwell, the fissures in which have yielded so large a series of Rhætic organic remains. Resting upon the Old Red Sandstone, which usually forms the more elevated portion of the Mendip range, the Carboniferous Limestone is seen to continue almost uninterruptedly to the Bristol Channel, and thence along the southern portion of the South Wales Coal-field.

3. *Basaltic Dyke.*—There is abundant evidence throughout the whole of this district that the upheaval and disturbance of the beds forming the Mendip Hills were caused by volcanic action; but indications at the surface of the presence of intrusive rocks had never been observed, probably owing to the gradual rise of their northern slope, their well-cultivated surface, and the general encroachment of Secondary deposits along their flanks. Hitherto the Old Red Sandstone has been considered the central axis of the Mendips; but I have now the satisfaction of announcing that during last summer (1866) I detected

Fig. 1.—*Section across the Mendip Hills.*



a. Inferior Oolite.
b. Lower Lias.
c. White Lias.
d. Rhætic beds.
e. New Red Sandstone.
f. Coal-measures.
g. Millstone-grit.
h. Carboniferous Limestone.
i. Shale.
k. Old Red Sandstone.
* Trap-dyke.

evidences of the mighty agent which, ages since, caused the elevation of the many thousands of feet of stratified rocks which are comprised in the Old Red Sandstone, the Carboniferous Limestone, and the Coal-measures of the Mendips. This is visible in a basaltic dyke of considerable thickness emerging from beneath the Old Red Sandstone at East End near Stoke Lane, and also under the Ridgeway, which forms the most elevated part of this line of hills.

My attention was directed to the spot by the report that some peculiar minerals occurred there. The dyke was not, however, visible at the surface, and I had to remove the turf at different points, immediately under which it appeared in a deep-green-coloured basalt, all the minutest cracks and fissures of which were permeated by manganese, giving its outer surface a dark purple tinge. From the general physical character of the Mendips, it is not improbable that the dyke is coextensive with the range. East and west of a line of which Stoke Lane forms nearly the centre, for a distance of seven miles there is an uninterrupted anticlinal. The direction of the dyke from East End towards Frome is evidently south of Leigh-on-Mendip, and between that village and Downhead, and thence to Little Elm, a distance of about four miles. It then probably passes through, and has modified, the Carboniferous Limestone of the valleys west of Frome, and has left its last physical evidences at Oldford, a mile north-east of that town, where the Old Red Sandstone is greatly contorted, and disappears in that direction under the Fuller's Earth.

Passing to the western side of the dyke from Stoke Lane, the Old Red Sandstone again forms the most elevated portions of the Mendip Hills by way of Pen Hill, North Hill, near Priddy, and Blackdown—in which direction, as a general rule, all the older rocks have a north and south dip, which would necessarily be the case throughout that range if their uplifting had been the result of any volcanic force exerted from beneath the Old Red Sandstone.

A north and south section across the Nettlebridge valley shows that, by the protrusion of the dyke, rocks of enormous thickness, comprising those from the Old Red Sandstone to the Coal-measures, have been carried bodily forward in a northerly direction for a great distance, and are not only left standing vertically, but are in some instances folded over upon themselves. In consequence of this there is the extraordinary physical phenomenon of a band of Carboniferous Limestone, one-third of a mile in length, at Luckington, which appears to have been carried away from the Mendip Hills, a mile and a half to the south, *under* which reversed Coal-measures are being worked; and that which formed the floor of the bed is now found to be its roof.

4. *Date of Upheaval.*—It will be important, as far as possible, to determine the relative time when the mighty agent to which I have alluded produced such physical changes in the districts under notice. This is to be arrived at in the first place by an examination of the rocks that have been subjected to its elevatory force, and next of those which have been subsequently deposited. A section of the Mendips from north to south at once shows that the only rocks which have been operated upon in this way are the Old Red Sandstone, the Carboniferous Limestone, and the Coal-measures. These have probably an aggregate thickness of 20,000 feet. Although there are local disturbances in deposits more recent than the Coal-measures, they are due in great part to subsequent oscillations; and it may be seen that the Secondary deposits, although presenting remarkable evidences of unconformability when they reach the flanks of the Mendips and come in contact with their older uplifted rocks, are in general horizontal and undisturbed. Many of the Secondary rocks will be shown to be absent *within* the Coal-basin, or, if present, to be very feebly represented; and we thus arrive at the conclusion that the elevation of the Mendips and their South Wales continuation may be assigned to a time not far removed from the deposition of the upper beds of the Trias or New Red Sandstone.

Having arrived at an approximate date respecting the upheaval of the great mass of the Mendip chain, it will be desirable to ascertain what evidence the later Secondary rocks afford on this head, and how they have been modified thereby. From a consideration of this point, I am unable to agree with that eminent physical geologist, Professor Ramsay, in his opinion that rocks to the thickness of a mile have been denuded from the summit of the Mendips, and from the districts surrounding the South Wales Coal-basin. In this case we should expect to find the denuded rocks entirely absent from the district; but it can be shown that many of the Secondary rocks which are supposed to have been removed are really represented, both around the edge and within the borders of the Coal-basin, though under conditions most remarkable and abnormal when compared with their typical development as uninterrupted deep-sea deposits elsewhere.

It is my belief that since the deposition of the Coal-measures the Mendips, although they have been subject to oscillations of level, have seldom been entirely submerged—that they formed a Carboniferous island, which for many ages proved a barrier to the incursion of the deeper-sea deposits which were taking place to the south, and in which were being accumulated the materials composing many of the Secondary rocks.

Some partsof this island were the home of the *Microlestes* and other Mammalia, and also of the *Scelidosaurus* (a large land reptile discovered by myself near Shepton Mallet), which lived during the Rhætic period. Along the southern flanks of this ancient island, we shall find evidences of a shallow-sea or shore deposit, and within the Coal-basin itself such interruptions and thinning out of important geological formations as could only have occurred by the interposition of a barrier like that I have referred to. Its operation seems to have been like that of a recent atoll, letting in only here and there, or receiving on its coast-line, peculiar lithological deposits, and as a consequence possessing also palæontological differences, rendering it difficult to collate them with contemporaneous deposits, which were at the same time being laid down under ordinary conditions in a deeper ocean.

5. *Denudation.*—From what has been said it must not be inferred that there are no evidences of denudation; on the contrary, when we examine the more depressed eastern end of the Mendips, in the Vallis, and in the Whatley and other combes near Frome, we have abundant evidence of its operation. Throughout the whole of this district the Carboniferous Limestone is highly inclined; and it follows that at the time of its upheaval it must have presented its ragged edges to the surface, often no doubt running up into considerable peaks; but the denuding action of more recent seas seems to have continued a sufficient time, and to have been powerful enough, to remove these inequalities; accordingly the upper surfaces of the edges of these upturned limestones may now be seen perfectly horizontal over a considerable area. The material so removed has served to form the various conglomerates of the district. From the evidence thus afforded, and also from the peculiar way in which Carboniferous Limestone fossils are found, both in the Mendips and South Wales, mixed with Secondary organic remains, we arrive at the conclusion that the Carboniferous Limestone has, in certain areas under consideration, formed the floor of the Secondary ocean over an enormously extended period, within which were deposited elsewhere all the beds between the Oolites and the Trias, and possibly even dating back to periods still more remote.

6. *System of Secondary veins.*—This view is also strengthened by the fact that every vein, fissure, or depression in the Carboniferous Limestone has received either horizontal deposits or infillings of

Rhætic, Liassic, or Oolitic age. Parallel veins, analogous to the mineral veins of other districts, traverse the Mendips in a direction east and west, from one end to the other, and are occasionally intersected by others from north to south. They appear to pass downwards through the whole thickness of the Carboniferous Limestone, and have been proved at Charter House to a depth of 260 feet. In general they are of Liassic age; but the mineralogical and palæontological variety they present show that they were not formed contemporaneously. Probably they were for a long time open to the Liassic seas, and must in many instances have received their contents very gradually; a Liassic fauna not only inhabited the ocean above, but lived within the Carboniferous Limestone walls of the open fissures, and the remains of Gasteropoda and other organisms may still be seen attached thereto. As we are able to arrive at the age of horizontal strata by the fauna they enclose, so are we able to indicate in many cases the probable relative age of mineral and other veins by the same palæontological law.

So numerous are these fissures in the Mendips, and so much of what appears Carboniferous Limestone is really of Liassic date, that the geological character can only be expressed on the Ordnance Map by drawing parallel lines of Lias throughout their length.

7. *Age of the Conglomerates.*—In the south-west of England and in Wales the Permian series, which in the north is found resting upon the Coal-measures, appears to be entirely wanting; and within the centre of the southern division of the basin, conglomerates, probably of Dolomitic age, lie unconformably upon the latter. These are found to vary from 3 to 60 feet in thickness. There is a large development of this conglomerate at Stratton-on-the-Fosse, where it comes in contact with the exposed edges of the Coal-measures, and again at Mells, whence a narrow belt passes beyond the village of Elm, skirting the limestones to Vallis. Conglomerates are also found continuously along the limestone escarpments, filling up the inequalities of the surface on both the north and south flanks of the southern portion of the Mendips. It is very difficult to obtain sections showing the age and relative stratified positions of many of these conglomerates; and few, if any, organic remains of a locality so disturbed as were the probably local coast-lines on which these pebbly deposits were laid down can be expected to have been preserved. Although it may be difficult of absolute proof, I have reason to believe that these conglomerates were accumulated at different geological periods. Those which rest unconformably upon the Coal-measures in the basin north of the Mendips are undoubtedly the oldest in the district, and probably represent the true Dolomitic period, as do many of the patches along this chain of hills. But the Rhætic period is not only represented by horizontal conglomerates, but also in the vertical fissures of the limestones, by material which would, under ordinary conditions and without the presence of organic remains, pass for unquestionable Dolomitic conglomerates. The Carboniferous Limestone of Durdham Down, near Bristol, is traversed by numerous fissures similar to those already alluded to as occurring

in the Mendips, from several of which I have also obtained organic remains. The conglomerate of Durdham Down, in which the reptile *Thecodontosaurus* was found, was first supposed to be of Permian age, but is now assigned to the Dolomitic conglomerate. It is not my intention in this paper to enter into a consideration of the Rhætic fauna; but from the fact that reptilian remains of the same genera are found in a conglomerate which is lithologically identical with that at Holwell, and deposited under the same circumstances, I have been led to infer that the Durdham Down deposits will have to be removed from the more ancient Dolomitic to the more recent Rhætic period. At Croscombe, near Shepton Mallet, some mining-operations have been carried on for the discovery of manganese and iron. In a gallery driven through the conglomerates at this place they were found to enclose numerous masses of blue and variegated marls, which I was unable to distinguish from the Upper Keuper marls. One of the veins at this spot shows distinct traces of carbonate of copper.

Conglomerates of Liassic age assist to fill many of the Carboniferous-limestone veins previously referred to. They may be found also resting on the limestone in the Frome Road at Holwell, and again in the line of the turnpike-road at Cranmore, near Shepton Mallet. The most remarkable evidence, however, of the conglomeratic character of the coast-line of the Liassic sea when bounded by the Carboniferous Limestone, will be shown when I refer to beds contemporaneous with the Lias of Shepton Mallet, at Sutton and Southerndown in South Wales, where there are conglomerates far exceeding in thickness any with which I am acquainted, even amongst the thickly massed Dolomitic deposits. The base of the Inferior Oolite, again, where it is unconformable to the Carboniferous Limestone is often a siliceous conglomerate; but, in this instance there is not the same difficulty in arriving at its exact position.

III. Stratified Rocks subsequent to the Mendip Upheaval.

As a general rule, it may be observed that, with the New Red Sandstone, deposits commence which have not been affected by the elevation of the Mendips, since, when these are compared with the older beds in that range, or with the Coal-measures in the basin, they will be found horizontal and lying against or upon the upturned edges of the latter.

It will be my endeavour to show (in proof of my position that the Mendips and their continuation in South Wales have to a great extent proved a barrier to the incursion of the Secondary seas within its northern borders) that, even drawing a line east and west so far north as Bath, most of the beds between the Coal-measures and the Oolites, where they can be examined, have been laid down either under abnormal or unconformable conditions; the latter fact will fully account for the reasons why, in the southern portion of the Somersetshire Coal-field, coal-shafts have been commenced, and coal has been soon won even through the Inferior Oolite.

I propose now to give examples of beds on certain geological horizons where they occur as deep-water deposits south of the Mendips and therefore beyond their influence, and those of the same age which either rest upon or are in contact with the Carboniferous Limestone, and then their representatives within the Coal-basin.

1. *The Trias.* *a. South of the Mendips.*—The best districts for a study of the upper members of this group in the West of England are along the numerous escarpments bounding the moorlands of Wedmore south-west of the Mendips, along the whole line of the Polden Hills to Bridgewater, and again from Compton Dundon by way of Somerton, Langport, and Hatch Beauchamp towards Taunton. Throughout the greater part of these districts the Lower Lias occupies the tableland, the Rhætic beds coming in immediately beneath and skirting the edge of the escarpments. The beds of the Keuper are also seen in narrow belts leading down to the base of the escarpments. As these beds are usually, if not entirely, on the same horizon as the variegated marls, and represent them (the highest member of the Triassic series), nothing could be known from any superficial examination regarding their general thickness, or the probability there might be of an extension of workable Coal-measures in this direction beneath them. As this point is one of so much importance, and is now receiving general attention from the scientific world, it is fortunate that the following section of the upper members of the Trias in this direction has been preserved. We are indebted for it to the late Earl of Ilchester, on whose lands at Compton Dundon an attempt to discover Coal was made in the year 1815, the work being under the direction of the late Mr. William Smith. The section and the notes appended thereto were then recorded by the latter gentleman.

Section of Strata bored through at Compton Dundon in 1815.

	yds.	ft.
Beds in the escarpment:—		
Lias (Rhætic clays)	} 30	
Clay stone		
Plaster		
Clay		
Strontian		
Clay		
Red earth		
Clay		
Red earth		
Top of the pit.		
Red earth	56	2
Alabaster, 4 feet.		
Red earth mixed with gypsum, to	69	0
Ditto, ditto, to	97	2
Light-grey marl, 3 ft. 6 in.		
Red earth, to	110	2½
Blue rock, 6 in.		
Red earth with gypsum, to	134	0
Blue clunch, 9 ft.		
Red earth, to	144	0
Very hard blue clunch, 3 ft.		
Red earth, to	150	0
Softer blue clunch, 3 ft.		
Red earth, to	153	0

	yds.	ft.
Brown rock, hard, 4 ft. 6 in.		
Red earth, to	157	0
Sandy brown rock, 2 ft.		
Red earth, to	160	0
Blue clunch, to	165	0
Dark-red hard marl, to	173	0

The Keuper escarpment at Compton Dundon is very abrupt; and the pit was commenced at its base. The beds marked "Lias" at the top of the section are the blue clays of the Rhætic series. It is thus shown that the boring was continued to a depth of 519 feet, to which is to be added 90 feet for the marls above, giving a total thickness of 609 feet. There is every reason for believing that down to the base of the gypseous beds, and probably in the whole of the strata given in this section, only the Keuper is represented; and the thickness of the Lower New Red Sandstone and anything that may be below can only be conjectured.

b. Triassic Beds within the Coal-basin.—In general the actual junction of the New Red Sandstone with the Carboniferous Limestone, either north or south of the Mendips, is rarely seen, either from its being covered by the Lias, or from a belt of conglomerate intervening. Within the Coal-basin this formation occupies a considerable superficial area, its greatest being at Chew Stoke, south of Dundry, whence it continues for some distance to the west, surmounted by occasional low platforms of Rhætic and Liassic beds. As compared with the New Red Sandstone outside the Mendips its thickness is insignificant. The greatest depth it appears anywhere to have attained is at the Tyning Pit, near Radstock, about the centre of the Coal-measures of the district. It is here 167 feet, and the conglomerate below 19 feet. At Norton Hill Pit in the same district the New Red Marls are reduced to 118 feet; but the conglomerates are 54 feet, on the whole slightly thicker than in the former working.

c. Batheaston Section.—Another attempt for coal was also made by Mr. William Smith, at Batheaston, in the year 1812, of which I possess a section preserved from that time. This has been given in "Conybeare and Phillips's Geology of England and Wales," p. 262. In this the beds are divided into

	ft.	in.
Upper Marls (embracing Middle and Lower Lias)	210	0
True Lias beds, including White Lias 10 ft.,	47	6
Lower Marls	20	0

Immediately following the last deposit, which belongs to the Rhætic, series, the New Red Sandstone was included in a thickness of 30 feet, and the conglomerate in one of 24 feet. It will thus be seen that within this part of the Somersetshire Coal-basin the Triassic rocks are reduced to a little over 50 feet, whilst south of the Mendips, and where only partially proved, they attain a thickness of 609 feet.

Notwithstanding the view expressed by Mr. Tawney with reference to the Sutton beds, of which I shall hereafter speak, I am of opinion that up to this time there is no evidence in this country of the presence of the St. Cassian and other strata found in the Austrian Alps, which, being supposed to be the marine equivalents of the fresh-or brackish-water deposits of the Upper Trias, I might have hoped to find somewhere on so extended a coast-line as that under consideration.

2. *The Rhætic Beds.*—Since the publication of my paper on the "Zones of the Lower Lias and the *Avicula-contorta* Zone," in the Journal of the Geological Society in 1861, much attention both in this country and on the continent has been given to the Rhætic formation, and many valuable memoirs have appeared almost simultaneously. At this time it is not my intention to give descriptions of the numerous Rhætic fossils I have added to the lists since the above publication, which I hope soon to do. I rather desire to describe some admirable typical sections which several new railway-cuttings have opened up, and to notice also the mode of their occurrence in the Radstock and other districts, and in South Wales. The sections previously known, and where they can still be studied, are at East Cliff and Westbury on the Severn, Watchet, Pyle Hill, Uphill, Saltford, Beer Crowcombe, Shepton Mallet, and Long Sutton in Somersetshire, and at Penarth Cliffs in South Wales. Additional sections are now open at Patchway, on the South Wales Union Railway, at Hatch Beauchamp, on the Chard and Taunton Railway, and at Willsbridge and Newbridge Hill, on the Bath and Mangotsfield line.

Since, in these sections, the beds of the Lower Lias are in every instance found reposing upon the Rhætic series, it will be more convenient, especially as I shall have to point out frequent evidences of their unconformability, and of the absence of some members of the Lower Lias, to consider the two formations together; and this will also the better enable me to correlate the South Wales sections with them.

One of the most desirable points in connexion with geological investigation is to give attention to the passage-beds between the established series of formations—to endeavour to find how they lead one into the other, and how the succession of organic life may have been modified thereby. In order to arrive at any satisfactory conclusions on these subjects, it will be manifest that such formations must be studied, not where they are in abnormal conditions (as is generally the case where they come in contact with older unconformable deposits), but where there certainly is an unbroken and uninterrupted passage from the one into the other; and fortunately there are such sections. These I shall now give, and with them, as typical, afterwards compare their equivalents elsewhere.

The horizon of the Rhætic beds commences above the Upper Keuper marls with grey or bluish sandstones or marlstones. Although varying in thickness, they are present in every section with which I am acquainted; and as they contain Rhætic fish and other remains at Watchet, Shepton, Willsbridge, &c., they form a distinct base-line for the formation; and above are included all the beds to the uppermost "White Lias" ("Sun Bed" of William Smith). They may therefore be divided into two groups—the *Avicula-contorta* and Bone-bed shales, and the "White Lias." Although there are local differences when various sections of these beds are compared, still their persistency over a wide area in the South-west of England is remarkable; and though the Lias above and the Keuper marls beneath, particularly within the Coal-basin, are repeatedly found unconformable from the absence of some of their members, the Rhætic beds are always present.

In a former paper I gave the Beer Crowcombe sections, and others near Langport, as typical, and these may still be considered correct; but I was under the disadvantage of having to trace the succession of beds in several quarries. I propose now to give an important section in the railway-cutting at Queen Camel, in which there is a succession of 260 beds, having a thickness of 375 feet, every one of which may be studied, and where at one view is seen the passage upwards of the Keuper, Rhætic, and Liassic beds. The passage between Rhætic and Lias beds seems here less broken than in many other sections; but, in this case as in every other, the peculiar lithological distinction in the two deposits can be immediately recognized, and you may at once place your hand upon the uppermost Rhætic "Sun Bed." This distinction is generally so strongly marked that any geologist, even if travelling by express train, may readily detect the junction of the Rhætic with the Liassic beds in the railway-cutting at Saltford, near Bath. The "White Lias" extends uninterruptedly from Lyme Regis through Somersetshire, however unconformable may be the beds immediately resting upon it; but it thins out or entirely disappears in North Gloucestershire and beyond; and it is noteworthy that continental geologists have not yet recognized its presence in any of their sections*.

The Rhætic beds appear to have been deposited under peculiar oceanic conditions, and in general must have been accumulated very slowly. The blue marls of the *Avicula-contorta* series at their base are usually most persistent, and are crowded with testacea. But at times the Bone-bed is entirely absent as a separate zone; and the vertebrate remains it yields are then either distributed throughout the other beds, or are found in little nests or pockets therein. The Aust section affords the best horizontal illustration of the Bone-bed, which is there a nodular stone of some thickness, the accumulation of which indicates a period of rest, or a lapse of time within which the organisms it encloses must have been living. Again, the *Avicula-contorta* limestone, or the "Flinty Bed" of my Beer Crowcombe sec-

* Since the above remark was made, I have seen M. Jules Martin's "Paléontologie Stratigraphique de l'Infralias," in which he remarks that M. Eug. Dumortier had found in the Departments of the Rhone and Ardéche, between the Gryphæa-limestone and the Trias, two distinct mineralogical zones, the upper composed of a whitish limestone with grains of clear quartz with *Cardiniæ* and, lower down, *Littorina clathrata*, Desh. The lower zone, he remarks, is composed of compact limestones in a very fine paste, almost "lithographique," of a clear grey tint, and often presents a multitude of round holes, which M. Leymerie attributes to perforating shells, these being known under these name of the *choin bâtard*; and he adds that they represent the common zone of *Littorina clathrata*. This description so completely accords with the lithological character of the Rhætic "White Lias" that I can readily suppose they are identical, in which case the Rhætic *Avicula-contorta* beds would probably be found immediately below.

tion, is only typical at that place and at Hatch. This bed is there about a foot in thickness; and in no other locality have its fossils been so perfectly preserved; it is frequently very thin or entirely absent.

As we pass upwards into the "White Lias" group, we reach a series of dense close-grained limestones, often light-blue at their base and cream-coloured in their higher members. Although a few of the testacea are common to the lower beds, and a few from the "White Lias" pass again into the true Lower Lias, still the palæontological change which occurs with these deposits is most remarkable. In the *Avicula-contorta* zone and the Bone-bed just below are the remains of Mammalia, land and marine Reptilia, and Fishes of many genera and species; but, although I have examined almost every known quarry of "White Lias" between Bath and Lyme, I have never obtained the slightest evidence of the presence of any vertebrate remains, or of any Cephalopoda throughout them. Often through considerable districts the "White Lias" will be found almost unfossiliferous, whilst in other localities the testacea will as individuals be very numerous, although few in genera. Some physical change in the character of the ocean must have occurred when these beds were being deposited, in order to account for the entire absence or extinction of the vertebrata, which must have teemed in the previous seas, throughout so wide an area. Since we had in the *Avicula-contorta* beds below a change from the fresh- or brackish-water deposits of the Keuper, we have probably a recurrence to the former conditions with the "White Lias," and therefore the destruction of all the marine vertebrata. The barrier thus interposed has, I believe, not allowed a single species of Rhætic vertebrata to pass into the Lower Lias; for hitherto, although some genera pass on, I have never, of this family, found any species common to both.

a. Succession of Keuper, Rhætic, and Liassic Beds at Camel Hill Railway-cutting, in ascending order.

	ft.	in.
Keuper.		
1. Grey Marls	14	6
2. Ditto with Strontian	6	6
3. Bed of Strontian		6
4. Grey marls with well-defined layers of Sulphate of Strontian	32	0
5. Thinly laminated grey marl	1	0
6. Grey marl passing into blue	23	6
7. Grey marl	2	6
	80	6
Rhætic.		
8. Grey sandstone with *Acrodus*-teeth, *Lepidotus*-scales, &c., and casts of *Axinus* and other shells	1	6
Carried forward	82	0
Brought forward	82	0
9. Grey marl		8
10. Bluish sandstone	1	0
11. Marl		5
12. Soft yellow sandstone	2	0
13. Blue shales, with *Cardium Rhæticum*, *Avicula contorta*, *Axinus*, &c. &c.	24	6
14. Stone, *Pecten Valoniensis*		3
15. Blue clay with ditto		2
16. Stone with ditto		3
17. Clay		2
18. Stone, *Avicula contorta*, &c.		1½
19. Clay		1
20. Stone		1
21. Clay		1½
22. Stone, *Pecten Valoniensis*, &c.		2½
Carried forward	112	0½

	ft.	in.
Brought forward......	112	0½
23. Clay, ditto		2
24. Stone, ditto..................		0½
25. Blue clay		1
26. Stone		0½
27. Clay..........................		0½
28. Stone		4
29. Blue clay	2	3
30. Thin layer with fish-scales &c.		2
31. Close-grained bluish-grey stone		6
32. Bluish-grey marl	2	6
33. Bluish concretionary stone		9
34. Grey marl		3
35. Marl not uncovered, about	10	0
	129	2
White Lias.		
36. White Lias stone		5
37. Ditto		7½
38. Ditto		6
39. Shale		1
40. White Lias stone		6
41. Ditto		6
42. Ditto		9
43. Ditto		6
44. Rubbly marl		7½
45. White Lias..................		4
46. Stone		3
47. White Lias..................		2½
48. Ditto	1	0
49. Ditto		6
50. Ditto		6
51. Ditto		4
52. Marl		2
53. White Lias..................		3
54. Marl		1
55. White Lias..................		3
56. Ditto	1	0
57. Ditto	1	2
58. Ditto		1½
59. Ditto		2
60. Ditto		4
61. Ditto	1	0
62. Marl		4
63. White Lias..................		4
64. Marl		3
65. White Lias..................		7
66. Marl		1½
67. White Lias..................		2
68. Ditto		8
69. Ditto		4
70. Ditto		11
71. Marl	1	0
72. White Lias..................		4
73. Marl		2
74. White Lias..................		2
Carried forward	146	8½

		ft.	in.
	Brought forward......	146	8½
	75. Ditto		7½
	76. Ditto, "Block Bed"	1	2
	77. Marl		4
	78. White Lias, "Sun Bed" of the Bath district	1	4
	Lower or Blue Lias.		
Insect and Crustacean Beds.	79. Laminated marl, no fossils..............		4
	80. Bottom "Blue beds," Insect-limestone very finely laminated, with Insects and *Modiola minima*		5½
	81. Marl		2½
	82. Insect-limestone......		6
	83. Indurated laminated marl with numerous *Eryon Wilmcotensis*		2
	84. Insect-limestone......		6½
	85. Marl with *Eryon* ...		5
	86. Dense laminated stone		9
	87. Marl, *Lepidotus*-scales		3
	88. Close-grained Insect-limestone called "Hat and Cap" 8 in. to		4
	89. Marl, *Lepidotus*-scales, vegetable and Coprolite-like markings		2
	90. "Cap" Insect-limestone		5
	91. Marl		2
Saurian and Ostrea Beds.	92. Coarse-grained limestone with *Ostrea liassica*, abundant		10
	93. Marl		2
	94. Firestone, numerous *Ostrea*, &c..........		6
	95. Ditto, ditto		6
	96. Marl		1
	97. Firestone		8
	98. Ditto		5
	99. Ditto		2½
	100. Ditto		7½
	101. Ditto, *Ammonites planorbis*		4
	102. Ditto..................		7
	103. Marl with laminated shells, *Cidaris Edwardsii*, *Modiola, minima*, small *Lima*, *Avicula*		6
	Carried forward......	160	3½

	ft.	in.
Brought forward......	160	3½
104. "Sandrock" *Avicula decussata, Cardinia, Modiola, Ostrea liassica*...		2
105. Marl, *Lima gigantea, Ostrea*....................		5
106. "Sandrock" *Ostrea arietis, O. liassica, Lima gigantea, L. duplicata, Astarte, Myacites, Avicula decussata* abundant, *Pecten*		8
107. Marl, *O. liassica, Pecten, Echini*, &c.		5½
108. "Sandrock," *A. planorbis, Lima duplicata, Pecten sublævis*		6
109. Marl		6
110. "Sandrock," *A. planorbis*, abundant; *O. liassica, Pentacrinites*......	1	0
111. Blue Marl, *Am. Johnstoni, A. planorbis, Ostrea*........................	2	6
112. "Slippery Bed," Ammonites, *Modiola, Astarte*, fish-scales		5½
113. Marl, numerous fossils, as above		2
114. "Slippery Bed," ditto...		7½
115. Marl, ditto		4½
116. "Sandrock," ditto		3
117. Marl, ditto		1½
118. "Sandrock," ditto		3
119. Marl, ditto		1
120. "Sandrock," ditto		9
121. Blue marl, ditto	1	0
122. "Sandrock," ditto		6
123. Blue marl, ditto	2	0
124. Stone, *Ammonites Johnstoni, Lima gigantea*...		8½
125. Blue marl, ditto		6
126. Stone, ditto		6
127. Blue clay, comminuted shells	3	6
128. Stone, with ferruginous pipes		5
129. Sandy marl, numerous *Entomostraca, Foraminifera*, &c.	3	0
130. Stone, *Unicardium, Lima gigantea*		7
131. Marl, fucoidal impressions		6
132. Stone........................		3½
133. Marl, *Entomostraca, Foraminifera, Lima duplicata*	1	8
Carried forward......	184	9

	ft.	in.
Brought forward......	184	9
134. Stone, *Lima Hermanni, L. gigantea*	1	0
135. Stone..........................		2
136. Blue clay, *Pecten sublævis* &c.	3	6
137. Stone..........................		2½
138. Clay	1	9
139. Ditto	1	2
140. Stone..........................		4½
141. Blue clay		9
142. Stone, *Lima gigantea* ...		5
143. Clay, ditto, *Ostrea liassica*	3	4
144. Septarian bed, *Nautilus, Gryphæa incurva, Ostrea*, &c.		5½
145. Blue clay	3	4
146. Septarian bed, *Gryphæa incurva, Lima gigantea, Ostrea liassica*	1	0
147. Blue clay, *Ostrea*, &c. ...	3	0
148. Stone, *Myacites, Ostrea*		5
149. Clay, *Ammonites planorbis*	2	0
150. Stone, Fish-bone, *Cardinia, Astarte, Myacites*		7
151. Clay		10
152. Stone..........................		5
153. Blue clay, *Ostrea liassica* &c.	2	6
154. Stone, ditto		8
155. Ditto, ditto		4
156. Blue clay, *Lima gigantea, Myacites*..................	3	0
157. Stone, *Nautilus, Pecten sublævis*		6
158. Clay, *Ostrea, Echini*, &c.		9
159. Stone, ditto		5
160. Clay, ditto..................	1	0
161. Stone, ditto		8
162. Blue clay	3	0
163. Stone..........................		5½
164. Clay	3	4
165. Stone..........................		6
166. Clay		1
167. Stone..........................		4
168. Blue clay	1	10
169. Stone..........................		5
170. Clay		1
171. Stone..........................		3
172. Ditto..........................	1	0
173. Ditto		5
174. Clay		2½
175. Stone..........................		5½
176. Clay	1	6
177. Stone..........................		4
178. Clay	1	9
Carried forward......	235	3

	ft.	in.
Brought forward ...	235	3
179. Stone		5
180. Clay		6
181. Stone		4
182. Clay	1	10
183. Stone		7
184. Clay	3	9
185. Stone		4½
186. Clay		4
187. Stone		6
188. Clay		11
189. Stone, *Ammonites planorbis*		6
190. Clay	2	0
191. Stone		6
192. Clay		2
193. Stone		9
194. Blue clay	3	4
195. Stone		7½
196. Blue clay	2	4
197. Stone		5
198. Clay		3
199. Stone		4½
200. Blue clay	1	4
201. Stone, *Ammonites planorbis*, and *Gryphæa incurva* more abundant...		4
202. Clay		9
203. Stone		6
204. Clay	2	0
205. Stone		8
206. Clay		1
207. Stone		8
208. Ditto		6
209. Blue clay, *Ammonites angulatus*	4	0
210. Stone		8
211. Clay	1	10
212. Stone		4
213. Clay	1	9
214. Stone		7
215. Blue marl	2	0
216. Stone		3
217. Marl	1	0
218. Stone		6
219. Marl	1	0
220. Stone		5
Carried forward	277	2½

	ft.	in.
Brought forward	277	2½
221. Marl	1	0
222. Stone		2½
223. Marl	1	0
224. Stone		4
225. Marl		2½
226. Stone		5
227. Marl		9
228. Stone		1½
229. Marl		8
230. Stone		6
231. Marl	1	0
232. Stone		6
233. Marl	1	0
234. Stone		3
235. Blue marl	11	0
236. Stone		6½
237. Marl		7
238. Stone		9
239. Blue marl	7	6
240. Stone		6
241. Marl	3	0
242. Stone		3
243. Marl	2	9
244. Stone		10
245. Marl	2	6
246. Stone		6
247. Blue marl	20	0
248. Stone		5
249. Marl		7½
250. Stone		5½
251. Marl		7½
252. Stone		9
253. Thick beds, blue marl, about	30	0
254. Stone		6
255. Marl	2	0
256. Stone		4
257. Marl	1	0
258. Stone		6
259. Marl	2	0
260. Stone		3
	375	4

Beds still continuing, but dipping under line of railway, thickness unknown.

In this important section we have a clear passage upwards, without any break, from the upper beds of the Keuper, though the Rhætic and White Lias series into the Lower Lias. The "White Lias" is here almost identical in thickness with the section (given in my former paper) at Steven's Hill, Long Sutton, about four miles distant; but whilst the limestone beds are thicker, there has been a corresponding decrease in the intervening beds of marl. There are large quarries near the railway-cutting in which the "White Lias" with the succeeding deposits can be well studied.

b. Organic Remains in Rhætic White Lias.—The organic contents of the "White Lias," considering the large area of its development, are comparatively few generically, and, being usually in casts, are difficult to determine specifically. It yields but two corals, a *Montlivaltia*, and *Thecosmilia Michelini*?; and it is worthy of remark that *Pecten Pollux* (*Suttonensis*, Taw.), in a dwarf form, appears in it for the first time, and in some localities is not uncommon.

Montlivaltia, sp.	Axinus concentricus.
Thecosmilia Michelini?	—— elongatus.
Cidaris Edwardsii.	Cardium Rhæticum.
Cythere liassica.	Lucina?
Avicula decussata.	Modiola minima.
Lima.	Myacites striato-granulata.
Ostrea intusstriata.	Pholadomya.
—— liassica.	Pteromya Crowcombei.
Plicatula acuminata.	Unicardium cardioides.
Pecten Pollux.	Chemnitzia, sp., casts.
——, sp.	Solarium, sp., casts.
Arca.	Turritella?, sp., casts.

c. The Insect and Crustacean Beds.—It is of importance to recognize this series of beds, Nos. 79 to 91, in the Camel section. With them we have again another very peculiar and interesting lithological and zoological change in the conditions of the period. Whilst the "White Lias" immediately beneath is throughout a concretionary deposit, without lamination, with a cessation of the conditions necessary to its formation, other beds succeed, which cover a very wide area, are most finely laminated, and thereby indicate very slow deposition. In this change we have another alternation from probably brackish-water deposits into those which are evidently marine, although of estuarine origin. My friend the Rev. P. B. Brodie, F.G.S., in his 'History of Fossil Insects,' as long back as 1845, pointed out the position in Warwickshire and Gloucestershire of certain "Insect-limestones;" and I am pleased to recognize their presence in the above beds, occupying the same geological horizon.

The numerous testacea which occasionally crowded the waters of the "White Lias" are almost wholly wanting in these beds; but rarely a few dwarfish *Modiola minima* are found therein. I have before remarked on the absence of Vertebrata and Cephalopoda in the "White Lias." The latter are still wanting in the Insect-limestone; for although Mr. Brodie alludes to the presence of *Aptychus* (the operculum of the Ammonite), in beds of Insect-limestone in some of his sections, I have no doubt that they are to be referred to a higher Insect-limestone, in which *Ammonites planorbis* occurs abundantly. This is the case in Liassic beds passing under the name of the "Black rock" (Nos. 31 to 36 of the section I gave in the Society's Journal for 1861, p. 485) at Beer Crowcombe. The vertebrata, in these Insect-limestones, come in very gradually, and are represented by a few scattered scales of *Lepidotus*.

Although my examination of these beds was somewhat hurried, I obtained specimens of Coleoptera and Orthoptera at Camel, and on the same horizon at Keinton Mandeville, four miles to the north-west. Next to the interest attaching to insect-life in these beds is the wonderful number of its Crustacea. I lately found on the railway at Pyle Hill, near Bristol, a block of stone which had come down from the top of that cutting; and, although only a foot square, it contained a colony of fifteen specimens, which my friend Mr. Woodward (see Geol. Journ. vol. xxii. p. 498) thinks belong to *Eryon Wilmcotensis*. At Wilmcote, near Stratford-on-Avon, this species comes from the "Bottom Block Bed" of the Lower Lias; at Pyle Hill also, from one of the basement beds*, and again at Camel it is found under similar circumstances, and apparently in as great abundance, as several specimens are to be observed in the same block. The persistency of similar conditions over so wide an area is of much interest. The quarrymen informed me that they had found vertebræ of either *Plesiosaurus* or *Ichthyosaurus* in these beds; but none came under my notice.

The beds 88 and 90 are called "Hat and Cap" by the quarrymen. Occasionally they contain concretions; and when these occur, the thin laminæ of the beds accommodate themselves to them, and often pass up in conical peaks to the upper surface of the superimposed limestone. When quarried, these flake off and form a rude "hat or cap," with which the boys occasionally adorn themselves.

The true passage from the Rhætic beds into the Lower Lias is through these beds; and wherever they are absent, to that extent there will be unconformability.

d. The Saurian and Ostrea Beds.—The "Firestones."—The next noticeable series of beds in the Camel-Hill section are the "Firestones," which are all composed of a dense coarse-grained blue limestone, lying very closely one upon another. These were included in my Beer Crowcombe sections under the "Saurian Zone," from the fact that they are the *chief* depository of the numerous *Plesiosauri* and *Ichthyosauri* of this period. It is from the "Firestones" that all the best paving-stones come, and they yield blocks of considerable superficial area. These limestones are worked at intervals in the south-west of England over hundreds of square miles, and, as previously shown by myself, they are found to be generally uniform in thickness over very wide districts, and the separate beds are often distinguished by the same names. From certain conditions, possibly their deposition in a shallower sea, or their encroachment on ancient coast-lines, the saurian contents of these beds may not continue. This is the case with their equivalents in South Wales, although in the district under notice, and in Gloucestershire and Warwickshire, the presence of saurians is so constant. In their absence this horizon is then to be recognized by the wonderful profusion of the *Ostrea liassica*, which in many instances literally cover the surfaces of the beds. This shell is also an abundant one in the "White Lias" below, and passes far upwards, although it occurs more sparingly in the higher members.

* The exact position of this bed will be seen on reference to the Bedminster section.

On the upper surfaces of the Firestone may be noticed species of *Cidaris*, fragments of *Lima* and *Pecten*, with casts of *Mya*, *Cardinia*, *Arca*, *Cardium*, *Modiola minima*, and a few fish-scales. The first notice of *Ammonites planorbis* was in bed No. 101, almost at the base of the Liassic series; and it is not improbable that it may be detected still lower.

e. The Ammonites-planorbis *and Sandrock Beds.*—Above the "Firestones" we reach a very thick series of beds which are always separated by intervening marl beds of greater or less thickness, the marls prevailing more especially in the upper members. The lower beds of this series at Camel Hill pass under the name of "Sandrock," though they are, like all the others, true limestones. The organic remains, although individually abundant, are still of comparatively few species in this district. In the beds 104 and 106 we find abundance of *Avicula decussata*, and on the same horizon also, at Hatch, a species which has hitherto been supposed to characterize the "White Lias," and in the latter bed *Ostrea arietis* (*multicostata*), so abundant in the Sutton Stone of South Wales. I shall hereafter show that this species passes high up into the beds of theBath district. The marls 129 and 135 are full of Entomostraca (of two new species, *Normania mundula*, Jones MS., and *Cytherella aspera*, Jones MS.), and more rarely Foraminifera (of the genera *Marginulina*, *Cristellaria*, *Frondicularia*, and *Trochammina*). It is important to observe that *Ammonites planorbis* passes, from the bed previously mentioned, almost, if not entirely, through the Camel Hill section. I was unable to examine the uppermost beds for it. With it occur, in bed 209, *Ammonites Johnstoni* and *A. angulatus*. With these are also *Lima gigantea*, *L. Hermanni*, and *Nautilus intermedius*. In bed 144 I observed the first *Gryphæa incurva*, which throughout the section is very rare, but is most abundant in No. 201, where it is associated with *A. planorbis*. Liassic Belemnites have hitherto been found only in the Bucklandi-beds; and not a trace of this family was seen at Camel.

I at first expected to find in a section of such thickness nearly all the Liassic series represented; but only its lower members are here exposed. The Bucklandi-beds which succeed are found at Evercreech, Alford, and other places around; but reference will more especially be made to these in the Bath district. At Alford I found part of an *Ichthyosaurus platyodon*, which is in the possession of the Rev. J. G. Thring, of Alford House. Taking into consideration the large development of the lower series as seen at Camel, the absence of the higher members, the dip of the beds, and the fact that the upper marls are in some places shown to be upwards of 100 feet in thickness, I am of opinion that the lower Lias in this part of England must have attained a thickness of from 600 to 800 feet.

f. Beer Crowcombe and Hatch Sections.—When I described the sections at Beer, in this Journal, vol xvii. p. 485, it was stated that the passage of the Rhætic beds upwards was not shown, and that the numerous Rhætic fossils there found were obtained from blocks that had been brought out of a canal tunnel. Within the last year an admirable section has been opened on the Taunton and Chard Railway at Hatch, which is on the edge of the same escarpment, but about two miles distant from Beer, in which the Keuper, Rhætic, and Liassic beds are again continuous.

On proceeding *by road* from Taunton to Hatch, the Keuper Sandstones are exposed about midway at Ruishton, and have yielded teeth of *Labyrinthodon*, serrated teeth of *Belodon*?, *Acrodus Keuperinus*, &c., with *Estheria minuta* in the more indurated marls. These beds are no doubt the equivalents of those yielding the same remains in Worcestershire and elsewhere.

Section of Keuper at Ruishton.	ft.	in.
Bluish-green marl	2	0
Brownish marl		3
Bluish marl	1	10
Red marl	1	4
Yellowish marl		1
Red marl		3
Grey marl		6
Red marl		9
Alternate bands of red and grey marl		9
Red marl	1	2
Bluish-green marl		8
Gritty conglomerate, with occasional sandy bands and intermediate layers of marl, with fish, reptile, and batrachian remains	1	2
Sandstone		2
Fine sandy bed		6
Thin bands, blue marl	4	0
Red marl with thin bands of grey	6	0

The above beds in their passage towards Hatch were seen, in shafts sunk on the line of railway, to be subordinate to gypseous marls, which were observed passing under the Rhætic and Liassic escarpment to the south-east. At Watchet, Aust, and Penarth, the Rhætic beds are seen to lie almost immediately upon these gypseous marls; but at Hatch there are clearly interposed a series of beds not only more varied in their general lithological character, but more regularly stratified than are the higher members of the Keuper generally. Although it may be suspected, it is very difficult to prove unconformability with these beds, owing to the almost entire absence of organisms through a great part of the series, and the similar lithological character they present. If we may assume that the gypseous beds at the bottom at Hatch, and those at the above places, are on the same horizon (which, from their mineralogical character, seems very probable), the beds which succeed in the Hatch cutting would be absent, and the Rhætic beds in those places would be unconformable.

Section of Keuper, Rhætic, and Liassic Beds at Hatch Beauchamp.

Keuper.—	ft.	in.
Gypseous marls, thickness unknown. Succession of seventy-five regularly stratified beds of grey, green, blue, and red marls and marlstones (a few beds honeycombed), without any trace of organisms, having an aggregate thickness of ...	70	0
which then pass into the following more argillaceous beds:—		
Dark-blue clay		4

	ft.	in.
Lighter ditto		4
Deep-black clay		3½
Lighter marl		6½
Grey clay		8½
Yellowish marl		5
Ditto		8
Blue marl		5
Grey ditto		5
Blue clay	3	9
Grey ditto		3½
Whitish sandy marl		4
Blue clay	2	0
Dark clay with nodular stones	2	0
Grey band		3
Black clay	1	8
Thin bands of grey and brown marl	4	0
Yellowish band		4
Greyish clays	2	0
Sandy grey marl		9

As the above have hitherto yielded no fossils, I am disposed to class them with the Keuper. They appear to graduate insensibly into the Rhætic beds which follow:—

Rhætic.	ft.	in.
Various beds of grey and brownish marl, with fish-remains ...	8	0
Grey oolitic stone with fish-bones, and teeth of *Hybodus* and *Acrodus*		5
Rubbly oolitic marl		7
Brownish marl	3	10
Blue clay with sulphurous-looking patches, *Avicula contorta*, &c.	7	0
The "Flinty Bed" of Beer Crowcombe		10
Yellowish and chocolate-coloured clay	1	3
Blue clay, with *Avicula contorta*, &c.	8	3
Followed on the east of the Hatch tunnel by grey laminated marl, and stone with *Acrodus*-teeth &c.		7
Grey stone with layers of darker colour	1	2
Light-blue marl	3	0
White Lias.		
White Lias, light-blue or cream-coloured	1	2
Thin rubbly beds full of *Arca*, *Ostrea intusstriata*, *Lucina*? *Myacites*, &c.		8
Light-blue marl	1	6
White Lias		9
Light-blue marl with shells	1	6
White Lias		6
Marl		2
White Lias		3
Ditto		7
Marl		4
White Lias		9
Rubbly layers of ditto		6
Nodular White Lias, *O. intusstriata*		6
Bluish nodular bed, ditto		2

The *Lower* or *Blue Lias* immediately follows; but as I have formerly given sections on the same horizon at Beer, they need not be repeated here. There are in this cutting 62 distinct beds above the "White Lias," having a thickness of about 60 feet. I have had therefore again in this section the advantage of an uninterrupted study of the upper beds of the Keuper, the whole of the Rhætic series, and the lower marls of the blue or Lower Lias, presenting in the whole about 186 beds, and attaining an aggregate thickness of 180 feet. The Insect and Crustacean beds are wanting at Hatch. As the Lias passes towards the station it becomes very much contorted, and the beds are in the greatest confusion. The organic remains are very similar to those at Camel, the only additions being *Ostrea intusstriata* in the bottom bed, and *Pholadomya ambigua* some way up. *Ostrea liassica* is abundant throughout the series, but *Ammonites planorbis* is less frequent than at Camel. About 10 feet above the White Lias, *Avicula decussata* is abundant in a bed of laminated blue marl.

The only observations necessary to make in addition to those in my former paper on the Beer Crowcombe sections are, that *Ammonites planorbis* has a wider range in them than was then indicated, and that I have found *Pecten Pollux* at the top of the series at this place.

Having given the above sections showing the normal condition of the succession of these rocks outside the Mendips and beyond their influence, I shall proceed to consider the same formations within the Coal-basin—reserving for future notice an important section at Shepton Mallet, with which it is my purpose to correlate the Sutton beds.

3. *Rhætic and Liassic Formations within the Coal-Basin.*—Although it will be shown, as has already been done with the Keuper, that the Liassic beds above the Rhætic series present very interesting points of comparison with those noticed south of the Mendips, an exception to the general unconformability of these groups must be made in favour of the Rhætic series within the Coal-basin. However varied or unconformable may be the formations which the Rhætic beds separate, the constant and uniform presence of the latter in the midst of so much that is unconformable is most remarkable. One reason in favour of my proposal in a former paper to include the "White Lias" in the Rhætic series, is to be found in the fact that the *Avicula-contorta* beds and the "White Lias" in this county invariably go together; and allusion has already been made to the continuity of these deposits over large areas in other districts. I believe it is correct to say that there is scarcely an exception *within* the Coal-basin south of Bath (and the same observation might apply *beyond* it) to the rule that where the Liassic beds are quarried, the "White Lias" may be found beneath. Whatever may be the beds above, invariably William Smith's "Sun Bed" (the top bed of the "White Lias") presents a uniform horizontal platform; and although these uppermost Rhætic beds are occasionally cut through by the subsequent formation of the valleys of the district in which they occur, their regularity and condition forbid the supposition that they have been subject to any important denuding agencies, which might have been expected had the thinning out, or the absence, of the Liassic rocks above them been due to denudation.

Within this area organic remains in the "White Lias" are very rare; and the general character of the deposit is such as we might expect to find in a lagoon, or inland sea, in which the beds were being very tranquilly deposited. The *Avicula-contorta* beds at the base of the "White Lias" are not usually exposed; but sections of these will be given in describing the railway-cuttings near Bath. Amongst the many localities in this district where the "White Lias" can be studied, may be mentioned Radstock, Camerton, Farringdon Gurney, Paulton, Norton, Willsbridge, Nettlebridge, Saltford, Beech, Bedminster, and a very peculiar deposit at Broadfield Down, near Bristol.

I now propose giving some of the most interesting sections in the Coal-field north of the Mendips; and though I have no special faith in precise Ammonite or other zones of life, to which I refer below, yet for the sake of establishing comparisons with the divisions of other geologists, and the more readily to realize the unconformable conditions of the beds in the district, I give the following horizons based upon the supposed range of Cephalopoda therein.

Upper Lias.	1. Ammonites Jurensis.
	2. A. communis.
Middle Lias.	3. A. spinatus.
	4. A. margaritatus.
	5. A. capricornus.
	6. A. ibex.
	7. A. Jamesoni.
Lower Lias.	8. A. raricostatus.
	9. A. oxynotus.
	10. A. obtusus.
	11. A. Turneri.
	12. A. Bucklandi.
	13. A. angulatus (A. cateanus, *Desh.*, A. Moreanus, *D'Orb.*).
	14. A. planorbis (A. Hagenovii, *Dum.*, A. psilonotus, *Quenst.*).

a. Section of Keuper, Rhætic, Lower Lias, Middle and Upper Lias, and Oolitic Beds at Camerton.

				ft.	in.
Inferior Oolite	6.		Inferior Oolite in roadway leading from Tunley to Camerton	3	0
Upper Lias	5.		Uncovered beds embracing Upper Lias, about...	40	0
Middle Lias......	4.		Irregular beds of marlstone and clay	2	0
Am. raricostatus......			*e.* Nodular stone, with *A. raricostatus*		3
			d. Brownish clay	2	0
			c. Blue limestone with fish-scales, *Aptychus*, and *Ammonites semicostatus*		6
Foraminifera-zone ...			*b.* Blue clay with Foraminifera	8	0
Spirifer-bank			*a.* Indurated marl, "Spirifer-bank" of Quenstedt.		6
Lower Lias	3.	Ammonites-Bucklandi or Lima-Beds.	Grey Lias		9
			Clay		1
			Grey Lias	1	2
			Clay		2
			Grey Lias		3
			Ditto		6
			Clay		1
			Grey Lias		3¼
			Clay		3
			Grey Lias		4
			Clay		2
			Corn Grit		8
			Clay		2

		ft.	in.
White Lias ...... 2a.	White Lias "Sun Bed"	1	3
	Thin bed		2
	White Lias		8
	Ditto		8
	Ditto		8
	Thin shell, six thin beds..............................	1	2
and	White Lias		6
	Clay		2
	White Lias		2
Rhætic Beds...... 2.	Ditto		5
	Ditto		5
	Ditto		5
	Ditto		2
	Ditto, "Tile Bed"		5
	Ditto		2½
	White Lias, Bottom bed.................................		7
	Avicula-contorta marls, estimated from coal-shafts..	14	6
	Greenish marls, base of Rhætic, in roadway to Radford..	10	0
Keuper........... 1.	Red marls of Keuper towards Radford...........		

In this truly interesting section are embraced within 100 feet all the beds between the Keuper and the Upper Ragstones of the Inferior Oolite.

The Keuper (1).—Red marls of this formation are exhibited in the roadway leading from Camerton to Radford, but do not call for any special observation.

Rhætic Beds (2).—The basement marls of this formation rest immediately upon the above. The superimposed *Avicula-contorta* clays, not being open, are estimated from sinkings made for neighbouring coal-shafts.

The White Lias (2 *a*) throughout the whole of this district varies very little in thickness, and has always present its uppermost characteristic "Sun-bed." Its general characters being so uniform, the former notice I have given of it at Camel and Hatch will suffice. In this district it is usually very unfossiliferous.

The Lower Lias (3).—The moment we pass the above horizon the most interesting evidences of unconformability are everywhere found. Between the "Sun Bed" and the "corn-grit" in this series we ought to find the two lower zones of *Ammonites planorbis* and *A. angulatus*. As the "Grey Lias" beds in this section are undoubtedly on the same horizon as the *Ammonites-Bucklandi* beds, it is at once seen that the lower members of the Lias are here altogether wanting. Not only are the basement Insect-beds absent, but the whole of the 186 beds given at Camel, above the White Lias, are unrepresented. In a section at the Wells Way Quarry, at Radstock, the beds on this horizon are about forty in number. At this place the thin bed of marl between the corn-grit and the White Lias has its thin laminæ accommodated to the undulated surface of the latter, and contains scattered remains of Liassic fishes. Wherever the Lower Lias is worked, for miles around, it is always in beds having the same geological horizon as the Camerton Grey Lias; and such is also the case at Twerton, Weston, Saltford, Keynsham, and other sections near Bath. It should be here noticed that, although *Ammonites angulatus* and *A. Bucklandi* are supposed to represent two distinct horizons, these sections are seen to have those shells in common; and often the former species will be found the prevailing one, and attaining very large dimensions.

The species found in the Camerton Gray Lias include:—

Ammonites Bucklandi.	Avicula inæquivalvis.
—— Conybeari.	Pinna.
—— angulatus.	Pholadomya ambigua.
—— Turneri.	Rhynchonella variabilis.
Nautilus striatus.	Terebratula numismalis.
Ostrea liassica.	—— punctata.
Gryphæa incurva.	Spirifera Walcottii.
Pecten sublævis.	Cidaris Edwardsii.
Lima gigantea.	Pentacrinus tuberculatus.
—— Hermanni.	Ophioderma.
—— duplicata.	Serpula strangulata.
Plicatula sarcinula.	Belemnites acutus.

The Spirifer-bank (*a*).—Lying upon the above beds we find an indurated brownish marl characterized by the enormous number of the *Spirifera Walcottii* it contains, some of which attain considerable size for this genus, and are in a good state of preservation. Professor Quenstedt has, in his 'Der Jura' recognized the presence of this zone in Germany on the same horizon; and it is interesting to observe that, though it is but 6 inches in thickness, its continuity has extended so far. The bed is of a somewhat conglomeratic character, and contains numerous casts of *Pholadomya ambigua*, *Myacites*, *Gervillia*, and *Ammonites semicostatus*.

The Foraminifera-zone (*b*).—This deposit, which is a laminated blue clay of 8 feet in thickness, may be truly so denominated, since I have found therein, for the first time in the Lias, not less than twenty-eight species of these beautiful little shells. They will be figured and described by my friend Mr. Brady, F.G.S., in the publications of the Palæontographical Society. Although at the top of the Lower Lias, many of the species are common to so-called Infraliassic beds; with them are associated *Plicatula spinosa*, many Entomostraca, Pentacrinites, and fish-scales.

Dentalina communis, *D' Orb.*	Marginulina raphanus, *Linn.*
—— interrupta, *D' Orb.*	—— lituus, *D' Orb.*
—— obliqua, *Linn.*	Nodosaria fascia, *Linn.*
—— obliquestriata, *Reuss.*	—— paucicostata, *Röm.*
—— ovicula, *D' Orb.*	—— radicula, *Linn.*
—— pauperata, *D' Orb.*	—— raphanus, *Linn.*
Cristellaria cultrata, *Mont.*	—— raphanistrum, *Linn.*
—— crepidula, *F. & M.*	Planularia Bronni, *Röm.*
—— costata, *D' Orb.*	—— cornucopiæ, n. sp.
—— rotula, *Lamk.*	—— longa, *Cornuel.*
Frondicularia complanata, *D' Orb.*	Trochammina incerta, *P. & J.*
—— striatula, *Reuss.*	Vaginulina legumen, *Linn.*
Involutina liassica, *Jones.*	—— lævigata, *Röm.*
Lingulina carinata, *D' Orb.*	—— striata, *D' Orb.*

A blue limestone (*c*) with a laminated fracture, weathering yellow externally, and somewhat resembling the Upper-Lias fish-bed, contains scattered remains of fishes, the *Aptychus*, and *Ammonites semicostatus*.

Ammonites-raricostatus *Zone* (*d*, *e*).—This Ammonite is abundant in a band of nodular stone (*e*) at the top, and by its presence usually distinguishes the line of separation between the Lower and the Middle Lias.

The Middle Lias (4).—In the Camerton and other sections of the district the passage is at once from the *Ammonites-raricostatus* zone into thickly bedded Marlstone containing a most abundant and varied series of organic remains. In the section which is at this time being worked at Camerton, the Foraminifera-clay is the highest member; but in a continuation of the beds, in a field adjoining, the other strata are present. The Marlstone is here seen to consist of irregular beds about 2 feet thick, immediately under the surface; but in Old Pit Quarry at Radstock, at Paulton, and in other sections, it occasionally attains a thickness of 15 feet. The bottom of the Marlstone at Radstock is conglomeratic, and contains *Ammonites raricostatus* and other shells, which appear to have been removed from the lower zones. In these marlstones a very prevailing shell is *Gryphæa Macculochii*; they also contain abundance of Brachiopoda, amongst which are *Terebratula punctata*, *T. Waterhousii*, *T. numismalis*, *Rhynchonella ramosa*, *R. furcillata*, &c. When these were figured from this zone at Radstock by my friend Mr. Davidson, the distinction between the different horizons in this district was not known; and these shells were supposed to be from the Lower instead of the Middle Lias.

Upper Lias and Inferior Oolite (5, 6).—No section of the Upper Lias is uncovered in this district, and, wherever present, it appears to be thin. From the Camerton quarry to the roadway under Tunley the position of the Inferior Oolite is seen. As the latter appears to be the equivalent of the Upper Ragstones of the Cotteswold Hills, there is with these formations a similar thinning out, such as I have intimated in the case of the Lower Lias, and all the beds from the base of the Middle Lias to the higher portion of the Inferior Oolite in the Cotteswolds, are embraced within a thickness of about 50 feet.

I might give many sections showing the same general characters; but one other, and that not the least remarkable, must suffice. At Paulton there are several quarries in which the White Lias and the Lima-beds above, with the Spirifer-bank and other zones are present, as in the Camerton section. Near Paulton is a roadside quarry in which the Lower Lias is still more feebly represented.

b. Section in Munger Road Quarry.

		ft.	in.
Middle Lias.	Various beds of rubbly marlstone	6	0
Lower Lias.	Grey sandy bed with *Leptæna rostrata*, Foraminifera, *Belemnites clavatus*, *B. acutus*, &c.	0	5¼
	Stone with *Ammonites raricostatus*	0	6¼

		ft.	in.
Lower Lias.	Grey sand with *Spirifer Walcottii*, *Gryphæa incurva*, &c., *Belemnites clavatus*, *B. acutus*, &c.	0	6
Rhætic White Lias.	Various beds as at Camerton, &c.	10	0

At this place there is the interesting phenomenon of only three beds, 18 inches in thickness, occurring between the Rhætic and Middle-Lias formations, and representing the great thickness of interposed beds elsewhere. As the thick-bedded marlstone, in every other section near, immediately succeeds the stone with *Ammonites raricostatus*, I am rather uncertain whether to classify the upper grey sand-bed with the Middle or the Lower Lias, or whether, from its having organic remains in common with both, it should not be regarded as a passage-bed. It is one of much palæontological interest, from the fact of my recognizing in it the genus *Leptæna*, and thus linking this Palæozoic genus in this county with the five species I have already discovered in the Upper Lias of Ilminster. My esteemed friend Dr. Deslongchamps, of Caen, whose valuable memoirs have added so much to our knowledge of the Secondary rocks of the south of France, has already discovered this species at Fontaine-étoupe-Four, in Normandy, and has described it under the name of *Leptæna rostrata*. It is stated by that author that it occurs exclusively in the Argiope-bed of that locality; but although, when I describe the Whatley section, it will be found in this association there, such is not, as far as my knowledge goes, the case at Munger. I believe that M. Deslongchamps's specimens have been collected from fossiliferous pockets of Liassic age redeposited on Silurian rocks; and if so, their geological horizon can be better fixed at Munger. Of the Belemnites associated with them, *B. clavatus* has been found in the Middle Lias, but *B. acutus* has hitherto been regarded as a Lower-Lias species. The four genera of Foraminifera given below are Middle-Lias forms; but these organisms are known to have a very wide range. The Starfishes are represented by a beautiful little *Tropidaster pectinatus*, Forbes, with its rays perfect, and only about a line in breadth.

The two lower beds undoubtedly belong to the Lower Lias; and if the upper is not considered to belong to this group, the horizon of *Leptæna rostrata* must be fixed at the base of the Middle Lias. As in France, it is accompanied by *L. Bouchardii*, hitherto found only in the Upper-Lias Leptæna-clays of Ilminster. The Munger beds are in great part composed of the disjointed ossicles of Pentacrinites.

List of Organic Remains from Munger.

Cristellaria rotula, *Lam.*
—— lituus.
Lingulina tenera, *Born.*
Nodosaria Zippei, *Röm.*
Cidaris.
Ophioderma (joints).
Pentacrinus.
Tropidaster pectinatus, *Forbes.*
Serpula.
Crustacea, claws of.
Entomostraca.
Discina (fragments).
Leptæna Bouchardii, *Dav.*
—— rostrata, *Desl.*
Rhynchonella furcillata.
Spirifera verrucosa (S. rostrata ?).

Terebratula punctata.
Thecidium Bouchardii.
——, sp.
Avicula.
Gryphæa incurva, *Sow.*
Lima, sp.
——, sp.
Pecten.
Plicatula spinosa, *Sow.*
Astarte, sp.
Trochus epulus, *Stol.*
Turbo.
Belemnites acutus.
—— clavatus.

Teeth of fishes, with Encrinital stems derived from the Carboniferous Limestone.

The organic remains from the Middle and Upper Lias, numbering about 580 species, have been noticed by me in a Memoir "On the Middle and Upper Lias of the South-west of England," in the Proceedings of the Somersetshire Archæological and Natural History Society for 1865–66.

4. *Relative Thickness of Secondary Beds within and beyond the Somersetshire Coal-basin.*—Having already referred to the thinning out and comparative insignificance of the Triassic beds within the coal-basin, as compared with their representatives beyond, we are enabled by the sections that have been given to realize the same fact with regard to the formations above. The Lower Lias, which is estimated at 700 feet, is at Munger reduced to 18 inches. The Middle and Upper Lias on the Dorsetshire coast is described by Mr. Day as 500 feet thick *. The latter, though thin in Somersetshire, is known to attain a very considerable thickness in Yorkshire. Above the Upper Lias there is again a great hiatus in the Oolitic series, no beds below the Upper Ragstones of Gloucestershire having been observed in any sections in the districts around Bath, the beds thus wanting, judging from the estimate of Dr. Wright in the Cleeve Hill† section, being 170 feet thick.

Comparing the greatest thickness of the Secondary beds without the coal-basin with the greatest reduction above the Coal-measures within it, we arrive at the following remarkable result:—

	Without Coal-basin.	Within Coal-basin.
	ft.	ft.
Triassic beds	2000	50
Rhætic beds	50	50
Lower Lias	700	2
Middle and Upper Lias	500	42
Inferior Oolite	170	25
	3420	169

5. *Whatley Lias and Fontaine-étoupe-Four.*—The intimate relations, both stratigraphical and palæontological, which exist between the Upper-Lias Leptæna-beds of Ilminster and those of Curcy, May, and Fontaine-étoupe-Four, in Normandy, are very remarkable. At Ilminster these Leptæna-beds are only 18 inches in thickness, and are overlain by the Saurian and Fish-bed with its numerous beautiful

* "On the Middle and Upper Lias of the Dorsetshire Coast," by E. C. H. Day, Esq., F.G.S., Quart. Journ. Geol. Soc. vol. xix. p. 279.

† "Additional Notes on Cleeve Hill Section," by T. Wright, M.D., F.R.S., F.G.S., Proceedings of the Cotteswold Naturalists' Field-club, 1865.

Teleosaurus temporalis, Ichthyosauri, Fishes, Crustaceans, and Insects. Although so thin, these beds are most precisely repeated in many of the Normandy sections; and not only does the thin line of the Saurian and Fish-bed yield its *Teleosauri, Ichthyosauri* and fishes, though generally not so perfect as are my examples from Ilminster, but the Leptæna-clays have yielded all the small though interesting series of Brachiopoda which have made this zone celebrated. Whilst at Ilminster and in Gloucestershire, where the same beds are found, they form part of an uninterrupted series of Liassic deposits, resting upon the Middle Lias marlstone, which is the upper member of that formation, and therefore always on the same stratigraphical horizon, at Curcy, May, and Fontaine-étoupe-Four they are found unconformable, in little depressions or basins on the edge of an extended series of Silurian rocks. M. Deslongchamps, in his "Mémoire sur la Couche à Leptæna du Lias," 1859, states that these more ancient beds belong to the Caradoc sandstone, and that they extend from Caen towards the south, by way of Bretteville-sur-Laize as far as Verson, to May, Ferguerols, Fontaine-étoupe-Four, &c. In some instances he states that the organic remains are assembled on the rugged edges of the upturned Silurian rocks, in which case they are found in great profusion. Although I was quite satisfied of the parallelism of the deposits of Curcy and May with those of Ilminster, though found under such dissimilar conditions, M. Deslongchamps subsequently described a fauna from Fontaine-étoupe-Four, which he considered to be of the age of the Middle Lias, containing the genera *Argiope* and *Suessia*, together with *Spirifera Davidsoni* and other interesting forms never recognized in England, and which I, knowing, as I supposed, almost every locality where they were likely to be found, almost despaired of ever obtaining in this country.

During a late visit to the Rev. J. S. H. Horner, of Mells, near Frome, the possessor of one of the most varied and interesting geological districts in this country (some parts of which I shall hereafter notice), that gentleman was driving me to the *Microlestes* quarry at Holwell, of which he is the proprietor, when, near Whatley, on crossing one of the pretty Carboniferous-limestone ravines which traverse this district, we passed a little section of almost vertical Carboniferous limestone, which extended for a few yards under the embankment of the roadway. On looking back I noticed a thin horizontal deposit of greyish-looking clay above it. Returning for its examination I was pleased to find that the thin band in immediate contact with the limestone was almost made up of organic remains, evidently pertaining to the horizon of the Middle Lias, although we were many miles from any recorded development of this formation. I soon removed all I could reach of the deposit, and in my examination had the satisfaction of realizing, as one new genus or species after another presented itself, that I had at last obtained the fauna of Fontaine-étoupe-Four in England; and so precisely does this fauna correspond with the descriptions of M. Deslongchamps, that a simple translation of his Memoir would almost suffice for its description.

Fig. 2.—*Section of Lias and Carboniferous Limestone at Whatley.*

			ft.	in.
	c.	Drifted deposit, partly composed of a ferruginous clay, enclosing blocks of Inferior Oolite	4	0
B.	b.	Grey clay with *Argiope, Suessia, Spirifera, Pentacrinites*, &c.	0	10
	a.	Grey laminated micaceous marl, without organisms	1	2
	C.	Carboniferous Limestone, exposed	3	0

The Carboniferous Limestone, which, though almost vertical, is seen to have been worn down to a very horizontal surface, is only open in this section for a few yards in length.

The uppermost deposit (*c*) is much hidden by the vegetable growth of the embankment, and must be as late as the Oolite, since it contains blocks of that age, having many imperfect casts of Echinodermata, with *Lima gibbosa* and *Lithodomi*. This is evidently a drifted deposit, and has mixed up with it many blocks of sulphate of barytes. The Oolite in this immediate neighbourhood, whenever it comes in contact with the Carboniferous Limestone, puts on very peculiar mineralogical conditions, its under surface being at times an iron-ore, whilst at others it is very porous and full of cavities, the matrix being composed of sulphate of barytes. On the opposite side of the roadway an oolitic rock is visible, which probably belongs to the Fuller's earth, as the clays of this formation come in immediately above it.

B. The Lias, 2 feet in thickness, which is intermediate between the Carboniferous Limestone and the Inferior Oolite, may be divided into two parts:—the first (*a*) is composed of a bluish or grey laminated micaceous marl; but after careful search I have hitherto been unable to detect any fossils in it.

b. The bed which follows is seen to rest immediately on the Carboniferous Limestone. In its upper part the fossils are rare, but, as it reaches the limestone, they become more abundant, and the basement is seen to be almost entirely composed of *Brachiopoda, Echini, Pentacrinites*, &c., which are held together by a somewhat friable calcareous matrix. Occasionally, on the Carboniferous Limestone, its base is converted into a thin indurated limestone, which is difficult to separate from the older rock.

That this remarkable representative of the Fontaine-étoupe-Four Lias is very local, there cannot be a doubt; for immediately below the section I have given there is a large Carboniferous-limestone quarry, on the upper surface of which I had hoped to find its continuation, but no trace of it was present. The hollows at the top were filled with Oolitic débris, and with the sulphate of barytes before mentioned.

In an examination of the fossils contained in this peculiar deposit, resting as it does on a floor of Palæozoic rock, and on a coast-line along which subsequent formations may have been subject to denudation, it would not have been singular to have found an admixture of the organic remains of several periods; but beyond a small *Spirifer*, and a few stems of Encrinites of Carboniferous-limestone age, this is not the case. It may, therefore, be safely inferred that the Whatley deposit represents a special horizon in time, which I think will have to be placed at the junctien of the Lower and the Middle Lias, or between the Spirifer-bank and the *Gryphœa-cymbium* beds of the Camerton section; and the discovery of *Leptœna rostrata* and other remains common to the two sections helps to support this conclusion.

The organic contents of the Whatley deposit show by their condition that they were not immediately covered by other deposits. The Spirifers and the Bivalves are usually in single valves, and the Echini and Pentacrinites are dismembered. This has given rise to many interesting instances of parasitic attachment; for instance, on the interior of a *Spirifera Deslongchampsii*, there is attached a *Plicatula spinosa*, and to this again a *Thecidium Bouchardii*, and Bryozoa of the genera *Berenicia* and *Neuropora*.

Of the Vertebrata I have obtained from Whatley several small striated teeth, which appear to have belonged to a very small *Ichthyosaurus*. Of fish-remains there are present the teeth of *Hybodus* and several other genera; a single dermal spine or scale probably represents the *Raiadœ*, and there are also several depressed spinous-looking bones or teeth not unlike *Sphenonchus*. I have found teeth of the same species of *Hybodus* in some of the deposit from May given me by my friend Mr. Davidson; and the same species occur also in the Leptæna-bed at Camerton.

The Cephalopoda, with the exception of *Belemnites clavatus* and *B. acutus*, are very rare. I have found a fragment only of a *Nautilus* and a *Rhyncholites* similar to one figured by M. Deslongchamps.

The Brachiopoda, on the contrary, are very abundant, and present a variety of forms new to this country. Amongst these are several species referred, with some doubt, to *Argiope*. Whatever it may be, I have previously found the same genus at Dundry, and described it as *Spirifera oolitica*; and the same species passes up into the great Oolite. Of this genus I have two, if not three, species from Whatley, *Argiope*? *Suessii*, E. Des., and *A.*? *Perieri*, E. Des., the latter being very abundant. *Leptœna rostrata*, previously noticed at Camerton, again occurs, and associated, as before, with *L. Bouchardii*. With the *Rhynchonella furcillata*, which is plentiful, we have two new forms—*R. egretta*, Des., and *R. fallax*, Des. *Spirifera*, again, affords two, if not three, new species. These are *S. oxygona*, Des., and *S. Deslongchampsii*, Dav. The latter very beautiful shell is particularly abundant, though it never occurs with its valves united, and not often in very good condition. *Thecidium Bouchardii*, the commonest Brachiopod in the Inferior Oolite of Dundry, is equally plentiful in the Whatley Lias, and reaches a good size for this genus. *T. Moorei*, Dav., *T. granulosum*, Moore, and *T. rusticum*, Moore, occur with it, but are rare.

The Bryozoa yield two genera—*Berenicea* and *Neuropora*.

The Echinodermata, of which the bed is in great part composed, yield the new genera *Cotylederma* and *Plicatocrinus* of Deslongchamps, with several other genera.

The following list contains a goodly series for so abnormal a deposit:—

Organic Remains from Whatley.

Argiope Suessii, *E. Des.*
—— liassina, *E. Des.*
—— Perieri, *E. Des.*
Crania Gumberti, *E. Des.*
Leptæna rostrata, *E. Des.*
—— Bouchardii, *Dav.*
—— Davidsonii.
Rhynchonella furcillata, *Theo.*
—— egretta, *E. Des.*
—— fallax, *E. Des.*
Spirifera Walcottii, *Sow.*
—— oxygona, *E. Des.*
—— Deslongchampsii, *Dav.*
Suessia imbricata, *Desh.*
Terebratula punctata, *Sow.*
Terebratulina Deslongchampsii, *Dav.*
Thecidium Bouchardi, *Dav.*
—— granulosum, *Moore.*
—— rusticum, *Moore.*
Cidaris Edwardsii, spines, &c.
——, sp,, spines.
——, sp., spines.
Pentacrinus robustus, *Wright.*
—— tuberculatus, *Mill.*
——, sp.
Berenicea Archiaci, *Haime.*
Neuropora Haimii, *E. Desh.*
——, n. sp,
Serpula, sp.
——, sp.
——, sp.
Apiocrinus Amalthei, *Quenst.*
Cotylederma fistulosa.
Cotylederma vasculum, *Des.*
Ophioderma, joints of.
Plicatocrinus Mayalis, *Des.*
Avicula inæquivalvis, *Sow.*
——, sp.
Gryphæa depressa, *Phillips.*
—— incurva?
Lima punctata.
—— Deslongchampsii, *Stol.*
—— Haueri, *Stol.*
——, sp.
——, sp.
Ostrea ocreata, *E. Des.*
—— monoptera, *E. Des.*
Pecten textorius, *Schloth.*
——, sp.
——, sp.
——, sp.
Plicatula spinosa.
Astarte, spec. nov.
Chiton (Peltarion) bilobatus, *Des.*
Trochus epulus, *Stol.*
——, sp.
Turbo, sp.
Belemnites acutus, *Mill.*
—— clavatus.
Nautilus, fragment.
Rhyncholites.
Hybodus, teeth of.
Raia, scale or spine.
Sphenonchus.
Ichthyosaurus, teeth of.

6. *Mells Middle Lias and Coal.*—In all the sections in which I have recognized the Middle Lias in this district, the beds are those containing *Gryphœa cymbium*, or *G. Maccullochii*, and are therefore the very bottom of this formation, resting immediately upon the Lower Lias. The Middle Lias of Ilminster, which is the equivalent of that in Gloucestershire, and of the ironstones of Yorkshire, is a much higher zone, and is well known by its *Pecten æquivalvis*, *Ammonites margaritatus*, *A. spinatus*, &c. The nearest point

at which this bed had been recognized was at Batcombe, near Bruton, eight or nine miles to the south.

A coal-shaft has lately been sunk at Holwell Farm, near Mells, on the property of the Rev. J. S. H. Horner, commencing in beds which are mapped as Inferior Oolite. Immediately to the south, at Mells, are Dolomitic Conglomerates of great thickness, which rest upon or against the Carboniferous Limestone of the Mendip range. Almost close to the pit are the Carboniferous limestones at Vobster, enclosed on the south and south-west by nearly vertical Coal-measures. From the "old men's" workings around, it was expected that coal would soon be reached; but before this the very interesting and unexpected section given below was passed through.

After passing through 18 feet of rubbly sandstone and clay, which graduated into a micaceous marl, the miners reached a rock which was described as dense and unstratified, and one with which they were quite unfamiliar. On specimens being sent me, I at once recognized, by its lithological structure alone, the presence of the marlstone, which was confirmed by the abundance of its characteristic fossils. Amongst these were *Ammonites spinatus*, *Pholadomya ambigua*, *Belemnites paxillosus*, and a *Montlivaltia*, the first coral found in the Marlstone of this district. In the blue marl above I found a perfect example of *Ophioderma Egertoni*, fine examples of which occur in a similar micaceous marl on the Dorsetshire coast.

Section of a Coal-shaft at Mells.

		ft.	in.
	1. Soil	1	0
Inferior Oolite?	2. Sandstone and sand	5	0
Middle Lias	3. Grey variegated clay	5	0
	4. Blue marl	7	8
	5. Middle Lias marlstone	9	0
Coal-measures	6. Fire-clay	3	6
	7. Coal	0	4
	8. Fire-clay	2	0
	9. Coal	1	0
	10. Bord binds with balls of mine	14	6
	11. Grey metal	8	9
	12. Fire-clay	1	0
	13. Coal	0	6
	14. Clod	1	0
	15. Coal	1	0
	16. Bord Cliff	5	0
	17. Mine	0	3½
	18. Grey metal	5	6¼
	19. Bord Cliff with balls of mine	7	3
	20. Grey metal	3	6
	21. Coal	0	10
	&c. &c.		

IV. Abnormal Secondary Deposits upon the Carboniferous Limestone.

The description I have given of the horizontal stratified deposits beyond the Mendips, and of their unconformable conditions within its coal-basin, will better enable us to understand the very interesting and abnormal conditions which deposits of the same age present when they are more immediately in connexion with the Carboniferous Limestone. When this is the case, they are found either resting immediately upon the limestone, filling up any basins or irregularities in its surface (when there have been any opportunities), passing down into its fissures, or lying against the southern outer edge of what there is every reason to suppose was the ancient Rhætic and Liassic coast-line presented by the Mendips at these and subsequent periods.

1. *Marston Road Section.*—Just above the hamlet of Holwell, in the direction of Marston, a small roadside section of about 10 feet in depth by about 30 yards in length, on the extreme south-eastern exposure of the Carboniferous Limestone, affords the first indication in this direction of the peculiar connexion of the Secondary with the Palæozoic rocks. At this spot large quarries of Carboniferous Limestone in the valley below are to be observed; and so precisely similar in its lithological aspect is most of the stone in this section, that, without an examination for its organic remains, it would readily be supposed to be of Carboniferous-limestone age. In this very small section, however, four geological formations are represented—namely, the Carboniferous, the Rhætic, the Lias, and the Inferior Oolite.

In the lower portion of the quarry there is a capping of horizontal Inferior Oolite 2 feet in thickness, rather dense and conglomeratic at its base, but containing many organic remains of that age. However altered may be the condition of the beds below this formation, the Oolitic rocks in this district, although they may be thinly represented and unconformable, are usually horizontal, and but little altered in character.

Immediately below the Oolite occurs a very dense unstratified deposit of Liassic age, in part composed of the disjointed ossicles of Pentacrinites, the matrix being a variegated yellow, pink, or brown limestone. The presence of *Gryphæa incurva*, *Belemnites*, *Spirifera Walcottii*, *S. Munsterii* (*S. lata*, Martin), *Terebratula punctata*, *T. Waterhousei* (*T. retusa*, Martin), with *Rhynchonella furcillata*, *R. variabilis* and *R. subvariabilis*, sufficiently attest its Liassic origin. It is, however, difficult to determine with certainty the precise stratigraphical horizon to which to assign it; but as most of the above species are found in or above the Leptæna-bed of the Camerton section, I am led to believe that the date of the deposit is about that of the passage of the Lower into the Middle Lias, and that it would therefore be on the horizon of the Fontaine-étoupe-Four beds, and of the Hierlatz-Schichten, which belief is strengthened by the presence of *Pecten verticillus*, *P. Rollei*, and *P. palosus*, all species from Hierlatz, whilst others, common to both, will be referred to from Liassic veins in the quarries below.

The Rhætic deposits are represented in the western end of this section by a friable marl, about 10 inches thick, in which occur teeth of *Acrodus*, *Sargodon*, &c., and vertebræ of *Lepidotus*, whilst in the floor of the quarry the Carboniferous Limestone is seen. To add to this remarkable variety, a mineral vein, 8 feet in thickness, has been left standing towards the roadway, and has met the base of the Inferior Oolite; and there are also two caverns in the Liassic limestone which have not been explored.

Similar conglomerates are found fringing the Carboniferous Limestone towards East Cranmore, in the direction of Shepton Mallet.

Holwell is at the southern end of the Nunney and Whatley combs, where, in this part, the Carboniferous Limestone has its greatest breadth—about half a mile. The ravine continues from Cloford to near Egford Bridge, the Inferior Oolite and Fullers' Earth, which form the tablelands on each side, encroaching upon the limestone, and narrowing its superficial breadth in this direction. At Egford Bridge, although the line of the valley can still be traced, the limestones are cut off superficially by a covering of these Oolitic beds. Their south-eastern exposure is about 5 miles in length.

On looking down upon the hamlet of Holwell, its various-coloured limestones give a very picturesque effect; and I have no doubt that the first conclusion drawn would be that everything there was Carboniferous Limestone; but a closer examination would show this to be an error.

Passing downwards from the quarry previously mentioned, we find, north of the road and parallel with it, a face of limestone-rock 30 feet in height by 120 feet in length, which lithologically has all the aspect of Carboniferous Limestone, but in which may be detected on close examination *Spirifera Walcottii*, spines of *Cidaris*, and other remains of Liassic age. Just below we obtain a key to the solution of the difficulties attending the interpretation of the section, which the facts just mentioned might otherwise have afforded.

2. *Holwell Carboniferous Limestone and Liassic Dykes.*—A roadway leads into the western face of two quarry-sections, extending for a length of 428 feet, all of which, again, would at first sight readily pass for Carboniferous Limestone. On looking at the general contour of the first quarry, which has a length of about 230 feet, it may be noticed that the quarrymen do not work it regularly, but rather follow certain blocks or vertical courses of stone into the hill, leaving irregular projecting vertical abutments, which are not touched until they are found to be in the way; and the reason they assign for this is, that the limestone is of different qualities, and their object is to extract the best. The ragged-looking dykes thus left projecting from the face of the quarry may be traced to the top, which is here without any capping of Secondary rock. In most instances they thicken as they pass down, and one which may be from 10 to 15 feet in breadth 30 feet below the surface of the quarry, may be scarcely traceable, or divided into thin cracks or fissures at the surface, through which in great part the infilling has taken place.

An examination of this supposed Carboniferous-limestone quarry shows that at least one-fourth of it is of Liassic age. The curious phenomena here observed, and especially the thickening of the dykes of more recent age downwards, are somewhat difficult to account for. An analogous state of things might arise, could we suppose

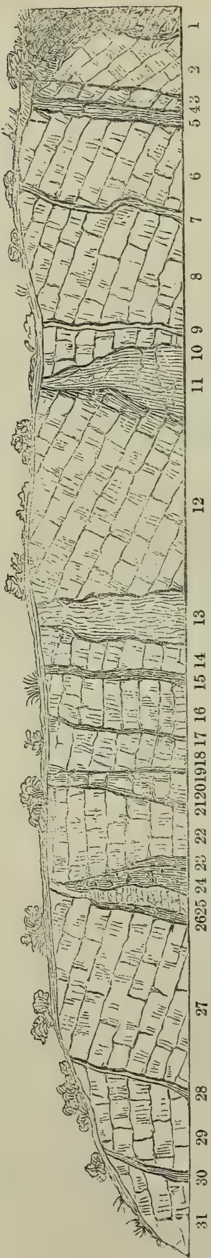


Fig. 3.—*Section at Holwell showing Liassic veins in stratified Carboniferous Limestone.*

that the Carboniferous Limestone at this point formed the wave-washed cliff of the Liassic sea, and that its caverns were subsequently filled by Liassic deposits. A longitudinal section at their junction would then show similar conditions; but we cannot strictly adopt this idea, from the fact that the same phenomena prevail throughout the whole line of the Carboniferous Limestone, and that the veins are continued to unascertained depths.

The section now described was as it appeared on the visit of the Members of the British Association in 1863; but every subsequent working alters its precise features, though its general character remains the same.

1. Immediately to the south-east, and parallel to the Marston road, may be seen a vertical face of limestone containing *Spirifera Walcottii*, *S. Münsterii*, *Echini*, &c., unquestionably of Liassic age. This appears to be a continuation of the long face of similar limestone noticed higher up the road. On entering the quarry, this limestone is seen to pass down as a vertical dyke, partly covered by vegetation on the south, but which appears to be about 6 feet thick. It is composed of a wavy, thinly laminated, yellow or bluish material, occasionally conglomeratic, and somewhat resembling marble. It has on its north side

2. A breadth of 10 feet of regularly bedded Carboniferous Limestone, showing a considerable inclination to the south, where it is cut off by the above.

3. A nearly vertical vein, the sides of which are composed of red, chocolate, or variegated impure limestone, sometimes with a central fissure stained with oxide of iron, or containing ironstone, at others filled with crystallized carbonate of lime, 9 inches.

4. A thin band of Carboniferous Limestone with organic remains, giving the appearance of a vertical vein of that limestone, 1 foot 3 inches.

5. Dyke of conglomeratic Lias, passing to the top, with occasional patches of

greenish crystalline rock of the same age; 2 feet 6 inches. On the north side of this there has been subsequently let in a band of clay with black siliceous pebbles and Rhætic bone-bed débris.

6. Breadth of inclined Carboniferous Limestone, 15 feet.

7. Irregular bed of clay with Carboniferous Limestone and siliceous pebbles, and fish and other remains of Rhætic age.

8. Carboniferous Limestone, 21 feet.

9. Vein of spar, occasionally enclosing Liassic stones, mottled or stained with oxide of iron, 6 inches.

10. Carboniferous Limestone, 3 feet.

11. Vertical vein of Lias, very various in colour (cream-coloured, yellow, pink, green, or blue), showing by its occasional thinly laminated structure that it was in fact very slowly deposited. This encloses angular fragments of Carboniferous Limestone. In this vein may be found occasional nests of Rhætic remains mixed with *Rhynchonella variabilis*, *Terebratula punctata*, and *Delphinula nuda*, Moore, and a crustacean claw of Liassic age. At the base of the quarry it attains a thickness of 13 feet.

12. Carboniferous Limestone, 30 feet.

13. Liassic infilling, having on the south a thin vein of carbonate of iron, 3 inches, next a band of deep-red and yellow conglomerate, 1 foot, succeeded by crystallized carbonate of lime 2 feet, and Liassic conglomerate 6 feet: 9 feet 3 inches.

14. Carboniferous Limestone, 3½ feet.

15. Irregular Liassic infilling, with thin veins of ironstone, 3 feet.

16. Carboniferous Limestone, 8 feet.

17. Vein of carbonate of lime, 1 foot.

18. Carboniferous Limestone, 6 feet.

19. Vein of carbonate of lime, 3 inches.

20. Carboniferous Limestone, 3½ feet.

21. Vein of carbonate of lime, 5 inches.

22. Carboniferous Limestone, 12 feet.

23. Liassic vein, variegated or red from oxide of iron, 2 feet, having in the centre a vein of spar showing traces of galena. This is followed by another vertical band of yellower limestone, having on its weathered sides multitudes of *Pentacrinite* stems, the infilling at this point being almost made up of them. On the side of this dyke, 30 feet below the surface, I noticed a nest of beautiful univalves mixed up with the Pentacrinites; and I was fortunate enough to cut out the block containing them, which, although only five inches square, contains forty-four specimens belonging to ten genera, some of the species being identical with forms from the Hierlatz-Schichten, noticed by Dr. Ferdinand Stoliczka, and with others from Fontaine-étoupe-Four.

24. Vein of crystalline carbonate of lime, 4 feet 4 inches.

25. Liassic stone, 2 feet 6 inches.

26. Vein of ferruginous stone, Liassic, 10 inches.

27. Carboniferous Limestone, 33 feet.

28. Vein of carbonate of lime &c., 1 foot.

29. Carboniferous Limestone, 14 feet.

30. Liassic vein, 2 feet.
31. Carboniferous Limestone, 18 feet.
32. Rocks not exposed, 50 feet.

These are again continued in an adjoining quarry for a length of 450 feet, with a repetition of the vertical infilling, though not of so decided a character.

Looking across the little stream which runs at the base of the above sections, a finely arched or anticlinal mass of Carboniferous Limestone may be seen, the upper beds having been worked back, leaving a wall of crescent-shaped thickly bedded limestone. On the inclined face of a bed of limestone beneath this wall the members of the British Association assembled. Immediately below them was a thick Liassic dyke composed of yellow or pink limestone, or changing into the various materials of which our mineral veins are composed. This uppermost dyke can be seen to pass completely through the length of the quarry, and is in some places left standing above the Carboniferous Limestone by the quarrymen. As it crosses to the southern end, itsvertical face is well exposed, it having been there left standing against the edges of the Carboniferous Limestone, beyond which it is lost in its passage between two masses of that formation. About the centre of the inclined floor of the quarry another vein joins the above at almost a right angle, and cuts off another mass of Carboniferous Limestone; whilst, apparently joining the first vein at the north of the quarry, another appears, taking a somewhat irregular course in an easterly direction, and again subdividing the limestone into sections. Where the working has ceased on the south, another dyke of considerable thickness is present, which appears to have passed across from the quarry on the opposite side of the stream; it is throughout of a deep-red colour, and yields some good samples of hematite iron-ore.

The following organic remains have been obtained from the Marston-road Liassic conglomerates, and from the Liassic dykes in the Holwell section.

List of Fossils from Holwell.

Cidaris Edwardsii.
Pollicipes.
Claw of Crustacean.
Pentacrinites basaliformis.
Crania.
Discina (fragments).
Rhynchonella concinna, *Sow.*
—— rimosa, *Zieten.*
—— variabilis, *Schloth.*
—— subvariabilis, *Dav.*
Spirifera Walcotti, *Sow.*
—— Münsteri (S. lata, *Martin*).
Terebratula Waterhousei, *Dav.* (T. retusa, *Martin*).
—— punctata, *Sow.*
Avicula inæquivalvis, *Sow.*
—— nuda, *Moore.*
Inoceramus.
Gryphæa incurva, *Sow.*
Lima scrobiculata, *Stol.*
—— densicosta, *Quenst.*
—— Deslongchampsii, *Stol.*
Ostrea ocreata, *Desl.*
Pecten sublævis?
—— verticillus, *Stol.*
—— Rollei, *Stol.*
—— palosus, *Stol.*
Placunopsis.
Plicatula sarcinula.
Opis triangularis, *Moore.*
Delphinula reflexilabrum, *Horn.*
—— nuda, *Moore.*
Rotella macrostoma, *Stol.*
Nerinæa Hornerii, *Moore.*
Phasianella turbinata, *Stol.*
Neritopsis lævis, *Stol.*

Solarium lunatum, *Moore.*
Trochus Holwellensis, *Moore.*
—— latilabrus, *Stol.*
—— gradatus, *Moore.*
Pleurotomaria Buchi, *Desl.*
Turbo Orion, *D'Orb.*
—— nodulo-carinatus, *Moore.*
Turbo solidus, *Moore.*
——, sp.
Amberleya Alpina, *Stol.*, sp.
Fish-teeth and scales.
Belemnites, fragments.
Corals derived from the Carb. Limest.

3. *The Microlestes Quarry.*—Passing again into the Shepton-Mallet road, from the section just noticed, several fine sections of Carboniferous Limestone may be studied. The first reached on the left is that from which I obtained so wonderful a harvest of Rhætic remains,—to which I propose to devote a special paper. The vein whence they came could then be traced taking an irregular east and west direction, and was probably a continuation of one of those described in the large section below. The limestone has since been worked back, and its position almost obliterated. Several other small veins may be noticed in this quarry, generally filled with a dense yellow or pinkish conglomerate, with occasional traces of Rhætic remains. Further up the road, on the same side, are other openings in which similar phenomena occur; but these we need not particularize.

Just above the Microlestes Quarry, on the opposite side, is, however, a remarkably fine section belonging to the Earl of Cork and Orrery, which deserves notice, and is the last I shall allude to at Holwell.

On entering this quarry a very long section is seen, the floor of which is formed of Carboniferous Limestone dipping rapidly to the south. The north side of the middle part of the quarry is formed of a high wall of Carboniferous Limestone. At the eastern end of this may be observed the face of a dyke of Lias, four feet wide, which in its passage westwards has been left standing as unprofitable material by the quarrymen, being chiefly composed of carbonate of lime. A section of the vein itself at this point shows that, within the limestone walls of the vein, there have been deposited vertical layers of crystalline carbonate of lime, and then, occupying the centre of the vein, an inner deposit of Lias, from which were obtained *Gryphæa incurva*, *Rhynchonella furcillata*, *Belemnites*, *Avicula*, &c., Liassic organisms showing themselves abundantly on its weathered sides. At the western end this vein thickens to ten feet, and is there cut off by a north and south vein with indications of iron-ore, beyond which it can be traced in other workings to a considerable distance. At the southern entrance to the quarry another very thick dyke of Lias is present, against which a mass of thick-bedded Carboniferous Limestone has been left standing. When the material of these dykes is composed of limestone, which often happens, it so accommodates itself to the angular irregularities of the older rock as to appear, when worked back upon, to be only a continuation of the same, the bedding seemingly passing from one into the other, and a careful examination is needed to distinguish the difference. When standing on the floor of this large section it is difficult to realize that, with the Carboniferous Limestone beneath your feet and everywhere around you, you are really between two parallel vertical dykes of a much later age, which are probably continued through many miles of the Mendip district.

Returning to Holwell, and following the valley in its northern direction to Nunney, the Carboniferous Limestone is worked near the Castle, and again a large dyke of Liassic age traverses it from east to west and passes under the Inferior Oolite immediately beyond. Towards Eggford the Carboniferous limestones are rather more continuous than is shown in the Ordnance Map, as they may be traced on the eastern side of the Whatley road under the Oolite. An outcrop of Carboniferous Limestone in a pasture-field under the roadway shows that it is entirely an oolitic limestone of a much coarser kind than is usually seen; and the rock is much mineralized, occasionally containing galena. Resting on the limestone are traces of the Liassic deposit noticed at Whatley. In a field above, a small shaft was sunk down to stratified beds of Inferior Oolite, when, resting on the latter beds, a rubbly deposit of sulphate of barytes, calamine, with a mixture of galena was passed through, of about a foot in thickness, these minerals being unquestionably of Oolitic age.

4. *Sections in the Vallis.*—Crossing the turnpike at Eggford, a roadway at once leads into the Vallis; and a short way on may be observed a fine exposure of Carboniferous Limestone, the Fullers' Earth in this direction encroaching upon it. On the southern side the stone first seen is the end of a vein with a tendency to underlie to the south; it rested against the outcrop of the Carboniferous Limestone before the quarry was worked back from this point. It is composed of different layers of variegated honeycombed limestone. Following this band towards the face of the quarry, there rests upon it thickly bedded masses of Inferior Oolite, containing abundance of *Lima pectiniformis, Lima gibbosa, Echini,* &c. In the southern corner and leading up to the top of the quarry, the Inferior Oolite is laid down upon the ancient Carboniferous-limestone sea-bottom, and has so accommodated itself to any inequalities in its surface as to make it exceedingly difficult to determine where the one formation begins or the other ends. So intimately united are these unconformable deposits that the same hand specimen may show portions of each, with Lithodomi, of Oolitic or any intervening age, still retained in their burrows in the surface of the Carboniferous Limestone *. In this valley, as in all the others described, there can be little doubt that these limestones formed the sea-bottom during a greatly extended period. In the face of this section are several irregular vertical fissures leading down from the top, the first one being filled with a ferruginous or ochreous sand. This dyke thickens towards the bottom of the quarry, but, before reaching it, is apparently cut off by the limestone; it then for a short distance takes the plane of the bedding and again passes down vertically: at this point it is divided in the centre by a siliceous band 1 foot thick, each side of which is composed of a ferruginous deposit

* This had been previously noticed by Sir Henry de la Beche, in his valuable Memoir on the "Formation of Rocks in South Wales and South-western England," p. 290.

with traces of galena. North of this another vein leads down about a foot in thickness, almost wholly filled with sulphate of barytes. There are no organic remains to test the age of either of the above. The northern end of the quarry, like the south, is bounded by a dyke of considerable thickness, the sides of which are composed of vertical seams or beds of limestone, within which are cavities with crystalline carbonate of lime, barytes, or patches of ferruginous sand, with occasional evidences of galena. The sides of this fissure afford traces of organic remains; and there is no doubt it is contemporary with those at Holwell, and of Liassic age. The surface of the Carboniferous Limestone above this vein is covered for a short distance with stratified Inferior Oolite.

Following the valley to the north, the sides are now clothed with wood for a considerable distance, and no doubt cover up interesting physical phenomena. Towards Hapsford the first quarry reached is again bounded by a vertical Liassic infilling, 2 feet in thickness, following which the Carboniferous Limestones are much contorted. From an examination of the beds above the limestone, I have evidence of the presence of horizontal deposits of Rhætic age. A thin bed of a waterworn pebbly conglomerate, which will be found continuous and of greater thickness in succeeding sections, makes its appearance, resting for a short distance immediately on the Carboniferous Limestone. In the southern corner this gives place to an altered limestone, which, though scarcely distinguishable from the Carboniferous Limestone, is probably Liassic. In a trough which reaches down to the Rhætic deposit, encroaching also on the Lias, and partly covering it, we then have regularly stratified beds of Inferior Oolite, 8 feet in thickness On examining the face of the limestone below these unconformable beds, we find, a few yards from the first vein at the south, several smaller veins of only two or three inches each in thickness, composed at the sides of a light-yellow stone, with veins of spar within, affording a well-marked distinction from the darker Carboniferous Limestone. These are followed, about seven feet beyond, by a vein of 6 inches, which passing upwards meets the former under the Lias, and may therefore be referred to that age. Fifteen feet of limestone succeed, and then a series of ferruginous-looking disturbed fissures, 2 feet; next, limestone, 27 feet, and then a small vein of vertically laminated yellow limestone; Carboniferous Limestone, 24 feet, divided by a small vein with pockets of hæmatite iron ore; limestone, 90 ft., on the top of which rests Rhætic conglomerate, and then a contorted vein of 18 in., which passes upwards and meets the base of the conglomerate.

An unopened piece of ground of 80 feet leads to another opening, in which the extraordinary variety presented by these sections is again manifested. The quarrymen appear to cease their workings on meeting the unprofitable material composing the fissures when they are of any thickness; and here once more the quarry is bounded on the south by a vein, 4 ft., composed entirely of carbonate of lime, which is seen to pass upwards through the Rhætic beds, and meets the base of the Inferior Oolite, and may therefore, though we have no direct evidence on this point, be as young as that formation. I have already referred to this quarry in the Society's Journal, vol. xvii. p. 497; and it has also been given by Professor Jones in his Monograph on "Fossil Estheria," p. 73, in the Palæontographical Society's Monographs for 1862. The limestone has been worked to a depth of about 15 feet, and has a dip of 35° N. W., which is much increased in sections adjoining. The surface of the limestone is quite horizontal, and has a capping of Rhætic blue clay, 4 inches thick, noticed for the first time in this district, containing numerous *Avicula contorta*, *Ostrea intusstriata*, *Chiton*, *Pollicipes Rhæticus*, and reptilian and fish-remains of true Rhætic age. The conglomerate noticed in the last section has been continued in this direction, but has increased to 2 feet thick; and mixed up with its rounded siliceous pebbles occasional fish-teeth and scales are found. Another bed of blue clay, 4 inches, with but few organisms, succeeds, and then another bed of conglomerate, 4 inches. This conglomerate is less dense than the former, and contains fewer pebbles. In the cream-coloured matrix which encloses them, the little crustacean *Estheria minuta* is occasionally found. Above succeeds a grey clay with thin limestone bands and nodules, within the laminæ of which are little nests containing many *Estheriæ*, associated with plants and wings of *Carabidæ*. Above this is stratified Inferior Oolite, 12 feet, with conglomerate at its base. Corals of Carboniferous-limestone age are found, not only in the Rhætic conglomerate but in the Inferior Oolite, in close proximity to the *Rhynchonella spinosa*.

Several small openings immediately following, in which are two or three Liassic dykes, lead to the last section I shall give, close to Hapsford, in which is found a considerable change in the Rhætic deposits.

Section at Hapsford Mills.

	ft.	in.
1. Carboniferous Limestone with horizontal surface, but very highly inclined		
2. Rhætic conglomerate, resting immediately on the above	0	4
3. Blue clay parting	0	2
4. Stratified conglomerate	0	10
5. Clay	0	2
6. Conglomerate	0	9
7. Clay	0	2½
8. Bed of conglomerate	1	0
9. Ditto.	0	6
10. Blue marl with flattened pebbles	0	9
11. Irregular conglomerates surrounded by blue pebbly marls	3	0
12. Series of thinly laminated grey marls without any trace of organisms	3	0
13. Irregular masses of conglomerate	2	0
14. Stone in lower corner, lithologically like "White Lias," but without any trace of organic remains, about	2	0

In this section organic remains of Rhætic age are abundant. Some blocks of the conglomerate contain many examples of *Avicula contorta* and *Ostrea intusstriata*, with *Cardinia*, and also a large *Discina*—probably *D. Townshendi*; but it is unfortunately generally crushed.

Ostrea fimbriata, Moore, is especially plentiful, and affords fine examples. As the shell is nearly always attached to the upper surface of the conglomerates, it is evident that the beds in this quarry have been accumulated at intervals, and less rapidly than might be supposed with a series of conglomerates. It is matter of regret that the thin laminated marls, No. 12, have not yielded any fossils, as they appear so suited for the preservation of any delicate organisms, such as *Estheria*, Plants, or Insects. The stone, No. 14, only occupies the lower corner of the section, and is lithologically so like the White Lias in its fracture, and the stratigraphical position in which it should be found above the *Avicula-contorta* beds, that I cannot help referring it to that horizon, though it is unknown for some miles. The Rhætic beds have no superficial development in a northerly direction beyond, but pass at once under Inferior Oolite, which is seen in the Hapsford road, and which, in the Radstock railway, attains an exposed thickness of 30 feet. At its base in this district this formation is at times highly siliceous and conglomeratic.

5. *Gurney Slade Liassic Dykes.*—My previous observations have had reference to the entire south-eastern breadth of the Mendip Carboniferous Limestone. That the Liassic infillings pass completely through the Mendips from east to west there cannot be a doubt, as they are to be recognized at points widely asunder. They occur again at Gurney Slade, about nine miles from the sections I have just been describing. At this place there is a large quarry on the right of the roadway leading from Old Down to Gurney Slade, where, in the middle of the Carboniferous Limestone, the quarrymen have left a large Liassic dyke standing up like a wall, and dividing the quarry into two parts. It is about 4 feet broad by 12 in height, and is, like those of Holwell, made up of vertical bands of stone, often intermingled with veins or pockets of excellent hæmatite iron-ore, and presenting all the attendant characteristics of a mineral vein. An examination of the sides of the deposit, particularly on the northern side, reveals the presence of a number of *Pentacrinites*, *Rhynchonella variabilis*, and other Liassic fossils.

Proceeding again another eight miles west of Gurney Slade, the same phenomena are present in the midst of the old Roman lead-workings of Charter House, and on the most elevated tableland of the Mendips.

6. *Charter House Liassic Lead Mine.*—The mineral districts comprised in this part of the Mendips and Priddy were extensively worked during the Roman occupation; and the great industry they manifested is shown by the enormous quantity of refuse slags and slimes left by them in some of its valleys. Owing to their imperfect mode of working, about 12½ per cent. of lead remains, which is now being extracted by several companies. In general, the lead-ores of the district "prove" near the surface; and so well and completely did the Romans appear to have exhausted the veins, that little has subsequently been worked profitably. I paid a visit to a shaft which had been sunk as an experiment by one of the companies, but which had lately ceased working, at Charter House Warren. It is

situated to the north-west of the highest Carboniferous-limestone platform of the Mendips. A mile to the north, the Old Red Sandstone, surrounded by the Carboniferous-limestone shales, is present, the Carboniferous Limestone itself, both on its north and south flanks, being fringed by Dolomitic Conglomerate, beyond which the New Red Sandstone succeeds.

The nearest horizontal deposit of Liassic age to the north is at Nempnett, 2½ miles distant, which yields *Pecten Pollux* and *Lima tuberculata*. Two miles to the east, above Harptree, a Carboniferous-limestone basin is filled with a siliceousLiassic deposit, in which are an abundance of *Lima gigantea* and *Pecten Pollux*, whilst to the south-west this formation is six miles removed.

In examining some blocks of conglomerate brought out of the above workings, I detected part of a *Cidaris Edwardsii*, and was thus induced to give a closer attention to it than I otherwise intended. The shaft was then covered up; but near it was a small heap of blue clay in which I found *Rhynchonella variabilis* and fragments of other shells, evidently of Liassic age. I was informed by one of the miners that this clay had been brought from the lowest part of the mine, before it had ceased working. To prove the correctness of this statement, and learning that the ladders had been left in, I induced the manager of the adjoining works to uncover the shaft that I might go down for its examination,—a work, from the state of the shaft, not unattended with some danger. On descending I examined several of the upper galleries, and found the materials therein chiefly composed of crystalline carbonate of lime, giving place occasionally to sulphate of barytes, conglomerate, and thin bands of vertical limestone, with all the ordinary features of a mineral vein. From the end of one of the galleries, at a depth of about 90 feet, I secured some samples of what appeared to be a sandy deposit, but which, when washed, was found to be almost entirely composed of the dismembered joints of Encrinites, chiefly (if not wholly) of Carboniferous-limestone age, and with occasional small pebbles of hæmatite iron-ore.

Proceeding to the bottom of the shaft, at a depth of 270 feet, I had the pleasure of reaching the object of my search, and there found a deposit of deep-blue or greenish clay, 12 feet thick, giving the appearance of having in places been deposited in thin horizontal layers, and therefore slowly, whilst at other spots it presented a more conglomeratic character, and contained drift wood, pebbles, &c. Owing to the difficulties attending the undertaking, and its satisfactory issue, I never returned to daylight with greater satisfaction than on this occasion. Having arranged for the removal of a quantity of the clay to Bath, it was there subjected to a long examination, and resulted in my obtaining a fauna in great part new to this country.

Although certain that the deposit belonged to the Lower Lias, I was then unable to determine with any precision the exact horizon it would occupy when compared with any of the known stratified beds. There can be little doubt that the Liassic seas at this period occupied the profound depths of the Carboniferous-limestone fissures, within which the organic remains were probably living, contemporaneously with the deposition of Liassic beds at other points. The delicacy and perfect condition of the fossils show that their presence is not due to the denudation and the redisposition of previously existing beds within the fissures.

We may deem it a most interesting fact, and one most difficult to account for by those who still advocate the Plutonic origin of mineral veins, that from this one locality there have been obtained at least 115 species of fossils below the Mendip horizon for workable minerals.

A few of these in the vein above, and also in the clay at the base, are, as might be expected, derived from the Carboniferous Limestone; but these species are readily distinguished from those of Liassic age, and are not more than twenty in number; they consist chiefly of different species of Bryozoa and Corals, with three species of Brachiopoda, viz. *Terebratula hastata*, *Orthis Michelini*, and *Atrypa*.

I found, therefore, under these peculiar circumstances, about ninety-five species of Lower Liassic organisms—a larger fauna than had to this time been obtained from any stratified bed of that age, or, I might almost say, from the whole Liassic formation in this county. Although the veins are chiefly productive in their upper portions, the blue clay in which these remains are found is mineralized, and contains almost 7 per cent. of galena. The wood in it is converted into jet, and its cells filled occasionally with that mineral.

On perusing the following list, and comparing its general fauna, it will be seen that many of the species are identical with those from Brocastle in South Wales; and these, again, with others from the Sutton Stone, to be hereafter noticed; whilst both those localities will be found to have species in common to the so-called Infralias of the Côte d'Or, Valogne, Luxembourg, and Hettange.

By an accident, several species of *Foraminifera*, in addition to the twelve given in the list, were lost. Theae are intimately connected with those from the Foraminifera-zonset the top of the Lower Lias at Camerton. Eleven species of Entomostraca are included in the list; and for their examination I am indebted to my friend Professor Jones, F.G.S., who, however, assures me that the known forms belong to species occurring in the Carboniferous rocks, some having been found also in the Permian; and that the new species have their allies in the same deposits. The Brachiopoda are of nine genera, several of them being specifically identical with forms from the Upper Lias and Inferior Oolite. Leaving out the minute Gasteropoda, which appear to unite this deposit with the continental beds, the general facies of the former would connect it with the *upper* portion of the Lower Lias; and the presence of *Belemnites acutus*, which hitherto has not been found lower than the upper part of the *Ammonites-Bucklandi* beds, would strengthen this conclusion. Several small casts of Ammonites were found with them, but cannot be recognized specifically.

7. *Terrestrial and Freshwater Fauna.*—Both palæontologically and as bearing upon my view of the former physical condition of the Mendip Hills, the recognition for the first time of a terrestrial fauna will

be considered of some interest. From the Tertiary beds downwards, until the discovery by Dr. Dawson (see Lyell's 'Elements of Geology,' 6th ed. p. 508) of a species of *Pupa* in the coal-beds of Nova Scotia, no evidence had been obtained of any terrestrial Mollusca, and there still remains this wide interval to be filled up. In this I have much pleasure in assisting, by recording the presence of three genera of land-shells at the bottom of the Mendip Mine, in the deposit above noticed. These are *Vertigo*, *Proserpina*, and *Helix*. I have the honour to propose for them the specific names *Vertigo Murchisoni*, *Proserpina Lyelli*, and *Helix Dawsoni*. A single seed-vessel of *Chara*, which unfortunately is not in good condition, indicates the presence of aquatic plants; and the occurrence of the genera *Valvata* and *Planorbis* establish the presence of terrestrial streams, and their communication with the Mendip fissures.

List of Organic Remains from Charter-House Lead-Mine, 270 feet from the surface.

Chara liassina, *Moore.*
Drift-wood, Jet.
Cristellaria rotula, *Lamk.*
—— costata, *D' Orb.*
Dentalina communis, *D' Orb.*
—— obliqua, *Linn.*
—— obliquestriata, *Reuss.*
Frondicularia striatula, *Reuss.*
Involutina liassica, *Jones.*
——, sp.
Marginulina lituus, *D' Orb.*
Nodosaria raphanistrum, *Linn.*
—— radicula, *Linn.*
—— paucicostata, *Reuss.*
Planularia Bronni, *Roem.*
Pentacrinites, joints of.
Cidaris Edwardsii.
Echinodermata, several species.
Ophioderma, joints of.
Serpula, sp.
Pollicipes rhomboidalis, *Moore.*
Crustacea, claws of.
Bairdia plebeia, *Reuss.*
—— brevis, *Jones & Kirkby.*
Cythere bilobata, *Münst.*
—— fabulina, *Jones & Kirkby.*
—— intermedia, *Münst.*
—— ambigua, *Jones*, MS.
—— æqualis, *Jones*, MS.
—— spinifera, *Jones*, MS.
—— Thraso, *Jones*, MS.
Kirkbya plicata, *Jones & Kirkby.*
Moorea tenuis, *Jones*, MS.
Bryozoa, sp.
Argiope.
Crania.
Lingula.
Rhynchonella variabilis, *Schloth.*
Terebratula punctata, *Sow.*
Spirifer, fragments, several sp.
Thecidium Moorei, *Dav.*
—— triangularis, *D' Orb.*
Zellania Davidsoni, *Moore.*
—— Laboucherei, *Moore.*
Lima, sp.
Plicatula spinosa, *Sow.*
Astarte, sp.
Cardinia multicostata.
Cucullæa.
Leda Heberti, *Martin*, non Titei.
Nucula, sp.
Opis, sp.
Cerithium gratum, *Terq.*
—— rotundatum.
—— paludinare, *Terq.*
—— Semele, *D' Orb.*
Chiton.
Fissurella.
Helix Dawsoni, *Moore.*
Melania alternata, *Terq.*
Nerinæa Mendipensis, *Moore.*
Orthostoma frumentum, *Terq.*
—— triticum, *Terq.*
Planorbis Mendipensis, *Moore.*
Pleurotomaria expansa, *Sow.*
—— Mendipensis, *Moore.*
Proserpina Lyelli, *Moore.*
Straparollus tricarinatus, *Mart.*
—— Oppeli, *Mart.*
Solarium lenticulare, *Terq.*
Trochus nitidus, *Terq.*
—— edulus? *Stol.*
—— sp,.
Turbo, sp.
——, sp.
—— Piettei, *Martin.*
—— aranus, *Martin.*
—— Martini, *Terq.*
—— tumidus, *Moore.*
Turritella Humberti, *Martin.*

Turritella Howsei, *Moore.*
Valvata anomala, *Moore.*
—— pygmæa, *Moore.*
Vertigo Murchisoni, *Moore.*
Ammonites, 2 sp.
Belemnites acutus, *Mill.*
Fish-remains abundant, including teeth of *Acrodus, Hybodus, Lepidotus,* &c., representing about ten species.
Ichthyosaurus, tooth of.

Derived from the Carboniferous Limestone.

Terebratula hastata, *Sow.*
Orthis Michelini, *Kon.*
Atrypa, sp.
Spirorbis.
Serpulæ.
Encrinites.
Bryozoa, various species,
Corals, several species.
Echinodermata.

V. The Bath District.

Having described the peculiar conditions under which the Secondary rocks are found south of Bath, I shall proceed to show, as I have before stated, that their unconformability is generally still continued in this direction.

The eastern edge of the Somersetshire coal-field no doubt passes close to, if not immediately under Bath, the continuation of the Carboniferous Limestone in this direction having been proved in the trial for coal at Batheaston. Small exposures of the same limestone occur at Grammar Rock, under Lansdowne, and at Wick and Codrington, clearly marking its eastern outline. The city of Bath is surrounded by Oolitic beds, except to the west, where they give place, in the valley towards Bristol, to Liassic, Rhætic, and Triassic beds, and to the Coal-measures. A series of north and south faults, which probably intersect the coal-basin, have brought up these older deposits, and given them, close to Bath, an inclination to the east. The surface of the Bath basin is covered with Postpliocene drift, containing abundant traces of extinct mammalia. Wherever these are passed through, they are found to lie on the upper blue marls of the Lower Lias, which present long lines of furrows, channelled out either by glacial action or the effects of Postpliocene erosion. The Rhætic and Liassic beds are continued through the western opening to Twerton, Weston, Saltford, Willsbridge, Keynsham, and Bristol. The chief section in which the Rhætic beds have been exposed was at Saltford; but there at present only the Upper "White Lias" portion is seen. At all these places, excepting Keynsham and near Bristol, the horizon of Lower Lias worked is the *Ammonites-Bucklandi* series, which usually rest unconformably upon the White Lias, and there are therefore absent from the greater part of the Bath district the zones of the Insect and Crustacean beds, the *Ostrea-*, and the *Ammonites-planorbis* beds of the sections at Camel and Beer Crowcombe*.

1. *Pinch's Well.*—A section of the beds below Bath, to the west, was made under the following circumstances, which are recorded by Mr. Armstrong, C.E. ("On the Tapping and Closing of a Hot Spring,"

* In the railway-cutting now in course of excavation at Newbridge Hill, thin representatives of the *Ostrea*-beds are present immediately above the Rhætic series, but are almost immediately overlain by others containing *Ammonites angulatus* and *A. Bucklandi.*

1838):—At a brewery in Kingsmead Street a well was sunk for an additional supply of cold water; but, in more ways than one, the proprietor got into hot water. A well 60 feet deep was first sunk, which was bored an additional 19 feet, and afterwards continued 91 feet more, making in the whole 170 feet. Very little water was found at 60 feet; and there was little increase until the boring had reached 79 feet, when the well-sinkers found a spring which yielded 50 hogsheads per day at 80° of heat; in the second operation they had no sensible increase, until they had reached the depth above stated. They had bored about a foot into the "red ground," and on leaving work left their rods in the hole. Next day they found the water running over the top of the well at 99°. On the rods being removed the water continued to discharge 114 imperial gallons per minute." At this well the hot-spring was tapped which supplied the baths 250 yards distant, the water in which very sensibly diminished, both in quantity and in temperature. The engineering operation to stop the spring and restore it to its original course was one of much difficulty.

The beds passed through show most clearly their succession under this part of the city,—

		ft.	in.
1.	Black marl (Upper blue marls of the Lower Lias)	50	0
2.	Thin beds of blue Lias, succeeded by blue Lias nearly solid	40	0
3.	White Lias	40	0
	Thin beds of White Lias and clay	16	0
4.	Very white clay	12	0
5.	Very black sulphurous clay	11	0
6.	Dark-red soil where the water rises	1	0
		170	0

There can be no doubt from the above that the Bath hot water was tapped at the junction of the Keuper and Rhætic beds, and that it reaches its present springs from a westerly direction. The dark-red soil represents the Keuper Marls. The black sulphurous clay, and probably the "very white clay" above, belong to the Rhætic *Avicula-contorta* series. The White Lias tells its own tale; and the nearly solid and other beds of the Lias above belong to the *Ammonites-Bucklandi* and *A.-angulatus* beds, which we find coming to the surface at Locksbrook and Weston beyond. When the coal-shaft was sunk in 1815 at Batheaston, 2½ miles north-west of Bath, a considerable body of tepid chalybeate water was reached at the same point, which is flowing in considerable quantities from the shaft to this day. It is said (but with what truth I know not) that the Bath springs were affected by the continuous pumping operations that were then carried on. Although the waters may have been reached at the junction of these horizontal beds, their source is likely to be more deeply seated, amidst older disturbed rocks, which are probably to be found not far below the Bath basin.

It is worthy of remark that in the wells connected with the baths there is a regular but slow accumulation of quartzose sand, amongst which may often be found hazel-nuts and many seeds, beautifully electrotyped with iron pyrites, and also Liassic and Oolitic organisms, and fragments of bones of extinct mammalia of the Postpliocene period, which must have been brought away from the gravels by the water in its passage through them to the surface.

2. *The* Ammonites-Bucklandi *Beds.*—The *Ammonites-Bucklandi* beds of the Bath sections are about forty in number, but vary in thickness in almost every quarry. The upper beds are usually brown; but they are followed below by a series of irregular beds, with clay partings of a deep-blue colour, all of which have evidently in their times been eroded by water. These rest on the "White Lias," which is invariably present, but, owing to the interposed beds just mentioned, is not often reached. It is seldom that any section exceeds 25 feet in depth. The beds at Weston are most largely worked, and afford an abundance of the organic remains of this horizon, the list being given below. The Bath and Mangotsfield Railway passes through the middle of the Weston quarries, and has opened up their succession from the *Ammonites-Bucklandi* beds through the "White Lias" and *Avicula-contorta* beds to the Upper Marls of the Keuper.

The section in the Saltford Railway-cutting affords a fine exposure of these beds. This section was carefully prepared by my friend William Sanders, Esq., F.R.S., and has been given by Dr. Wright in his paper "On the zone of *Avicula contorta*, and the Lower Lias of the South of England," in the Society's Journal, vol. xvi. p. 399. In this section the *Ammonites-Bucklandi* beds, with associated *A. angulatus*, *Lima gigantea*, *Ostrea arietis*, and an abundance of *Gryphæa incurva*, are seen resting immediately upon the Rhætic White Lias.

The lithological distinction between the thick-bedded cream-coloured "Sun-bed" of the White Lias and the unconformable *Ammonites-Bucklandi* beds is so marked as to be perceptible to any geologist, however rapidly he may be passing by train through the cutting, at its eastern end.

In the Weston quarries a bed called the "Gutter Bed" shows in its weathered edges many of the Gasteropoda of the Côte d'Or sections. This bed is close below the "Red Bed" in the same quarries, containing an abundance of *Ammonites Bucklandi*, above which also the same Gasteropods pass. A thin but very persistent bed of indurated marl occurs at the top of all the sections, which will be again referred to in describing the section at Keynsham.

List of Organic Remains from Weston, Bath.

Plantæ, sp.
Foraminifera, sp.
Montlivaltia Sinemuriensis, *D'Orb.*
Echinodermata, sp.
Serpula.
——.
Cythere.
Normania mundula, *Jones.*
Cytherella aspera, *Jones.*
Rhynchonella variabilis.
Spirifera Walcottii.
Terebratula punctata.
—— strangulata, *Martin.*
Anomia irregularis, *Terq.*
—— pellucida, *Terq.*
Avicula inæquivalvis.
—— infraliasina, *Martin.*
Gryphæa incurva.
Inoceramus.
Lima gigantea.
—— Hermanni.
Lima duplicata.
Ostrea arietis (O. multicostata, *Terq.*).
—— intusstriata.
—— liassica.
—— irregularis.
Pecten Pollux, *D'Orb.*
—— sublævis.
——, sp.
Plicatula Hettangiensis, *Terq.*

Arca pulla, *Terq.*
Astarte, sp.
Cardinia Listeri (C. Eveni, *Terq.*).
Cardita multicostata?
Pinna folium.
—— semistriata, *Terq.*
Cucullæa similis, *Terq.*
Modiola producta, *Terq.*
Myacites.
——, sp.
Nucula, sp.
Pholadomya ambigua, *Sow.*
Unicardium cardioides.
——, sp.
Cerithium Semele, *D'Orb.*
—— trinodulosum, *Martin.*
—— Collenoti, *Martin.*
—— gratum?, *Terq.*
Chemnitzia polita, *Martin.*
Dentalium.
Littorina clathrata.
Melania abbreviata, *Terq.*
Pleurotomaria Anglica, *Sow.*
—— expansa, *Sow.*
—— trochotoma.
——, sp.
Trochus Piettei, *Martin.*
Turbo liassicus?, *Martin.*
Turritella Humberti, *Mrt.*
Ammonites angulatus.
—— Bucklandi.
—— Conybeari.
—— Turneri.
——, sp., young, as at Brocastle.
Nautilus lineatus, *Sow.*
—— intermedius, *Sow.*
Rhyncholites.
Geoteuthis, hooks of.
Acrodus, teeth of.
Hybodus, teeth and spines.
Leptolepis.
Ichthyosaurus, bones of.
Plesiosaurus, bones of.

3. *Willsbridge Section of Lower Lias, Rhætic, and Keuper Formations, and Coal-Measures.*—The Mangotsfield Railway, after passing through the sections at Weston just mentioned, continues on the Keuper Marls until it crosses the River Avon, at Saltford, where it again intersects the *Ammonites-Bucklandi* beds. It then soon turns to the north, and at Willsbridge, before it enters the coal-district, reveals the following most interesting combination of rocks of different geological eras, within a distance of less than 100 feet:—

	ft.	in.
1. *Lower Lias.*		
Series of 25 beds of Lias, with intervening beds of marl, occupying the centre of a small trough containing *Lima gigantea*, *Nautilus*, &c. &c.	8	10
2. *Rhætic Series.*		
a. White Lias	0	5½
Ditto	0	7½
Ditto	0	10
Shale	0	3
White Lias	0	4½
Ditto	0	5
Ditto	0	2
Ditto, various rubbly beds, with *Arca*, *Axinus*, *Pteromya*, *Modiola*, and *Avicula decussata* on the surfaces of the beds	0	9
b. Laminated light-blue clay, with *Estheria minuta*, *Cythere liassica*, *Avicula decussata*, &c.	4	0
c. Occasional bands of conglomeratic stone, with fish-scales &c., occasionally passing into "Landscape-stone"	1	0
d. Light-grey conchoidal Marlstone, sometimes passing into layers of indurated Marlstone, full of comminuted shells, and often yielding good examples of *Cardium Rhæticum*, *Pecten Valoniensis*, *Axinus concentricus*, and *Cardita*, with plant-like impressions	6	6
e. Blue laminated clay, crowded with Rhætic shells	6	0
f. Black laminated slaty clay, with numerous large coprolites, bones of *Plesiosaurus rugosus*, fish-scales, teeth, and *Discina Townshendi*	4	0
g. Conchoidal light-blue marl	11	0
3. *Keuper.*		
Variegated red and blue marls, with Sulphate of Strontia passing into regularly bedded New Red Sandstones, without organisms ... about	25	0
4. *Coal-Measures.*		
Thickly bedded Pennant rock, deeply coloured by iron.		

The Lias in this curious section is most regularly bedded, and is seen by reference to the diagram to occupy the centre of a small trough, into which its beds are compressed, with the Rhætic White Lias as regularly underlying it. The *Avicula-contorta* series below was largely opened; and I have never had the pleasure of seeing any other section to be compared with it. The Keuper Marls and rocks of the New Red Sandstone were met with at the southern end of the cutting; and all were abruptly cut off at a short distance to the north by the Pennant rocks of the Coal-measures, through which the railway is afterwards continuous to Mangotsfield.

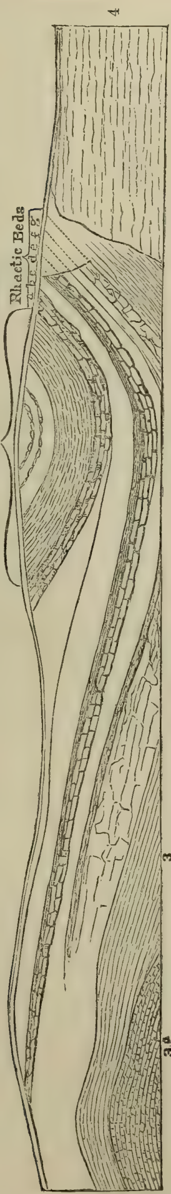


Fig. 4.—*Section of the Willsbridge Railway-cutting.*

1. Lower Lias. 2. White Lias. *Avicula-contorta* series. Rhætic Beds. 3. Keuper. 3*a*. New Red Sandstone. 4. Coal-measures (Pennant Rock).

1. Lower Lias. 2. Rhætic Beds (White Lias and *Avicula-contorta* series).

Although the present conformation of these beds is due to subsequent disturbance, the peculiar thickening of the *Avicula-contorta* series below the White Lias to the south would lead me to suppose that they must have been deposited on an uneven sea-bottom.

At the base of the Lias in this cutting there are thin representatives of the *Ostrea-liassica* beds, but without any trace of the Insect and Crustacean beds as in the section at Camel (p. 462). The "White Lias" which follows is reduced to a few beds of less than four feet in thickness.

The surface of the laminated clay (2 *b*) is often entirely covered by *Cythere liassica*, the specimens being generally so uniformly arranged lengthwise as to show the direction of the current of the water by which they were last washed.

Large coprolites in the bed 2 *f* led me to look carefully for reptilian remains; and although it was not so rich as was expected, I obtained from it scattered vertebræ and a large humerus of *Plesiosaurus rugosus*?; and this bed is noteworthy also from my being able to fix it as the horizon of the large *Discina Townshendi*, Davidson, of which I secured two specimens.

No separate bone-bed occurred in this section. Rhætic bones and teeth were either distributed throughout the strata or were found washed into any little depressions in them.

In most of the sections to which reference has been made within the coal-basin, the lower beds of the Lias, included in the zones of the Insect-limestones, the Ostrea-beds, and the still higher ones of *Ammonites planorbis* and *Ammonites angulatus* as a distinct horizon, are wanting; and everywhere the *Ammonites-Bucklandi* beds, with *Ammonites angulatus* associated, repose immediately on the Rhætic White Lias.

One of the most important zoological features incident upon the very thinly represented and unconformable conditions of the Lias within the coal-basin is the paucity of Saurian remains within the area; and the same observation applies to the Liassic beds in connexion with the South Wales Carboniferous Limestones. In no part of the latter district have I yet found a single Saurian bone; and their absence south of Bath is most marked, notwithstanding that at Lyme and other localities they are so abundant in the *Ammonites-Bucklandi* beds. They appear more plentiful from Bath to the western edge of the coal-basin, but even there are usually met with only as scattered bones; and I have no hesitation in saying that, outside the coal-basin, more reptilian remains would be found in one year in a single quarry than in all the Liassic workings put together within the basin south of Bath.

4. *Sections near Bristol.*—The quarries of Bedminster Down are at the western edge of the Somersetshire coal-basin; and it is interesting to observe that with them we have a return to the ordinary conditions, and to the succession from the Keuper Marls upwards, of the lower typical beds of Camel and Beer, although they are not so thickly represented.

Section at Bedminster.

		ft.	in.
Rhætic White Lias.			
	1. Thin layers of light-blue stone and marl, exposed	2	0
	2. Rubbly White Lias, with very numerous shells	2	0
	3. Marl	0	2
	4. White Lias	0	2
	5. Marl	0	1
	6. White Lias	0	3
	7. Marl	0	1
	8. White Lias	0	3½
	9. Marl	0	3
Lower Lias.			
	10. *Insect and Crustacean Bed* ......1 in. to	0	3
Ostrea-beds.	11. Marl	0	3
	12. Ostrea-bed	0	2
	13. Ditto	0	2
	14. Ditto	0	4
	15. Marl	0	3
	16. Ostrea-bed	0	4½
	17. Marl	0	2
	18. Ostrea-bed	0	2
	19. Ditto	0	2
	20. Marl	0	1
	21. Ostrea-bed	0	3
	22. Marl	0	1
	23. Ostrea-bed	0	3
	24. Marl	0	6
	25. Ostrea-bed	0	2½
	26. Ditto	0	3

	ft.	in.
27. Marl	0	6
28. Stone, with numerous *Lima gigantea*, *Ostrea multicostata*, *Lima tuberculata*	0	7
29. Marl	0	8
30. Stone	0	7
31. Marl, numerous Entomostraca	0	8
32. Stone	0	7
33. Marl	0	2
34. Stone	0	3
35. Marl	0	4
36. Stone	0	3
37. Marl	0	3
38. Stone	0	5
39. Marl	0	3
40. Stone in thin laminæ, with *Ammonites planorbis* and insects	0	7
41. Laminated clay	1	3
42. Stone	0	8
43. Clay	0	2
44. Stone	0	3
45. Clay	0	4
46. Stone	0	6
47. Rubbly stone and clay to top	3	0

In the road under the Waterworks the variegated Marls of the Keuper are visible. Above, near the works, a trench had been cut across the outcrop of the White Lias with the Insect and Crustacean bed, No. 10, and the Ostrea-beds succeeding. On the top of this were drifted blocks, in which were at once to be recognized *Pecten Pollux*, and *Lima tuberculata*, characteristic bivalves of the Sutton Stone, which I subsequently found *in situ* in bed No. 28 of the above section.

The bed No. 40 is made up of thin laminæ, dark-coloured within, but weathering white from exposure. It is an Insect-limestone, with crustacean remains, and contains *Ammonites planorbis*. I felt certain before examining this bed that it was the equivalent of the "Black Rock," No. 31, of the *Ammonites-planorbis* beds in Hornibrook's Quarry, Beer Crowcombe (see p. 485, vol. xvii. Quart. Journ. Geol. Soc.), and that the bed of clay above, No. 49, was the "Hookstone Clay," No. 37, of the same section. The presence of *Ammonites planorbis* at once confirmed this view. In the paper just quoted I remarked on the extraordinary uniformity the Lower Lias presents over very wide areas where uninterruptedly deposited, of which examples were then given; but I did not expect to find illustrations of this fact at Bedminster. However, on referring to the Beer section, and reckoning the beds of the Lower Lias *upwards* above the White Lias in both places, the *A. planorbis* beds are No. 31 in both the sections; and we therefore find beds that are forty miles apart in a direct line, and separately of but a few inches in thickness, occupying the same horizon, and though differing from those both above and below, of precisely the same lithological character, and with the same peculiar organic remains.

It is impossible to have a more striking contrast than is here presented between the uniformity of succession from Bedminster through the whole of the West of England, and the unconformable and abnormal conditions previously described, when the strata have been deposited under other circumstances.

All the Bedminster Lias is below the *Ammonites-Bucklandi* series. There is no doubt the lower beds in the above section will repay a careful examination. In the marl No 31, I found *Avicula decussata* and *Discina Davidsonii*, Moore, which will be shown to occur also at Shepton and Southerndown, and the valves of a species of *Chiton*.

5. *Sections at Keynsham and Stout's Hill.*—There can be no question that the quarries of Keynsham are on the horizon of the *Ammonites-Bucklandi* beds; but, notwithstanding, it will be seen that, with those of Stout's Hill in the same district, they afford an important key to the determination of the age not only of the fauna from the Charter House Mine, but also of that from Brocastle and Sutton in South Wales, and, as a consequence, of that also of the beds of Valogne, the Côte d'Or, and other continental localities.

At a coal-wharf on the banks of the river Avon, between Keynsham and Stout's Hill, there is a quarry in which the basement Liassic beds are present, and in which the lower horizons of the Camel section are repeated, viz.:—

1. *White-Lias*, at the base, but not fully uncovered (Insect and Crustacean beds wanting).
2. *Ostrea-beds.* Eighteen beds of stone and marl, crowded with the characteristic *Ostrea liassica* and with *Mya*, sp., *Cardium Philippianum*, Terq., *Cypricardia Bronni*, Martin, *Cardinia exigua*, Terq., and *Myacites*: 3 ft. 6 in.
3. Seventeen more nodular beds of stone and clay, about 5 ft. thick, containing *Ammonites planorbis*, *A. angulatus*, *A. Johnstoni*, *Nautilus*, *Pinna*, *Unicardium cardioides*, *Astarte psilonoti*, Quenst., *Pecten Pollux*, and *Lima tuberculata*.
4. Thick grey clays, about 6 ft. (divided by several bands of septaria), containing multitudes of Echini and bones of *Plesiosaurus rugosus*, Owen.

The beds in this section dip very rapidly in the direction of the *Ammonites-Bucklandi* quarries at Keynsham and pass under them, though the intermediate beds are not shown.

In the uppermost portion of the *A.-Bucklandi* series there is a thin band, from two to three inches thick, composed of a brown, indurated, laminated marl, interposed between the limestones, over the area of Bath, Weston, Twerton, Saltford, and Keynsham; it shows an interruption in the ordinary Liassic deposits, and indicates a precise horizon at the top of the series throughout the district. In this thin bed are many plants, including *Araucarites*, with remains of *Hybodus*, *Acrodus*, *Lepidotus*, and the heads and tails of *Leptolepis*, the body having perished. *Avicula inæquivalvis* is particularly abundant, associated with *Ostrea ocreata*, Desl., and *Ostrea liassica* (*O. anomala*, Terq.); and it is the only horizon in which I have found *Anomia pellucida*, Terq. (p. 25. fig. 5); the fig. 5 *a* of that author is also found in this bed, but is apparently a *Plicatula*. Had the Hybodus-spine figured by M. Terquem, pl. 12. fig. 3, of the "Infralias of Hettange," been placed in my hands for a determination of its horizon, I should at once have referred it to this bed, as these species are found therein at Keynsham.

But the most important point remains to be noticed. This thin bed is interposed between thick-bedded limestones; and below it in particular are found the fine examples of *Ammonites Bucklandi* yielded by this locality, and a great profusion of *Gryphæa incurva*. In the ragged and weathered edges of the beds which enclose this band of marl are to be found, in great part, the fauna described by

MM. Martin and Terquem, from the sections of the Côte d'Or and the Grès calcareux of Luxembourg and Hettange. The same Mollusca continue upwards in thinner beds of stone, interposed between beds of clay, but they do not weather out so perfectly. On the surfaces of the latter beds are many examples of *Involutina liassica*, Jones, which are also frequent in the Mendip mine, and more rarely at Brocastle, and again at Stout's Hill.

Returning again to the Avonside wharf section, and crossing several steep fields above this quarry, Stout's Hill is reached. A large field has, in former times, been completely quarried; but there only remains a very small section open, exhibiting beds 4 or 5 feet in thickness. Scattered over the surface of the field are many specimens of *Gryphæa incurva*, and occasional fragments of *Ammonites angulatus*, *A. Bucklandi*, and *A. Conybeari*. Under the hedge, on the western boundary of this field through its greater length, the Lias may be seen, and there will be again found, as the following list will sufficiently show, nearly all the "Infralias" species of the continent. With them are present many *Gryphæa incurva*, and examples of *Ammonites Bucklandi*, *A. Conybeari*, and *A. angulatus*; and, as though no doubt should hereafter arise respecting this fauna, the little Gasteropoda and other remains are to be seen by thousands within the chambers of the Ammonites themselves. Specimens of *Ostrea intusstriata* are attached to some of the *Gryphææ* of this place. From the clays of Keynsham I have obtained a microscopic or young form of *Montlivaltia*, and from Stout's Hill an example of *Thecosmilia Michelini*, the first example I have recognized out of South Wales*.

The beds of the Lower Lias above the *Ammonites-Bucklandi* series in this part of England are very thin and seldom exposed, and soon pass under the marls of the Middle Lias.

List of Organic Remains from Stout's Hill and Keynsham.

Cristellaria rotula, *Lamk.*
—— costata, *D'Orb.*
—— cultrata, *Mont.*
Dentalina communis, *D'Orb.*
—— obliqua, *Linn.*
—— obliquestriata, *Reuss.*
Involutina liassica, *Jones.*
Frondicularia striatula, *Reuss.*
Marginulina lituus, *D'Orb.*
Nodosaria raphanus, *Linn.*
—— radicula, *Linn.*
Planularia Bronni, *Roem.*
Trochammina incerta, *P. & J.*
Thecosmilia Michelini.
Montlivaltia, microscopic.
Echinodermata, sp.
Serpula, sp.
—— strangulata, *Terq.*
Encrinite stems.
Crustacean claw.
Cythere.
Cytherella aspera, *Jones.*
Normania mundula, *Jones.*
Neuropora, sp.
Stomatopora, sp.
Lingula.
Rhynchonella variabilis.
Terebratula punctata (T. strangulata, *Terq.*).
Thecidium triangulare.
Spirifera Walcottii, *Sow.*
Zellania obesa, *Moore.*
Avicula inæquivalvis.
—— Alfredi, *Terq.*
Gryphæa incurva, *Sow.*
Avicula Dunkeri, *Terq.*
Anomia pellucida, *Terq.*
—— irregularis, *Terq.*

* Since the above was written, I have found under the Carboniferous Limestone escarpment, a little east of East Cranmore, blocks of Lower Lias, with *Thecosmilia Michelini* and other corals, associated with *Gryphæa incurva*.

Lima dentata, *Terq.*
—— Hermanni, *Volk.*
—— gigantea, *Sow.*
—— Hettangiensis, *Terq.*
—— duplicata, *Sow.*
——, sp.
—— tuberculata, *Terq.*
Ostrea intusstriata, *Em.*
—— liassica.
—— irregularis.
—— arietis, *Quenst.*
Pecten sublævis.
—— æquiplicatus, *Terq.*
—— Pollux, *D'Orb.*
Pinna semistriata, *Terq.*
Plicatula? pellucida, *Terq.*
Arca Collenoti, *Martin.*
—— pulla, *Terq.*
Cardinia, sp.
Astarte, sp.
——, sp.
—— psilonoti, *Quenst.*
—— irregularis, *Terq.*
Cardinia exigua, *Terq.*
Cardita multicostata.
Cardium Terquemi, *Martin.*
—— Philippianum, *Terq.*
—— Heberti, *Terq.*
Cucullæa Hettangiensis, *Terq.*
Cypricardia Bronni, *Martin.*
Leda Heberti, *Martin*, non *Titei.*
Modiola minima, *Sow.* (Mytilus rusticus, *Terq.*).
Mya.
Myacites.
Nucula, sp.
Pholadomya Heberti, *Terq.*
Saxicava Sinemuriensis, *Martin.*
—— arenicola, *Terq.*
Tancredia securiformis, *Terq.*
Unicardium cardioides, *Phil.*
Actæon Sinemuriensis, *Martin.*
Cerithium gratum?
—— Semele, *D'Orb.*
—— Henrici, *Terq.*
Cerithium acuticostatum, *Terq.*
—— paludinare, *Terq.*
—— Collenoti, *Martin.*
—— trinodulosum, *Martin.*
Chemnitzia polita, *Terq.*
Melania abbreviata, *Terq.*
Orthostoma oryza, *Terq.*
—— triticum, *Terq.*
——, sp.
Pleurotomaria Hettangiensis, *Terq.*
—— concava, *Martin.*
—— nucleus, *Terq.*
——, sp.
—— expansa, *Sow.*
Purpurina (Turbo) tricarinata, *Martin.*
Turritella Humberti, *Martin.*
—— Jenkeni, *Terq.*
Phasianella liassica, *Terq.*
Solarium lenticulare, *Terq.*
Straparollus tricarinatus, *Terq.*
——, sp.
Trochus tubicola, *Terq.*
——, sp.
——, sp.
Turbo Piettei, *Martin.*
—— costellatus, *Terq.*
—— gemmatus, *Terq.*
—— liassicus, *Martin.*
—— nanus, *Martin.*
——, several species.
Ammonites Bucklandi.
—— Conybeari.
—— angulatus.
—— planorbis.
——, young.
——, do.
Belemnites acutus.
Nautilus intermedius, *Sow.*
Hybodus, spines and teeth.
Acrodus, teeth.
Lepidotus.
Spinal bone as at Whatley.
Ichthyosaurus.
Plesiosaurus rugosus?
Araucarites peregrinus.

6. *Rhætic White Lias and Carboniferous Limestone at Broadfield Down.*—This section has been referred to by E. B. Tawney, Esq., F.G.S., in his paper "On the Western Limit of the Rhætic Beds, and on the Position of the Sutton Stone." In the Carboniferous Limestone platform of Broadfield Down, there is a basin about a mile in length, the deposit in which, in the older geological maps, was coloured as alluvial, but which has lately been recognized as of Rhætic age. The following beds are present:—

	ft.	in.
Stone	0	6
——	1	0
——	2	1
——	2	0

	ft.	in.
Stone	1	8
——	0	10
——	2	3
Ragstone and rubbly beds	7	8
Conglomerates, thickness unknown.	——	
	18	0

In all the sections of White Lias that have been previously noticed, the lithological character of the beds is precisely alike; for, in all, the beds have been deposited under ordinary conditions; but no sooner do they meet the Carboniferous Limestone, and are unconformable, than their texture is entirely changed, and they become thickly bedded and conglomeratic. The abundance of *Modiola minima* and other remains shows clearly that this deposit belongs to the White Lias; but its texture is so precisely like the Sutton stone that it might readily be mistaken for that rock. Like the Sutton stone it is very durable, and may be raised in blocks of many tons weight, and, were there facilities for its transit, might be largely used. At the base of the quarry there are thick conglomerates with *Ostrea intusstriata*, the thicknesses of which are unknown, and in which galena is found, as at Sutton. A *Thecosmilia* in casts is rather plentiful at this place.

7. *Section near Shepton Mallet.*—As the Liassic beds of Shepton Mallet are of much interest, and will have an important bearing on the correct determination of the age of the Sutton-stone series, I give them in detail. They have been deposited on the southern slopes of the Carboniferous Limestone of the Mendips, and in some instances rest unconformably upon it. I shall first give their passage from the Keuper upwards along the line of the railway from Shepton to Wells. The beds dip gradually to the east, passing under the Middle and Upper Lias and Inferior Oolite at Doulting.

Section in a Railway-cutting West of Shepton.

	ft.	in.
Keuper: Variegated marls	0	0
Rhætic beds: light-blue sandy stone and marl-beds	8	9
Band of clay	0	2
Stone	0	8
Blue clay	1	0
Stone	0	8
Thin bands of clay and stone	1	8
Dense black clay, full of Rhætic shells and metacarpal bones of *Scelidosaurus*	12	0
Flinty bed?	1	6
Blue clay	3	0
White Lias: eighteen beds of a bluish-grey colour	8	0
fifteen beds, cream-coloured	6	0
Lower Lias:—		
1. Blue clay, with numerous *Ostrea intusstriata*, *Ostrea liassica*, &c.	0	4
2. Gritty blue limestone, with *Ostrea liassica*	0	3
3. Blue clay	0	4
4. Bed of irregular stone	0	2
5. Clay	0	3
6. Rubbly stone, with *Terebratula punctata*, *Rhynchonella variabilis*, *Lima gigantea*, *Ammonites planorbis*, *A. Johnstoni*, *Pecten Pollux*, *Lima tuberculata*	0	6

	ft.	in.
7. Blue clay, with nodular stone and *Pentacrinites*	1	0
8. Yellow stone	0	6
9. Rubbly stone	0	6
10. Clay, with *Lima gigantea*, abundant	3	0
11. Stone	0	3
12. Clay	0	4
13. Stone, with *Ammonites angulatus*	0	5
14. Yellow marl, with Pentacrinites	0	9
15. Stone	0	4
16. Rubbly beds, *Ammonites Bucklandi*, &c. &c.	6	0

The succession from the Keuper through the Rhætic clays and "White Lias" is admirably shown on the line of railway, the Rhætic series being crowded with its characteristic fossils. We need only refer to the discovery, for the first time, of two metacarpal bones of a large land reptile, allied to *Scelidosaurus*, from the *Avicula-contorta* shales, a genus which has hitherto been recognized only in the upper portion of the Lower Lias.

On comparing the Liassic beds with the Camel section, it will be at once apparent that the lower members are absent, and the upper at this point but feebly represented. Close down upon the Rhætic beds we find *Ammonites planorbis*, with *Pecten Pollux*, and *Lima tuberculata* of the Sutton stone, associated with Brachiopoda hitherto found only in the *Ammonites-Bucklandi* beds. As we pass along the section towards Shepton, the group of beds No. 16 comes in. These beds are composed of a greyish, sandy, irregularly bedded limestone, and are full of organic remains, amongst which are *Ammonites Bucklandi*, *A. Conybeari*, *A. angulatus*, *Nautilus striatus*, and *Spirifera Walcottii*, the fauna at once indicating that they belong to the *A.-Bucklandi* series. The railway continues upon them until the Shepton station is reached, where the beds can be again seen; and as the stone has been used throughout for the ballast of the line the organic remains of this stage can be well studied. On this horizon we have unquestionably many of the Sutton-stone and Southerndown fossils. Amongst these we find the large *Cerithium* so abundant at Southerndown, which at Shepton retains its shell, and which I propose to name *C. nodulosum*. A small flat *Montlivaltia* is remarkably plentiful on the line of railway, as many as a dozen examples occurring in a hand specimen. Independently of the general fauna, several curious coincidences connect the *Ammonites-Bucklandi* beds of Shepton with the Southerndown series. Washed into the Sutton and Southerndown beds are many blocks of dark siliceous stone, to which are frequently attached *Ostrea intusstriata*; and the same occurs, though more rarely, at Shepton. Again, on the inside of a *Nautilus striatus*, and in the chamber of a *Cerithium nodulosum*, Moore, from the Shepton railway-cutting, small individuals of *Discina Davidsoni*, Moore, attached themselves, which are not unlike *D. Sandersi*, Moore, of the Upper Lias. In the hollow chamber of the phragmocone of a very large Belemnite, from Southerndown, the same little *Discina* occurs!

A close examination of the matrix of the *Ammonites-Bucklandi* beds, which is generally very dense, shows that it may be almost denominated a *Foraminiferal Reef*. It is almost entirely composed of minute organisms; and four or five genera of Foraminifera may be detected within a square inch, and also Entomostraca. The former include *Involutina, Dentalina, Cristellaria, Nodosaria, Planulina*, &c. The number of species cannot be arrived at, as they are generally broken across.

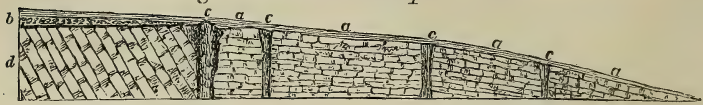
It may be noticed that along the railway-section no beds are present which have the lithological character of the Sutton stone; and, except that the upper ones are rather more arenaceous, and are more closely bedded, they are in the usual condition of the Lias; but as they meet the Carboniferous Limestone the Sutton-stone character appears.

Looking across from the railway towards the Mendips, a large quarry of Carboniferous Limestone may be observed at Windsor Hill. In passing through the town in this direction, in about a mile, a roadside-section of considerable interest is reached, which has been noticed by Sir Henry de la Beche in his memoir on the "Formation of the Rocks of South Wales and South West of England," p. 278*. The town of Shepton Mallet is cut across by several ravines; and there is little doubt that the Carboniferous Limestone is not far below the surface, and that it again formed the sea-bottom of this district during the Liassic period.

The road to Windsor Hill passes up a small ravine on the south of the Mendips; and a short way out of the town we reach a series of thickly bedded Liassic rocks, without any clay partings, extending for a length of 96 feet, the beds dipping south towards the town. This portion of the section is cut off by a fissure containing crystalline carbonate of lime, 1 foot wide, from a continuation of the same beds (but dipping at a less angle), 84 feet in length. Another vein of 1 ft. 4 in. separates this block from more thickly bedded rocks, which are nearly horizontal, 114 feet in length. A wall of 42 feet succeeds, which has probably been built against disturbed and broken rocks, and covers the connexion of the latter beds with another vein 2 feet thick, which at this point separates the Lias from a section of Carboniferous Limestone, which extends for a distance of 120 feet, and which is seen to be continuous in thick-bedded limestones on the opposite side towards Cowl Street. At the upper end of this Carboniferous Limestone there rests immediately upon it several thin beds of conglomerate, 1 foot in thickness, belonging to the Rhætic bone-bed, and perfectly identical with the conglomerate I have before noticed at Hapsford Mills. It is composed of rounded pebbles, mixed with which are many Rhætic teeth and bones. The littoral character of this deposit may be seen when it is mentioned that, in a block a few inches square, I have a fine vertebra of *Plesiosaurus rugosus* (?), teeth of *Acrodus*, *Avicula contorta*, and abundance of bones, and Carboniferous-Limestone, Encrinites.

* Mem. Geol. Survey, vol. i.

Fig. 5.—*Section at Shepton Mallet.*



a. Lower Lias. *c.* Veins of Lias.
b. Rhætic Conglomerate. *d.* Carboniferous Limestone.

The beds in this section in ascending order are as follows :—

	ft.	in.		ft.	in.
Stone	0	10	Stone	0	4
——	0	8	——	1	0
——	1	0	——	0	7
——	2	9	——	0	7
——	2	0	——	0	10
——	2	10	——	0	10
——	1	0	——	0	8
——	1	2	——	0	8
——	0	10	——	0	6
——	0	6	——	0	4
——	1	3	——	0	4
——	1	3	——	0	6
——	1	3	——	0	6

The stone at Sutton, in South Wales, is of two kinds :—the Bastard Sutton stone at the base, which is a very coarse conglomerate, and in which alone the corals of that place are found; and finer-grained whiter limestones above, which are without corals, and with but few univalves as compared with the beds below. In lithological character the above section at Shepton is perfectly identical with the finer-grained or true "Sutton Stone;" and so far as their organic contents are concerned, it is impossible to recognize any distinction. There is the same abundance of *Pecten Pollux*, *Lima gigantea* and all the other characteristic shells of the same horizon, and, in this instance, in association, as at the railway section, with *Ammonites Bucklandi* and a still higher Liassic form, *A. obtusus*? The same *Discina Davidsoni*, Moore, mentioned before, again occurs attached to the shells from these beds; and I have also found *Pollicipes*, identical with one which is abundant in the upper beds at Langan.

Crossing Cowl Street from this roadside-section, and taking a pathway up the hill through a field to the waterworks, blocks of stone may be seen containing abundance of *Lima duplicata* and *Ostrea liassica*. The waterworks reservoir is not far below the Carboniferous Limestone quarry of Windsor Hill, and where the lower beds of Lias would be expected to meet that formation; and we here find the bastard or lower Sutton stone represented by thick crystalline limestones containing in abundance the cherty and other pebbles, as at Sutton and Southerndown; and so alike are the deposits that it is impossible to distinguish between them; and again are repeated, excepting the corals, the organic remains of the Sutton stone, *Montlivaltiæ* being the only corals found at Shepton.

Owing to the different character of the matrix of the stone at

Windsor Hill and at Sutton, the shells have often lost their outer structure; for which reason care is needed in the determination of species. Nearly all the Mollusca quoted by Mr. Tawney from the Sutton series are present, and others in addition; but, unfortunately, from that gentleman having missed the key to the interpretation of the age of the beds, and from the altered appearance of the shells, many of them are only varieties of species that have already been described.

List of Fossils from Windsor Hill.

Montlivaltia.
Pollicipes rhomboidalis, *Moore.*
Cythere mundula, *Jones.*
Discina Davidsoni, *Moore.*
Avicula decussata.
Hinnites, sp.
Lima gigantea (L. Dunravenensis *Taw.*, L. Fischeri, *Terq.*, L. exaltata, *Terq.*).
—— tuberculata, *Terq.*
—— duplicata (L. subduplicata, *Taw.*, L. Hettangiensis, *Terq.*).
—— sp.
—— Hermanni, *Voltz.*
Ostrea liassica (Anomia socialis, *Taw.*, Ostrea lævis, *Taw.*).
—— arietis, *Quenst.* (O. multicostata, *Terq.*).
—— intusstriata.
Pecten Etheridgii, *Taw.*
—— Pollux, *D'Orb.* (P. Suttonensis, *Taw.*).
—— sublævis, *Phillips.*
Pinna semistriata, *Terq.* (P. insignis, *Taw.*).
——, sp.
Cardinia, casts, several species.
Modiola Hillana, *Sow.*
—— producta, *Terq.*
Melania abbreviata, *Terq.*
Turritella Jenkeni, *Terq.*
Trochotoma, sp.
Ammonites Bucklandi.
—— obtusus?
—— Conybeari.

List of Organic Remains from the Shepton Mallet Railway-section.

Ammonites-planorbis Beds.

Ammonites planorbis.
—— Johnstoni.
Terebratula punctata, *Sow.* (T. strangulata, *Terq.*)
Rhynchonella variabilis.
Lima gigantea, *Sow.*
—— tuberculata, *Terq.*
Pecten Pollux, *D'Orb.*
—— sublævis, *Phil.*
Ostrea liassica.
Pholadomya ambigua.
Unicardium cardioides.
Normania mundula, *Jones.*
Cytherella aspera, *Jones.*
Dentalina.
Trochammina incerta.
Nodosaria.

Ammonites-Bucklandi Beds.

Ammonites Bucklandi, *Sow.*
—— Conybeari, *Sow.*
—— angulatis, *Phil.*
—— Johnstoni?
Nautilus striatus.
Involutina liassica, *Jones.*
Dentalina, several sp.
Cristellaria, ,,
Nodosaria, ,,
Planulina, ,,
Montlivaltia.
Echini, sp.

Ophioderma, joints.
Pentacrinites.
Serpula.
Entomostraca, sp.
Discina Davidsoni, *Moore.*
Terebratula punctata, (strangulata *Terq.*)
Rhynchonella variabilis.
Spirifera Walcottii, *Sow.*
Avicula decussata.
Gryphæa incurva, *Sow.*
Lima gigantea, *Sow.*
—— tuberculata, *Terq.*
—— duplicata.
——, sp.
Ostrea intusstriata, on chert pebble.
—— arietis.
—— liassica.
—— irregularis.
Spondylus liassicus, *Terq.*
Pecten Pollux, *D'Orb.*
Pecten sublævis.
Pinna semistriata, *Terq.*
Plicatula Hettangiensis, *Terq.*
Cardinia Listeri.
—— elongata.
Modiola, casts of.
—— producta, *Terq.*
Myacites.
Pholadomya ambigua.
Unicardium cardioides.
Cerithium nodulosum, *Moore.*
—— paludinare, *Terq.*
——, sp.
Turritella Deshayesii, *Terq.*
Littorina clathrata, *Desh.*
Melania (Pterocera) dubia, *Terq.*
Pleurotomaria densa, *Terq.*
—— Hettangiensis, *Terq.*
—— expansa, *Sow.*
Solarium lenticulare, *Terq.*

8. *Value of Zones of Zoological Life.*—Before passing to a consideration of the Secondary rocks of South Wales, it may be desirable to say a few words on the value to be attached to precise zones of zoological life. Although it is exceedingly convenient to the geologist to be able to refer certain faunæ to horizons such as those known as Ammonite-zones, of which, as far as possible, I have availed myself, still, with our increased knowledge of the range of specific forms, such limits may prove arbitrary and may mislead. In the same district, or even at wide intervals, as is the case with the Upper Lias of Ilminster and of May in Normandy, or Whatley and Fontaine-étoupe-Four, where beds have been deposited under the same physical conditions, we may expect, as a general rule, to find identical species, or even, after a considerable interval in time, when favourable conditions occurred, to find their recurrence; but when the beds have been otherwise deposited, it would not be surprising if this law failed. I have previously shown such recurrence with some of the Brachiopoda, and it is also the case with many of the Foraminifera.

Avicula decussata has hitherto been considered to belong only to the Rhætic "White Lias;" but we now find this species to occur in the Lower Lias of Hatch, Camel, and Bedminster, and in the *Ammonites-Bucklandi* beds of Shepton. *Ostrea intusstriata* was also supposed to be confined to the Rhætic beds; but it is abundant at Sutton, passes through the Liassic beds of Bridgend &c., and is found with the *Ammonites Bucklandi* at Shepton and Bath. From the latter quarries I have it attached to the interior of *Gryphæa incurva*, and also to the exterior of a large *Ammonites angulatus* from the same beds, to which there are not less than 114 attached specimens. *Ostrea liassica* is abundant in the "White Lias," but has its greatest development in the Ostrea-beds of the Lower Lias, and then passes upwards, though more sparingly, into some of the higher beds.

The same may be shown of the range of many of the Ammonites.

A. angulatus, to which has been accorded a special horizon between the zone of *A. planorbis* and that of *A. Bucklandi,* is really the prevailing shell in the latter around Bath, where it sometimes reaches a great size. In a garden near the railway station at Keynsham, there is a specimen which attains 5 feet 10 inches in circumference, and 2 feet in diameter. This species is quite common at Southerndown, where also, in a garden leading down to the cliffs, is a very large specimen; and in its young form it may be seen to pass up into the very highest beds at Bridgend, where it is found associated with *A. semicostatus* and *A. Sauzianus.* *A. Bechei,* from the base of the Middle Lias, passes through that formation, whilst *A. radians, A. variabilis,* and *A. Moorei* of the Upper Lias, the discovery of which in the sands of the Inferior Oolite suggested the removal of the latter beds to the Lias, are with other species found as low down as the Marlstone of the Middle Lias.

Pecten Pollux occurs as a dwarf form in the Rhætic White Lias, and passes uninterruptedly in association with *Ostrea arietis* (*O. multicostata,* Terq.), *Plicatula acuminata,* and other Sutton and "Infralias" species through all the Lower Lias to the *A.-Bucklandi* beds; and I know of no single locality, on whatever horizon, where more or less frequently these species are not to be found. Not only is this so, but the general "Infralias" fauna passes up into the *A.-Bucklandi* beds at Bath and Keynsham, the limit to their discovery in the very highest beds at these places being evidently determined by the denser character of the matrix, which prevents their weathering out. The "Infralias" fauna will be found again in the highest beds at Southerndown and Bridgend, accompanied by *Gryphæa incurva.* The latter shell is to be found abundantly with the Coral-fauna of Brocastle, through the Sutton and the greater part of the Bridgend section, and is shown in the Camel section to have been contemporaneous with *Ammonites planorbis.*

These passages might be multiplied; but they are sufficient to show that although in a special locality we may arrive at correct conclusions regarding the range of genera and species, yet where a wider area is considered, and especially should the beds in which the fossils are found have been deposited under different circumstances, they will not be found correct.

VI. The South Wales District.

Having pointed out the peculiar characters of the Secondary deposits connected with the Mendips and the Somersetshire coal-basin, I now proceed to a consideration of similar phenomena on the southern edge of the coal-basin of South Wales.

It has before been stated that the upheaval of the Old Red Sandstone and Carboniferous beds of South Wales was probably contemporaneous with that of those of the Mendips, of which they form a natural continuation; and such being the case, it might be expected that in association with them similar abnormal conditions would be observed.

I have not given a critical examination to the whole district, having chiefly confined my attention to the South Wales coast, where the beds of the Sutton and Southerndown series occur—in connexion with the age of which I am compelled to differ from the conclusions arrived at by Mr. Tawney, who has suggested their being of Rhætic or even of St. Cassian age.

1. *Penarth Rhætic and Liassic Section.*—The most important section showing the Rhætic series is that of Penarth Head. In general this formation is more feebly represented in Wales than in most of the Somersetshire deposits; this is more especially the case with the "White Lias," which, though so constant in the latter county, is frequently scarcely recognizable in the Welsh sections.

At the base of the Penarth section are thickly bedded gypseous red marls of the Keuper, above which the *Avicula-contorta* beds come in, but, from the difficulty of getting access to them, are not so readily to be studied as the Rhætic sections given at Camel, Shepton Mallet, and Hatch. The "White Lias" seen opposite the Docks, instead of being composed of thickly bedded limestones, is represented by grey shales about 30 feet thick, and contain only two beds of 3 inches of White Lias stone. In the limestone quarry above, west of the cliff, a fine section of the Lower Lias series may be seen, at the base of which occur about twenty beds, which represent the Ostrea and "Firestone" divisions of Camel, and in the upper of which are numerous *Ostrea liassica*, *Plicatula acuminata*, and *Lima gigantea*. These are succeeded by thirty-six other beds, with *Ammonites planorbis*, *Lima gigantea*, *L. duplicata*, *L. tuberculata*, and *Pecten Pollux*.

In this section the Liassic beds have been deposited beyond the Carboniferous Limestone coast-line, and, having their usual sequence through Keuper and Rhætic formations, are undistinguishable from the Somersetshire beds; and it is not improbable that the same uniformity previously noticed might on close examination be pointed out.

2. *Bridgend Liassic Sections.*—A reference to the Geological Survey Map shows an almost uninterrupted development of the Lower Lias on the South Wales coast, from Penarth to Sutton and Southerndown; and there is in this direction the last westerly extension of this formation. The coal-basin on the south-east is bounded by continuous Old Red Sandstone and Carboniferous Limestone. As these rocks come to the south of the basin, they are much broken, and present numerous basins in which New Red Sandstone, Conglomerates, and Liassic Beds have been enclosed, and there is again repeated the phenomenon, noticed on the Mendip coast-line, of later beds deposited on a sea-bottom of Carboniferous Limestone. One of these may be seen in what may be termed the Bridgend and Brocastle basin. A few miles to the north the long-extended escarpment of the uplifted Coal-measures, to the base of which the above Secondary rocks reach, may be observed. The Lias within this basin is cut off from its larger development towards the coast, except by a narrow neck of that formation passing between projecting ranges of Carboniferous Limestone between Brocastle and Ewenny. The Lias from this point inclines slightly towards the

centre of the basin at Bridgend, in which its greatest thickness (of stratified beds) is manifest. After giving the Bridgend section I propose to consider the Lias in its junction with the Carboniferous limestone.

In the valley west of Bridgend the Keuper Sandstones are largely worked, but their succession upwards into the Lias is not well exposed. At the iron-works close to the west end of the Bridgend Quarry a well, lately sunk for water, passed through about 90 feet of blue and red marls, which, from the account given of them, probably represented the upper Keuper beds. The beds dip rapidly to the south-east; and between the well and the iron-works, on a higher horizon, is a deep pit, which is now being filled with quarry--refuse, and contains water, most likely sunk through the Rhætic beds. Above this the sides were covered for about 25 feet. Dark-brown or grey nodulated limestones are then seen, about eight feet thick, succeeded by about twenty beds, some of them containing numerous cherty or flinty layers and nodules, which are also to be found in most of the Liassic sections of the district. The fossils are not numerous; but there occurred *Pinna semistriata*, *Pentacrinites*, and several specimens of *Gryphæa incurva*, which I left, as they indicate the presence of the latter shell low down in the Liassic series of this district. In the adjoining quarry the following important section occurs taken from the west end in ascending order. The term "clod" is used by the quarrymen for intervening beds of clay or marl.

Section at Bridgend.

	ft.	in.		ft.	in.		ft.	in.
Stone	0	7	Clod, ditto	3	0	Clod	0	3
——	0	10	Stone	0	7	Stone	0	8
Clod	0	3	Clod	0	3	Clod	0	5
Stone	0	3	Stone	0	10	Stone	0	5
Covered beds	4	0	—— with chert	0	4	Clod	0	2
Stone	0	6	——	0	7	Stone	0	5
Clod	0	3	Clod	0	3	Clod	0	3
Stone	0	7	Stone	1	0	Stone with *Ammonites Conybeari*	1	0
——	0	3	Clod	0	3	Clod	0	5
Clod	0	8	Stone	1	0	Stone	0	8
Stone	0	5	Clod	0	3	Clod	1	0
——	0	10	Stone with *Gryphæa incurva*	0	10	Stone	0	4
Clod	0	1	——	0	7	Clod	1	0
Stone	0	11	——	0	4	Stone	1	0
——	1	0	——	1	4	Clod	0	3
Clod	0	7	——	0	7	Stone	0	8
Stone	0	7	——	0	8	Clod	0	2
Clod	0	2	——	1	0	Stone: *Chemnitzia, Pinna*	1	0
Stone	0	10	——	0	10	Clod	1	0
Clod	0	2	Clod	0	2	Stone: *Montlivaltia*	0	4
Stone	0	3	Stone	0	7	Stone with numerous univalves, *Pinna*, and *Gryphæa incurva*	2	0
Clod	0	2	Clod	0	3	Clod	0	3
Stone	0	4	Stone	0	5	Stone	0	6
——	1	2	Clod	0	3			
Clod	0	2	Stone	0	5			
Stone	0	5	Clod	0	3			
——	0	4	Stone	0	8			
Stone with *Myacites*	0	10						

	ft.	in.
Stone with *Pentacrinites*, univalves, and *Montlivaltia*	1	0
Clod	0	3
Stone: *Montlivaltia*	1	0
—— with numerous *Turbo* &c.	1	2
——	0	7
Clod	0	1
Stone	0	4
Clod	0	2
Stone	1	2
——: *Pinna* &c.	1	0
Stone	0	9
Clod	0	2
Stone	0	5
——	0	10
Clod	0	1
Stone	1	0
Clod	0	2
Stone, shells, and large boulders of flint	0	11
——, ditto	1	0
Stone	0	4
——	1	0
——	0	3
——	0	9
——	0	8
Clod	1	0
Stone	0	8
Clod	0	6
Stone	0	8
Clod	0	1
Stone	1	0
——	0	3
——	0	10
Clod	0	3
Stone	0	4
Clod	0	1
Stone	1	0
Clod	0	2
Stone	0	8
Clod	0	1
Stone	1	0
——	0	2
——	0	7
Clod	0	3
Stone	0	6
Clod	0	2
Stone	0	7
Clod	0	2
Stone: *Pentacrinites*	0	10
Clod	0	4
Stone: *Pinna*	0	8
Stone	0	6
Clod	0	2
Stone	0	6
Clod	0	4

	ft.	in.
Stone with numerous *Ammonites* (sections)	0	10
Clod	0	4
Stone	0	8
Clod	0	4
Stone	0	4
——	0	2
Clod	0	2
Stone with band of Chert	0	7
Stone	0	5
——	0	6
—— with Chert	0	8
——: *Montlivaltia*	0	6
Beds with face covered by Carbonate of Lime	6	0
Stone	1	0
——	1	3
—— with Chert	1	0
—— with *Pentacrinites*	1	3
——	0	6
——	1	3
—— with *Pinna*	0	3
——	1	4
——	0	5
Clod: *Pinna semistriata*	0	3
Stone	0	5
Clod	0	2
Stone	1	0
Clod	0	6
Stone	0	6
Clod	0	7
Stone	0	7
Clod	0	2
Stone	0	4
Clod	0	4
Sixteen rubbly beds with clod parting, with many *Gryphæa incurva*, *Pentacrinites*, *Ammonites*	8	0
Stone: *Gryphæa incurva*	1	0
Blue clod	0	2
Stone	0	6
Clod	0	3
Stone	1	0
Clod	0	1
Stone	0	7
——	0	10
Clod	0	4
Stone	0	8
Clod	0	2
Stone	0	4
——	0	5

	ft.	in.
Stone	0	5
Clod	0	2
Stone	0	4
——	0	4
——	0	8
Clod	0	4
Stone	0	5
——	0	8
Clod	0	7
Stone	0	8
Clod	0	3
Stone	0	4
Clod	1	0
Stone	0	5
Clod	0	3
Stone	0	4
Clod	0	6
Stone	0	5
Clod	0	5
Stone	0	8
Clod	1	0
Stone	0	7
Clod	0	9
Stone	0	4
Clod	1	0
Stone, with numerous *Gryphæa*, the beds becoming more blue	1	0
Clod	0	7
Stone	0	5
Clod	0	3
Stone	0	6
Clod	0	4
Stone	0	7
Clod	0	6
Stone	0	4
Clod	0	3
Stone	0	5
Clod	0	2
Stone	0	4
Clod	0	6
Stone	0	5
Clod	0	9
Stone	0	8
Clod	1	8
Stone	0	5
——	0	6
——	0	4
Clod	0	9
Stone	0	4
Clod	0	4
Stone	0	7
Clod	1	0
Stone	0	9
Clod	0	8
Stone	0	9
Clod	1	0
Stone: *Pinna folium*	1	5
Clod	0	1

	ft.	in.
Stone	0	4
Blue clod or clay...	1	2
Stone: *Rhynchonella variabilis, Cardinia*	1	3
Clod	0	10
Stone: *G. incurva*	1	2
Clod	0	4
Stone	0	4
Clod	0	6
Stone	0	4
Clod	0	1
Stone	0	8
Clod	0	6
Stone	0	9
Clod	0	3
Stone	0	4
Clod	0	4
Stone	0	3
Clod	0	1
Stone	0	9
Clod	0	2
Stone	0	6
Clod	0	1
Stone	0	4
Clod	0	4
Stone with *Pentacrinites, G. incurva*, and *Pinna* ...	0	2
Clod	0	2
Stone	0	10
Clod	0	2
Stone with univalves, *Pinna, G. incurva*	0	9
Clod	0	2
Stone	0	10
Clod	0	2
Stone	0	4
Clod	0	3
Stone	0	3
Clod	0	1
Stone	0	9
—— with *Ammonites Bucklandi*	1	3
Clod	0	1
Stone	0	8
——	1	0
Clod	0	4
Stone: *Gryphæa incurva*	1	3
——	1	4
Clod	1	0
Stone	0	9
Clod	1	0
Stone	0	10
Clod	0	4
Stone	1	2
Clod	0	3
Stone	0	8

	ft.	in.
Clod	0	3
Stone	0	8
Clod	0	4
Stone	0	5
Clod	1	0
Stone	0	7
Clod	0	3
Stone	0	4
Clod	0	2
Stone	0	4
Clod	0	9
Stone	1	0
Clod	0	7
Stone	0	4
Clod	0	3
Stone	0	9
Clod	0	9
Stone	0	8
Clod	1	2
Stone	1	0
——	1	0
——	0	9
Clod	0	4
Stone	0	9
Clod	0	9
Stone	0	7
Clod	0	4
Stone	0	5
——	1	0
——	0	9
Clod	1	2
Stone	0	10
Clod	1	6
Stone	0	9
Clod	0	4
Stone	0	6
Clod	0	4
Stone	0	9
Clod	0	6
Stone	0	4
Clod	0	2
Stone	0	8
Clod	1	0
Stone	1	3
Clod	0	2
Stone	1	0
Clod	2	0
Stone	0	7
——	0	8
——	0	6
Clod with *Gryphæa incurva*	0	3
Stone	0	2
Clod	0	6
Stone	1	0
Clod	0	3
Stone	0	4
Clod	1	0
Stone	0	2
——	1	0

	ft.	in.
Clod	0	2
Stone: *Ammonites Sauzianus*, univalves	0	8
Clod	1	0
Stone: *Pecten subilævis, Pinna, Pentacrinites, Ostrea liassica* &c., and Spongiform nodules	0	4
Stone	1	0
Clod	0	9
Stone, very fossiliferous: *Gryphæa, Avicula inæquivalvis, Cardinia, Turbo, Ammonites Sauzianus*, and *A. semicostatus*	1	0
Clod	0	2
Stone, very fossiliferous	0	10
Clod	0	6
Stone: *Pinna*, &c.	1	0
Clod	0	3
Stone	0	10
Clod	0	3
Stone	0	10
Clod	0	6
Stone	0	6
——	0	4
Clod	0	1
Stone	1	0
Clod	0	2
Stone	1	0
——	1	4
Clod	0	9
Stone	0	11
——	0	9
Clod	0	3
Stone with *Cardinia, Gryphæa*, &c. ...	0	5
——	0	9
——	0	8
Clod	0	5
Stone	0	9
Clod	0	6
Stone: *Gryphæa* ...	1	2
Clod	0	5
Stone	0	8
Clod	0	7
Stone	0	9
Clod	0	4
Stone	0	5
——	1	3
Clod	0	3
Stone	0	6
Clod	0	1

	ft.	in.
Stone	0	9
Clod	0	8
Stone	1	0
——	0	9
Clod	0	7
Stone	0	7
Clod	0	2
Stone	0	8
Clod	0	2
Stone	0	7
Clod	0	6
Stone	0	9
Clod	0	4
Stone with *Gryphæa*, *Ammonites Sauzianus*	0	9
Clod: *Belemnites*	0	4
Stone	0	7
Clod	0	7
Stone	0	10
Clod	0	2
Stone	0	8
——	0	10
Clod with *Gryphæa*	0	7
Beds curved and faulted	50	0

	ft.	in.
Stone	0	9
——	0	4
——	0	10
Clod	0	2
Stone	1	1
Clod	0	1
Stone	0	4
Clod	0	1
Stone	1	0
Clod	0	1
Stone	0	9
Clod	0	3
Stone	0	7
——	0	6
——	0	5
Clod	0	4
Stone with *Belemnites acutus*, *Pecten sublævis*	0	10
Clod	0	2
Stone	0	6
Clod	0	4
Stone	1	3
Clod	0	6
Stone	0	9
Clod	1	0

	ft.	in.
Stone	1	3
Clod	0	9
Stone	0	6
Clod	0	4
Disturbed and covered beds	15	0
Stone	0	6
Clod	0	4
Stone, *Ammonites Sauzianus*, *Chemnitzia*, &c.	0	6
Stone	0	4
Clod	0	3
Stone	0	5
Clod	0	2
Stone	0	4
——: *Gryphæa incurva*, *Cardinia*, &c.	0	6
About twenty-five somewhat irregular beds, with *Gryphæa*, &c., about	12	0
(476 beds.)		

Owing to the peculiar conditions under which the beds in this section have been deposited, I find it almost impossible to establish any precise horizons in order to compare it with other Liassic districts. It is to be observed that the *Gryphæa incurva* passes almost through the whole series, that *Ammonites Conybeari* occurs very low down, and *A. Bucklandi* about the middle of the section, whilst towards the top are numerous *A. Sauzianus* and *A. semicostatus*, which indicate the higher members of this series. The Ostrea-beds, so well marked at the base of the Lias in other sections, are not so here. From the palæontological evidence I should therefore incline to the opinion that the greater part of this section represents the *Ammonites-Bucklandi* beds, and passes into the still higher members at the top.

Mr. Tawney, in his paper (p. 79) states that the upper beds belong to the *Middle* Lias; but this is an error, as everything in this section belongs to the Lower Lias, no Middle Lias having yet been recognized in Wales.

Since the above was written, I have had an opportunity of comparing the fauna of the upper beds at Bridgend with that described by MM. Martin and Terquem from the continental "Infralias" beds. Below are given the species I have obtained from beds in which are *Ammonites Sauzianus* and *A. semicostatus*, though no doubt the list may be increased. I was scarcely prepared for the interesting fact that the faunæ are evidently identical; but such is the case, so far as my series of fossils is concerned.

Ammonites Sauzianus, *D'Orb.*
—— semicostatus, *Young* and *Bird.*
—— angulatus, *Schlot.*
——, sp., young.
Belemnites acutus.
Gryphæa incurva, abundant.
Rhynchonella variabilis.
Lima gigantea.
——, sp.
Pecten.
Arca pulla, *Terq.*
Astarte.
Cardinia scapha, *Terq.* (C. elongata, *Dunk.*).
——, several sp.
C. sublamellosa, *Martin.*
Cardita tetragona, *Terq.*
Cucullæa Hettangiensis, *Terq.*
Leda Heberti, *Martin.*
Lithodomus.
Nucula, sp.
Actæon angulifer, *Martin.*
Ampullaria angulata, *Desl.*
Alaria.
Cerithium Henrici, *Martin.*
—— Semele, *D'Orb.*
—— Dumortieri, *Martin.*
—— Sinemuriensis, *Martin.*
—— acuticostatum, *Terq.*
—— paludinea, *Terq.*
—— gratum? *Terq.*
—— porulosum, *Terq.*
——, sp.
Dentalina, sp.
Littorina clathrata, *Terq.*
Orthostoma averna, *Terq.*
Tornatella Buvignieri, *Terq.*
Pleurotomaria concava, *Martin.*
Turritella Humberti, *Martin.*
—— Jenkeni, *Terq.*
Turbo triplicatus, *Martin.*
——, sp.
——, sp.
Turritella Deshayesii, *Terquem.*

3. *Cowbridge Section.*—Before describing the Brocastle and Sutton sections, it may be desirable to say a few words with reference to others which have yielded some species of the coral-fauna I have placed in the hands of Dr. Duncan for description, and more especially as some of the sections yield fixed horizons, which will enable me to determine their positions in the Liassic series. From Brocastle along the line of the Golden Mile to Cowbridge the Lias abuts against the Carboniferous Limestone, and is usually conglomeratic and much mineralized. Immediately opposite the railway-station at Cowbridge a quarry is being worked, in which there are compact beds of crystalline Lias of a thickness of 30 feet, its depth below being unknown. The lower beds of this section thicken and contain many layers or nodules of flint, alternating with the limestone. The larger fossils are chiefly in these bands, and, though numerous, are very friable and in bad condition; amongst them are *Plicatula acuminata*, *Ostrea intusstriata*, *Pecten Pollux*, *Ostrea liassica*, Sow., *Lima gigantea*, *Cardinia*, *Astarte*, &c. Close to this quarry is another, in which the beds are rather higher as well as thinner and more rubbly. One of these is in great part composed of specimens of *Thecosmilia Michelini*, Terq. and Piette, which stand out thickly from the abraded surface of the bed. Like the Shepton *Ammonites-Bucklandi* beds, the matrix appears almost wholly composed of organisms; for in polished specimens of this bed the interspaces between the corals contain numbers of Entomostraca &c. This bed also contains attached *Ostrea intusstriata*, Em., and *Neritopsis exigua*, Terq. In a roadside quarry near Cowbridge we again find *Pecten Pollux*. From the lithological look of the Cowbridge Lias it would readily pass for Carboniferous Limestone; I have found no Ammonites in it, and it is difficult to assign for this section its precise horizon. There is a *general* absence of the coral-fauna of Sutton and

Brocastle; and altogether I am disposed to place these beds below those sections.

4. *Llanbethian Quarries.*—In the quarries at Llanbethian, about a mile south-west of Cowbridge, the *Ostrea liassica* beds are present, and show that here there are present the lower horizons of the Camel section. In the upper bed of this quarry this determination is also confirmed by the presence, for the first time in this neighbourhood, of *Ammonites planorbis*, associated with *Neritopsis exigua*, Terq., and *Melania*. The beds are, in ascending order:—

Section at Llanbethian Quarry.

		ft.	in.
	Stone, with *Pinna semistriata*, Terq. (*P. insignis*, Taw.), *Pecten Pollux*, *Plicatula acuminata*, *Lima gigantea*, &c.	0	5
	—— ——	0	4
	Grey marl	0	4
	Stone	0	6
	——	1	0
	——	0	3
	—— *Modiola Hillana*	0	4¼
	Stone	0	8
	——	0	2
	——	0	6
	——	0	3
	Clay	0	1
	Stone: *Ostrea liassica*, *Arca*	0	8
	—— ——	0	4
	—— —— *Thecosmilia* and *Montlivaltia*	0	4
	—— ——	0	4
	—— ——	0	3
	——: *Lima gigantea*, *Arca*, &c.	0	4
	Six thin beds with many *Cardinia*	1	0
	Stone	0	4
Ostrea-beds.	Stone with *Cardinia*	0	5
	Stone	0	4
	——	0	4
	——	0	4
	——	0	4
	——	0	3
	——	0	8
	——	0	3
	—— with *Cardinia* &c.	0	9
	Rubbly Stone with *Pecten Pollux*, *Lima duplicata*, *L. gigantea*	1	0
	Stone	0	5
	——: *Cardita*, *Arca*, *Lima gigantea*	0	4
	Clay	0	1
	Stone: *Cardita*, *Lima*, &c.	0	7
	——: —— and univalves	0	6
	——: *Melania*	0	6
	——: *Chemnitzia* &c.	0	4
	——	0	6
	——	0	8

Twenty beds of about 10 feet, which could not be traced, then succeed; and above these, in the western corner of the quarry, the highest contains many *Ammonites planorbis* with *Neritopsis exigua*, *Melania*, &c..

List of Organic remains from Llanbethian.

In the lowest beds.
Hinnites, sp.
Pecten Pollux, *D'Orb.*
Plicatula acuminata.
Lima gigantea.
Lima tuberculata.
Pinna semistriata, *Terq.* (P. insignis, *Taw.*).
Plicatula Hettangiensis, *Terq.*
Modiola producta, *Terq.*
Ostrea intusstriata.

In the Ostrea-beds.
Hemipedina Bowerbankii, *Wright.*
Ampullaria carinata, *Terq.*
Melania (Pterocera) dubia, *Terq.*
—— turbinata.
—— abbreviata.
Turritella Dunkeri, *Terq.*
—— Jenkeni, *Terq.*
Turbo rotundatus, sp., *Terq.*
Montlivaltia.
Thecosmilia Michelini, *Terq.*
Arca pulla, *Terq.*
Astarte cingulata.
Cardita Heberti.
Cardinia Listeri, *Stutch.*
——, sp.
Cucullæa similis, *Terq.*
—— Hettangiensis, *Terq.*
Modiola minima.
Ostrea liassica.

In the Ammonites-planorbis *beds.*
Ammonites planorbis.
Pecten Pollux, *D'Orb.*
Lima tuberculata, *Terq.*
—— gigantea, *Taw.*
Ostrea arietis, *Quenst.*
Pinna semistriata, *Terq.*
Ampullaria planulata, *Terq.*
Melania (Pterocera) dubia, *Terq.*
Neritopsis exigua, *Terq.*

In this, as in all other sections in which the Ostrea-beds are found, those shells occur in myriads, and the beds generally present the same Liassic character; but in some loose thin blocks from this horizon on the Llantrissant railway the bed is conglomeratic and contains a multitude of greenish chert pebbles in a grey matrix, and assumes the character of the Sutton Stone.

5. *Laleston Quarry.*—The Ostrea-beds are also well exposed in the sections mentioned by Mr. Tawney at Laleston and at the Stormy Cement Works. At the base of the former section that gentleman notices a bed similar in character to the Sutton Stone, and having between it and the Ostrea-beds some indurated marls containing *Monotis decussata.* As this quarry is not worked, it is difficult to examine the lower beds or to compute their thickness. The only block I could get out contained an abundance of *Lima gigantea, Ostrea intusstriata*, and *O. liassica.* There are also sections of small univalves, casts of *Cardinia*, and *Monotis decussata.* The bed is also crowded with a coral, of which sections in the fracture only can be seen, the Sutton-stone species and those of Brocastle being absent. The indurated marls resting on this are one foot thick, and would be of much interest could they be worked, as they contain most perfectly preserved impressions of plants, together with Entomostraca and *Monotis decussata* in abundance. Mr. Tawney has inferred from the presence of this shell that the lower beds are below the Rhætic series; but my discovery of it in higher zones, as it occurs also in the bed under notice, shows that it may mislead. From the presence of *Ostrea liassica,* I believe this bed must be classed with the others on that horizon, and that it will be found to occupy a lower position in the Liassic series than the beds of Sutton, Southerndown, and Brocastle.

From Dr. Pritchard's quarry in the same village I obtained a slab from the Ostrea-beds containing four of the most beautiful specimens I had ever seen of the *Hemipedina Bowerbankii*, Wright, showing all their spines in position. *Thecosmilia Michelini*, Terq. and Piette, is in great abundance in this quarry, and is found on the same horizon as at Llanbethian; its position is therefore satisfactorily fixed in these sections at the base of the Liassic series; and its discovery at Stout's Hill shows that it continued upwards to the horizon of *Ammonites Bucklandi*.

6. *Stormy Quarry*.—At the Stormy Cement-works the Keuper marls have been exposed in excavating the cement-stone. When compared with the West of England section, the Rhætic beds at this spot are very insignificant. A single bed of black marl containing *Pecten Valoniensis* and other Rhætic shells succeeds the variegated marls, and upon this a dark limestone 4 inches, and next a bed (in texture very similar to the "White Lias") 2 feet thick. The *Ostrea-beds* then follow, and are almost made up of *Ostrea liassica* and its varieties. Above these succeed rubbly limestones with *Ammonites planorbis*, and with *Pecten Pollux*, *Lima tuberculata*, and *Ostrea arietis* in the same block with *Lima gigantea*. The latter beds are identical in their general character with the lower horizon of the South-west of England; and we may safely assume that at Stormy, Laleston, Llanbethian, and, perhaps, at Cowbridge the basement beds of the Lower Lias are present.

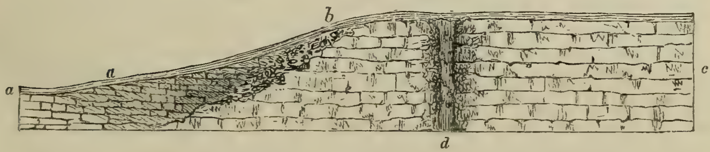
7. *Section at Ewenney*.—Directly at the back of the Brocastle quarry a roadway leads to Ewenney. The Carboniferous Limestone forms its floor. In some small openings along the line, the coralliferous conglomerate can be occasionally seen resting upon it. In passing down the hill towards Ewenney the limestones are disturbed, and large veins filled with crystalline carbonate of lime and conglomerate cross the road. Not far below, the Lias in the Ewenney quarries may be seen regularly bedded, and abutting against and filling a forked space in the Carboniferous Limestone. With the exception of *Astrocœnia dendroidea*, Dunc., and *A. reptans*, Dunc., the interesting fauna of Brocastle is entirely wanting. The upper beds of Lias at Ewenney are about 10 feet in thickness, divided by beds of marl, in which are present *Pollicipes rhomboidalis*, Moore, found also at Langan and Shepton. The beds, however, are encrinital, like those which adjoin the conglomerate at Brocastle; but the same is also the case with the *Ammonites-Bucklandi* beds at Southerndown. The Lias in the Ewenney quarry is much fissured, and a lead-vein passes through it. At the base of the quarry at the time of my visit the men were extracting stone identical with the upper or finer quality of the Sutton Stone, and they volunteered the remark that it was identical. It is slightly conglomeratic, and contains minute chert pebbles. Shells in it are very rare, the only one I noticed being a small example of *Pecten Pollux*.

The beds putting on the lithology of the Sutton Stone are here only two in number, each of 20 inches in thickness; and it is curious to observe, as illustrating the local character of the Sutton Stone, that those immediately below return to the ordinary dense and thinly bedded character of those above.

8. *Section at Brocastle.*—On taking the road from Bridgend to Cowbridge, numerous small Liassic sections are passed, in which *Ammonites Sauzianus* and other remains show that they represent the higher members of the Bridgend section. After passing these quarries and finding them all of the same general character, it was my intention to proceed direct to Cowbridge; but when midway, at Brocastle, at the mouth of the Liassic inlet previously indicated, I observed a limekiln some way up an arable field, on the right of the roadway, and thinking the beds there might occupy a different horizon I determined to give them an examination. Instead of a Liassic, it proved to be a Carboniferous Limestone quarry, very full of encrinital and other remains of that age. A shallow cartway from the field led into the northern face of the limestone. On leaving the quarry, a thin deposit of conglomerate, resting on the limestone immediately under the soil, attracted my attention, and was at once seen to contain many beautiful corals and univalves, the age of which could not then be recognized, but the Liassic character of which subsequent examinations revealed.

The section itself, given below, rendered at first but little assistance in determining the age of the deposit.

Fig. 6.—*Section at Brocastle.*



a. Lower Lias. *c.* Carboniferous Limestone.
b. Conglomerate. *d.* Lead-vein.

d. A vertical fissure about 3 feet wide, formerly sunk about 50 feet in depth for lead-ore.

c. Eastern face of nearly horizontal Carboniferous Limestone, 12 feet thick, leading in from the field to the quarry.

b. Capping of Liassic conglomerate, accommodating itself to the edges of the beds or to the surface of the Carboniferous Limestone when it formed the base of the Liassic sea, averaging about 1 foot in thickness.

a. Dense irregularly bedded Pentacrinital Liassic limestones with *Rhynchonella variabilis* and corals, exposed for about 5 feet in height, but the thickness of which is unknown, dipping slightly towards the centre of the Bridgend basin, abutting against and gradually passing into the conglomerate.

The very interesting fossiliferous deposit, No. 3, is in part composed of angular blocks of Carboniferous Limestone, united by a very dense variegated yellow, grey, or bluish Liassic limestone, and enclosing also small pockets of Carboniferous Limestone sand, with organic remains of that age, and into which colonies of Liassic *Lithodomi* have penetrated.

The bivalves of this deposit are usually so surrounded by its dense matrix as to be difficult of extraction, and for this reason are as yet but imperfectly represented in my collection. Some of the corals, however, and the Gasteropoda especially, have attached themselves to the honeycombed or ragged edges of the bed, or have passed down and are found united to the sides of any veins or fissures in the Carboniferous limestone itself. The organic remains are very varied, and when the above is the case are often in the most beautiful condition.

The peculiar character of the deposit, and the fact that few if any of its organisms had previously been found in any stratified beds in this country, rendered it exceedingly difficult to arrive at a satisfactory determination of its precise age, though the presence of one or two somewhat imperfect specimens of *Gryphæa incurva* at once pointed it out as belonging to the horizon of that shell. By an examination of some of the smaller genera and species, however, a partial key to their recognition was obtained, some of them being found identical with those in the Liassic deposit at the bottom of the Charter House Lead-mine, and with others in the Sutton Stone, and, again, with species in the Lias of Bridgend and Bath.

A close examination of the weathered surfaces of the Brocastle deposit shows that it is to some extent composed of sponges, their spicules being readily detected. Of this family there are at least two genera, some of the spicules we have been able to detach showing them to be triradiate and calcareous and allied to the recent *Grantia* of Fleming.

Foraminifera are exceedingly rare: a single specimen of *Involutina liassica*, Jones, and a *Planularia* are all yet seen.

The Zoophyta have afforded a most remarkable harvest. A few years ago, on the publication of the Monograph on Oolitic and Liassic Corals by MM. Milne-Edwards and Jules Haime, I possessed two out of three of the then known corals of the Lias; and it has been meanwhile considered quite fortunate to have increased that number by some six or eight species. From this single locality I have been able to furnish Dr. Duncan, in whose hands they are placed by the Palæontographical Society for description, with not less than thirty-one species; and to these many will be added from other localities.

The Echinodermata, which appear to have been abundant, are chiefly represented by dismembered joints of *Pentacrinites* and by detached spines and plates of *Echini*. Of the latter there are two or three genera, and part of the test of what appears to be a *Cidaris Edwardsii*, the same species being present in the Charter House Mine.

The Articulata at Brocastle are species of *Serpulæ*, which are common. Although I have hitherto been unable to detect Cirripedia, this family, which is now recorded for the first time from the English Lias, is common at Langan, and at Ewenney, close to Brocastle; and the same species is found at Charter House and in the equivalent of the Sutton Stone at Shepton-Mallet—though from the latter place I have but one example.

The Crustacea are to this time entirely confined to Entomostraca, for the notes on which I am indebted to Professor Rupert Jones, F.G.S. In the whole, six species are present at Brocastle, two of these, *Moorea obtusa*, Jones, and *Cythere curva*, being new and peculiar to the deposit. The others are considered to be of Carboniferous Limestone species. Two of these, *Cythere fabulina* and *Bairdia plebeia*, not only occur in the Charter House Mine, but I have found them also in the Allenhead and other lead-mines of the North of England.

I have before expressed my belief in the recurrence of generic and specific forms under favourable circumstances after long intervals; and such I believe to be the case with the above. A derived and redeposited shell usually presents a condition which a practised eye readily detects when compared with the later fauna with which it may be associated. In this instance they have been washed out by myself from the soft matrix of the Liassic blocks, are not in the least abraded, the other remains found with them being, except in very rare instances, undoubtedly Liassic.

Circumstances which were so favourable to the life of the Zoophyta might have been considered equally so to the Bryozoa; but examples are very rare, and appear confined to what I suppose to be two species of *Neuropora*?

The Brachiopoda as a family are also very feebly represented; I have hitherto detected only the genera *Rhynchonella*, *Terebratula*, *Thecidium*, *Crania*, and *Zellania*. Of the first I possess from Brocastle but two specimens of *R. variabilis*, one of them being from the Pentacrinital limestone; the *Terebratulæ* are two very young specimens of *T. punctata*? The *Thecididæ*, on the contrary, are very abundant and may be seen in almost every block; these are of three species, namely *T. Moorei*, Dav., *T. rusticum*, Moore, and *T. triangulare*, D'Orb. The two former species I have found in the Charter House Mine and in the *Ammonites-Bucklandi* beds of the Lower Lias. The *Zellaniæ* at Brocastle are also not uncommon; and though they present considerable variety in their form, I am unable to distinguish them from *Z. Davidsonii*, Moore, of the Inferior Oolite. We have therefore again, with the latter shells, a recurrence of specific forms, through the Lower Lias into and through the Middle and Upper Lias, and, with the latter shell, even into the Inferior Oolite. It is curious to observe that, though the latter genus has so extended a range, and is so wide-spread, no other author appears to have yet recognized it.

The Lamellibranchiata to this time have yielded forty-nine species, without including some doubtful and fragmentary forms; and no doubt the list may be still increased. In general, however, they are imperfect, and in single valves, and are most commonly, either wholly or in part, enclosed in the matrix, from which they cannot easily be extricated. *Gryphæa incurva* is one of the most abundant bivalves at Brocastle.

Unlike the former shells, those of the Gasteropoda are usually in a most beautiful state of preservation, and retain to a considerable extent their ornamentation. It is rarely that they can be recognized in the matrix of the stone itself in this section; they are, rather, usually attached to its outer surface, or to the hollows presented by the conglomeratic character of the bed; and if anything could be decided regarding the comparative age of remains found in the same section and in the same deposit, I should say they were slightly younger than some of the bivalves with which they are associated; and the same remark would apply to some of the corals which stand out as they originally grew on the Carboniferous-Limestone coast-line of the Liassic sea. Little or no denudation could subsequently have taken place; nor were any deposits ever laid down above them, as the hollows and open veins to the sides of which some of these remains are still attached sufficiently attest. The Gasteropoda, for a single locality, are wonderfully varied, since not less than eighty-two species have been recognized.

Two new genera are present, for which I propose the names of *Pterocheilos* (*P. primus*, Moore) and *Pleuratella* (*P. prima*, Moore); the latter appears to be allied to *Delphinula*, and may constitute a subgenus of it.

The shells of the class Cephalopoda unfortunately afford but little assistance in determining the more exact age of the Brocastle deposit, as we have recognized in it only two small *Ammonites*, both of which are young forms. It is, however, clear that they do not belong to species low in the Liassic series. Both are of smooth exterior, and without ornament; the same forms occur both at Southerndown and in the higher beds of Bridgend, and appear identical with the young of the *A. semicostatus*.

From this most truly interesting Brocastle deposit it has been my good fortune to recognize in the whole not less than 198 species, which are given below.

List of Organic Remains from Brocastle.

Ammonites.
Nautilus.
Grantia antiqua, *Moore*.
Spongia.
Involutina liassica, *Jones*.
Planularia, sp.
Montlivaltia simplex, *Dunc.*
—— Walliæ, *Dunc.*
—— Brodiei, *Dunc.*
—— Murchisoniæ, *Dunc.*
—— pedunculata, *Dunc.*
—— brevis, *Dunc.*
Thecosmilia irregularis, *Dunc.*, and 1 var.
—— Terquemi, *Dunc.*
—— affinis, *Dunc.*
—— Walliæ, *Dunc.*
—— dentata, *Dunc.*
—— plana, *Dunc.*
—— Martini, *E. de From.*
—— Michelini, *Terq.*
Septastræa excavata (*De From.*).
Isastræa Sinemuriensis (*D' Orb.*, sp.).
Isastræa globosa, *Dunc.*
Montlivaltia polymorpha, *Terq. et Piette.*
Latimæandra denticulata, *Dunc.*
Cyathocœnia dendroidea, *Dunc.*
—— costata, *Dunc.*
Astrocœnia plana, *Dunc.*
—— Kutorgiana, *Jones.*
—— curva, *Jones*, MS.
—— dendroidea, *Dunc.*
—— minuta, *Dunc.*
—— reptans, *Dunc.*
—— favoidea, *Dunc.*
—— spinigera, *Dunc.*
—— pedunculata, *Dunc.*
—— costata, *Dunc.*
—— gibbosa, *Dunc.*
—— insignis, *Dunc.*
Neuropora mammillata.
——, sp.
Cidaris Edwardsii.
Echinus, sp.
Ophioderma, joints of.
Pentacrinus tuberculatus, *Mill.*
——, sp.
Serpula socialis, *Goldf.*
——, several spp.
Bairdia plebeia, *Reuss.*

Moorea obesa, *Jones*, MS.
Cythere fabulina?, *J. & K.*
—— Ku torziana, *Jones.*
—— cvrva, *Jones*, MS.
Crania liassica, *Moore.*
Rhynchonella variabilis, *Scloth.*
Terebratula punctata, *Terq.*
Thecidium Moorei, *Dav.*
—— rusticum, *Moore.*
—— triangularis, *D' Orb.*
Zellania Davidsoni, *Moore.*
Anomia irregularis, *Terq.*
Avicula Dunkeri, *Terq.*
—— Buvignieri, *Terq.*
—— infraliassina, *Martin.*
—— Alfredi, *Terq.*
—— Deshayesi, *Terq.*
Gryphæa incurva, *Sow.*
—— depressa, *Phil.*
Gervillia acuminata, *Terq.*
Isodonta Engelhardti, *Terq.*
Lima tuberculata, *Terq.*
—— amœna, *Terq.*
—— gigantea, *Sow.*
—— dentata.
——, sp.
Ostrea arietis, *Quenst.*
—— liassica.
—— irregularis.
—— intusstriata, *Emm.*
Pecten Pollux, *D' Orb.*
—— sublævis.
——, sp.
——, sp.
Placunopsis.
Plicatula Hettangiensis.
—— Bay'ei, *Terq.*
Arca pulla, *Terq.*
—— Sinemuriensis, *Martin.*
Astarte exigua, *Terq.*
—— cingulata, *Terq.*
Cardinia elongata, *Dunk.*
—— Morrisi, *Terq.*
—— Listeri.
——, several species.
Cardita Heberti, *Martin.*
—— tetragona, *Terq.*
Cardium Terquemi, *Martin.*
Cucullæa asimilis, *Terq.*
—— Hettangiensis, *Terq.*
Cypricardia, sp.
—— inclusa, *Terq.*
Gastrochæna liassica, *Terq.*
Lithodomus arenicola, *Terq.*
Mytilus liassinus, *Terq.*
—— lamellosus, *Terq.*
—— arenicola, *Terq.*
—— Simoni, *Terq.*
—— Sinemuriensis, *Terq.*
Pholadomya arenicola, *Terq.*
Saxicava Bronni, *Martin.*
Tancredia securiformis, *Terq.*

Alaria rudis, *Moore.*
Alaria fusiformis, *Moore.*
Amberleya grandis, *Moore*
—— apicalis, *Moore.*
Ampullaria planulata, *Terq.*
Cerithium acuticostatum, *Terq.*
—— gratum, *Terq.*
—— Jobæ.
—— pellucidum, *Moore.*
—— pentacostatum, *Moore.*
—— planicostatum, *Moore.*
—— paludinare, *Terq.*
—— pupa, *Martin.*
—— Semele, *D' Orb.*
—— spiratum, *Moore.*
—— Sinemuriensis, *Martin.*
Chemnitzia Oppeli, *Martin.*
—— polita, *Martin.*
Chiton radiatus, *Moore.*
Dentalium, sp.
Discohelix cornucopiæ, *Moore.*
—— fimbriatus, *Moore.*
Fusus Becketti, *Moore.*
—— Jenynsi, *Moore.*
—— Terquemi, *Moore.*
Hinnites liassicus, *Terq.*
——, sp.
Littorina circularis, *Moore.*
—— ovalis, *Moore.*
Melania acuta, *Moore.*
—— abbreviata, *Terq.*
—— (Pterocera) dubia, *Terq.*
—— usta, *Terq.*
Nerinæa acuminata, *Moore.*
—— rudis, *Moore.*
Neritina arenacea, *Terq.*
—— canalis, *Terq.*
—— Hettangiensis, *Terq.*
Neritopsis cancellata, *Moore.*
—— exigua, *Terq.*
Orthostoma avena, *Terq.*
—— frumentum, *Terq.*
—— oryza, *Moore.*
Patella Dunkeri, *Terq.*
—— ornata, *Moore.*
—— Schmidti, *Terq.*
Phasianella liasina, *Terq.*
—— nana, *Terq.*
Pleurotomaria Mendipensis, *Moore.*
—— Henrici, *Martin.*
—— lens, *Terq.*
—— rotelliformis, *Dunk.*
Pleuratella prima, *Moore.*
Pterocheilos primus, *Moore.*
Pyrula liassica, *Moore.*
Rimula elegans, *Moore.*
—— liassina, *Terq.*
Solarium liassicum, *Moore.*
—— lenticulare, *Terq.*
Straparollus Oppeli, *Martin.*
Trochotoma Brocastellensis, *Moore.*
—— Lycettii, *Moore.*

Trochus Deslongchampsii, *Moore.*
—— Elizæ, *Moore.*
—— nitidus, *Terq.*
Turbo apicalis, *Moore.*
—— Brocastellensis, *Moore.*
—— costellatus, *Terq.*
—— gemmatus, *Terq.*
—— striatus, *Moore.*
Turbo reticulatus, *Moore.*
—— turritus, *Moore.*
—— tumidus, *Moore.*
—— Piettei, *Martin.*
Tornatella Buvignieri, *Terq.*
—— secale, *Terq.*
Turritella Howsei, *Moore.*
—— Humberti, *Martin.*

9. *The Sutton Stone and the Southerndown Series.*—The coast-section which has been given by Mr. Tawney, in the Society's Journal, vol. xxii. p. 75, faithfully represents the general character of the rocks between Sutton and Dunraven. The vertical section, however, which only represents the beds as they appear on the *coast-line*, fails to convey the great aggregate thickness of the beds of the district. This section gives a thickness of 110 feet; but, including the beds which come in on the Down, above the edge of the cliffs, I think the whole cannot be estimated at less than 250 feet. An inspection of the cliff-section east of Dunraven will assist in arriving at this conclusion, as there may be seen at this point at least 300 regularly stratified beds, with intervening marls between each, above the sea-level. My section of the Sutton beds, which was prepared before the publication of Mr. Tawney's paper, does not materially differ from that given by him. I need only give the lower or Sutton-stone beds in detail.

	ft.	in.
Various closely bedded conglomeratic or granular hard greyish limestones, cherty, or in great part composed of flattened pebbles of Carboniferous Limestone, giving the stone the appearance of a pea-grit, estimated at their western outcrop	200	0
Granular and closely bedded limestones resting on the Sutton Stone, containing *Gryphæa incurva* at their base, with *Ammonites angulatus, Lima gigantea, L. duplicata,* &c.	25	0
Sutton Stone, conglomerate	0	9
Sutton Stone, conglomerate	1	0
Sutton Stone	1	1
Sutton Stone, conglomerate	0	8
Sutton Stone	1	6
Sutton Stone, coarse conglomerate	1	6
Sutton Stone	2	5
Line of conglomerate	0	4
Sutton Stone	1	0
Line of conglomerate	0	2
Sutton Stone	3	0
Sutton Stone	1	0
Bastard Sutton Stone, coarse conglomerate	0	8
Bastard Sutton Stone, coarse conglomerate	1	0
Bastard Sutton Stone, coarse conglomerate	2	2

* * * * * * * * *

Carboniferous Limestone.

It has been proposed by Mr. Tawney to divide the series into,—

1. The Sutton Stone.
2. The Southerndown series.
3. The *Ammonites-Bucklandi* beds, divided from the former by the zone of *Ostrea liassica.*

1. The Sutton series has been considered by that gentleman to be

slightly anterior in age to the Rhætic *Avicula-contorta* beds, from the absence of that shell in them, and the presence of others, which he considers may represent the Muschelkalk, though he would include them in the Rhætic period. Before the publication of his paper, when applied to by Dr. Duncan for my collection of corals from this locality, I expressed my opinion that all these beds were of the age of the Lower Lias, though deposited under very abnormal conditions.

A reference to the Camel, Shepton, and other sections, where the succession from the Keuper through the Rhætic and Liassic beds occurs, will show that where there is undoubted uniformity of deposition the absence of any representative of the Sutton Stone is unquestionable. A consideration of the Table of organic remains and their range, given by Mr. Tawney, shows a most marked distinction between the palæontology of the Sutton Stone and that of the Rhætic beds. The latter occur in many places in the district; and had the Sutton Stone belonged to this period, palæontological evidence would not have been wanting; but the only fossils quoted as common to the two horizons are *Myophoria postera*, *Monotis decussata*, *Plicatula intusstriata*, and scales of *Gyrolepis Alberti*. The latter, after what I have said of the Frome district, may readily be supposed to be derived. The two former are not characteristic, as I have shown them to have a wide range in the Lias; and, from the great difficulty attending a determination of some of the Sutton-stone shells, it is possible that the *Myophoria* may not belong to that genus, which has never been found above the Rhætic series. These facts, I think, are sufficient to show that a different horizon must be sought for the Sutton and Southerndown series.

2. It is also proposed by Mr. Tawney to separate the Southerndown group from the Lias, leaving the Liassic *Ammonites-Bucklandi* beds unconformable above them; but their position must follow as a consequence upon any determination arrived at for the Sutton Stone.

The beds under consideration appear to have been deposited in a basin of Carboniferous Limestone, and are cut off abruptly by that formation on the north, from Sutton to Dunraven; and between these places they have an average breadth of about half a mile. On following the southern edge of the limestone to Brocastle, that village may be seen in the centre of a narrow neck of Lias, on which the Carboniferous Limestones of the Golden Mile and Ewenney encroach; this narrow Liassic belt connects the latter formation on the south with that within the basin of Langan and Bridgend, before referred to.

In the Sutton section I have indicated a break between the Carboniferous Limestone and the lowest Sutton Stone, in order to point out that, assuming the Liassic age of the latter, there is evidence of the presence of a Liassic fauna before the deposition of any of the stratified Liassic beds; and it will be shown that between these points must also be interposed a great thickness of Liassic conglomerates, which may have been accumulated contemporaneously with Liassic beds elsewhere.

I have already shown that the interesting fauna of Brocastle is derived from a thin band of conglomerate resting immediately upon the Carboniferous Limestone, and that, wherever any fissure in the limestone occurred, a Liassic fauna, as was also the case in the Mendip Hills, occupied it. The same phenomena prevail at Sutton. The Carboniferous Limestone below the Sutton Stone has been washed by the Liassic seas; and corals and shells, some of them identical with those of Brocastle, are attached to the surface of the limestone, and have also passed down into its fissures, and are with difficulty removed from its more ancient matrix. At the Sutton quarries the conglomerate I propose hereafter to intercalate is not seen, the Sutton Stone resting there immediately upon the Carboniferous Limestone.

a. *Local Deposition of the Sutton Stone.*—In the railway-section at Shepton, p. 505, no Liassic beds are present which indicate a condition of sea-bottom like that presented by the Sutton Stone; but when the former are followed to the edge of the Carboniferous Limestone, they assume identical lithological characters. It is not necessary that the beds thus changed should always be on the same geological horizon; for it has been shown that at Ewenney a Sutton-stone condition is interposed between granular Liassic limestones, and that probably at Laleston a Sutton Stone older than that at Sutton is found. At Broadfield Down, near Bristol, the Rhætic White Lias is changed into a Sutton Stone; and at Harptree the Lima-beds are also metamorphosed, though they are more siliceous than the above. I believe that an examination of the Southerndown coast-line will show that there also the Sutton Stone is only an abnormal (and probably a shore-) deposit, accumulated on ledges, or in bays or basins of Carboniferous Limestone, and that it dies out, giving place to thinner and more regularly bedded Liassic limestone.

The coast-section from Sutton, in the direction of Dunraven, can be seen only at low water; and care must be taken in its examination. On descending from the Sutton quarry down the face of the ragged Carboniferous Limestone to the beach, a cavern (which I propose to call No. 1) is reached, of which the Sutton Stone forms the arch, the Carboniferous Limestone occupying its sides and floor. A few yards beyond, cavern No. 2 is seen, where the Sutton Stone is thrown down by a fault, and is found resting upon a base of conglomerate which is not to be recognized in the quarries, and which appears to have filled a basin or break in the Carboniferous Limestone. It is composed of large pebbles of quartz, chert, and limestone in a dense blue or grey matrix, differing from the Sutton Stone above, and, unlike it, is not bedded.

As my examination was necessarily very hurried, I am unable to give distances; but still further the Sutton Stone again forms the crowns of the arches of caverns 3 and 4, and also the sides, the darker conglomerate just mentioned being at its base, all above belonging to the true Sutton Stone, which here becomes very much thicker. It is next seen resting once more upon the Carboniferous Limestone, becomes much thinner, accommodating itself to the irregularities of the limestone, and passing down any fissures observable therein. At caverns 5 and 6 the Carboniferous Limestone still forms the sides, at the latter becoming red and regularly bedded, with a gradual dip seaward. The Sutton Stone is here reduced to one-half its former thickness. At cavern No. 7 the limestone becomes much inclined, and the whole of the Sutton series is included in four or five thick beds.

The beds included by Mr. Tawney in the Southerndown series have now assumed considerable thickness; but the Sutton Stone is still thinner, and rests upon almost vertical Carboniferous Limestone. At caverns 8 and 9 the beds are faulted and thrown down, and the Sutton Stone again becomes thicker. From this point the beds again rise and are somewhat horizontal towards Dunraven. It may now be observed that the lower beds of Lias have gradually changed in colour and in structure, becoming a dull olive, and in texture almost like Carboniferous Limestone. Instead of a deposit like the Sutton Stone, the beds have become less conglomeratic, and only thin bands or patches of conglomerate have been washed in here and there, resting upon the surfaces of the beds, which soon again pass into their ordinary conditions; and hence to Dunraven the Sutton Stone is no more seen. My view of its local deposition is strengthened by the coast-section given by Mr. Tawney, in which it is seen that the Sutton Stone should again have come to the surface under Southerndown: but this is not the case; and in the very lowest beds at this point that the tides at low water would allow us to reach, *Gryphæa incurva*, *Pholadomya*, *Rhynchonella variabilis*, *Ostrea*, and other evidences of Liassic life were found.

b. *Organic Remains from the Sutton Stone.*—High up in the vertical section given by Mr. Tawney, and immediately under the *Ammonites-Bucklandi* beds, that gentleman has indicated a zone of *Ostrea liassica*. I have shown the special horizon of this shell at Camel and Bedminster, and also at Stormy, Laleston, and Llanbethian, near Sutton, where it is found below the *Ammonites-planorbis* beds and at the base of the Liassic series; its presence therefore on the horizon thus pointed out would necessarily place all the beds on which it reposes, supposing it to occupy the same position as in the above sections, below the Liassic series. This shell is abundant in the Sutton Stone, and passes upwards; but I was unable to recognize it as occupying a special horizon like that indicated in the above sections.

Before the deposition of the Sutton Stone, the species of corals found therein had attached themselves to the floor of Carboniferous Limestone or to its fissures; and under the same circumstances eleven species of Mollusca which recur in the Sutton Stone have been found. In addition to these, there are two (*Pleurotomaria obliqua*, Terq., and *Trochus sinistrorsus*, Desh.) which I have not yet recognized elsewhere. In the very mineralized matrix of the vein-stuff under the Sutton Stone, Entomostraca are to be recognized.

The species from the Sutton Stone are not so numerous as might have been expected when the very fossiliferous nature of the bed was first seen. Owing to the character of the matrix many are in bad condition, and, from the outer shell-structure having perished, difficult to recognize specifically. In consequence of this, some of Mr. Tawney's species represent known Liassic forms, whilst others have been previously described from the Lower Lias, or "Infralias" beds of the Continent *.

In addition to the 15 species of corals described by Dr. Duncan, 7 of which are special to it, I have recognized 35 other species in the Sutton Stone, which, with the 2 hitherto obtained only in the fissures below, make a list of 52 species.

List of Organic Remains from the Sutton Stone.

Ammonites angulatus.
Cerithium, sp.
Neritopsis exigua.
Phasianella (Pteroceras) dubia, *Terq.*
—— usta, *Terq.*
Patella Dunkeri, *Terq.*
—— ornata, *Moore.*
Turbo Juliani, *Terq.*
Trochus.
Cardinia Moreana, *Martin* (C. ingens, *Taw.*).
——, sp.
Cardita tetragona, *Terq.* (Astarte Duncani, *Taw.*).
—— rhomboidalis, *Taw.*
Cypricardia Winwoodii, *Moore.*
Astarte cingulata, *Terq.*
Lithodomus, casts.
Mytilus, sp., cast.
Modiola, sp.
Pinna insignis, *Taw.* (P. semistriata, *Terq.*).
Lima gigantea, *Sow.* (L. exaltata, *Terq.*; L. compressa, *Terq.*; L. Fischeri, *Terq.*).
—— Dunravenensis, *Taw.*
—— duplicata (L. Hettangiensis, *Terq.*).
—— tuberculata, *Terq.*
—— dentata, *Terq.* (L. subduplicata, *Taw.*; L. planicostata, *Taw.*).
Pecten Pollux, *D'Orb.* (P. Suttonensis, *Taw.*).
—— Etheridgii, *Taw.*
Ostrea intusstriata, *Linn.* (Spondylus liassicus, *Terq.*).
Plicatula acuminata, *Terq. & Piette.*
Ostrea liassica (O. arcuata, *Lamk.*; O. anomala, *Terq.*).
—— arietis, *Munst.* (multicostata, *Terq.*).
—— irregularis (Anomia socialis, *Taw.*).
Gryphæa incurva (Ostrea lævis, *Taw.*).
Serpulæ. Entomostraca. Acrodus-tooth, derived. Fish-palate, fragment.

* Immediately after the reading of Mr. Tawney's paper I communicated my views on the age of the Sutton and Southerndown series to my geological friends in London, and I then informed Mr. Bristow that they were of Liassic age. He has since surveyed them and made sections for the Geological Survey. In a short paper read with my own and published in the last Number of the Society's Journal, I was pleased to find him in entire accordance with myself respecting their age. At this time Mr. Tate had an opportunity of inspecting the large collection I forwarded with the Sutton and Brocastle Corals to Dr. Duncan—his views then being that they belonged to the *Ammonites-planorbis* series; and I informed him they belonged to still higher horizons. Since my paper was read, he has given one on the "Fossiliferous Development of the *Ammonites-angulatus* zone," in which there will be seen a repetition of many of the points in my paper, and a general agreement with its views.

A comparison of the foregoing list with that of Brocastle will show that there are only 18 species common to the two localities, although at Brocastle there are in the whole nearly 200. Five of the above are corals. This very marked distinction is sufficient to show that the deposits must occupy different horizons.

At Sutton as well as at Brocastle the organic remains are most abundant where the Liassic deposits come in more immediate contact with the Carboniferous Limestone. Thus the corals at Sutton are chiefly found at the base of the series, and with some of the other remains become rare or entirely absent in the higher portion of the series.

An examination of the great thickness of the beds above the Sutton Stone proper will show the peculiar conglomeratic and lithological characters they present at their outcrop, to which allusion has been made. This condition disappears in their passage to the east. The stone is very dense and intractable, and the organisms very difficult to extract. From immediately above the Sutton Stone I obtained the following:—

Ammonites angulatus, rather abundant.	Ostrea liassica.
Gryphæa incurva, rather abundant.	Pholadomya ambigua.
Cypricardia, sp.	Pecten dispar?
Cardita multicostata.	Phasianella.
Lima gigantea.	Cerithium nodulosum, *Moore.*
—— duplicata.	Trochus.
Ostrea arietis.	Thecosmilia Michelini.

Following the coast-line from Sutton, under the Southerndown cliffs, the presence of multitudes of *Gryphæa incurva*, at about high-water-mark, sufficiently attests the Liassic age of the beds in this direction. Beneath them are very peculiar, gritty, thickly bedded limestones, on the top of which, though rarely, and in the beds below them seaward, Liassic remains are still found.

On the Dunraven side, above the gritty beds just referred to, are some very ragged or cavernous beds, from which were obtained the following:—

Ammonites angulatus.	Pecten Thiollieri?, *Martin.*
Belemnites acutus.	Plicatula Hettangiensis.
Gryphæa incurva.	Cardita multicostata.
Lima gigantea.	Melania crassilabrata, *Terq.*
—— duplicata.	Dunravenensis, *Moore.*
Astarte, small.	Littorina clathrata, *Desh.*
Cardinia, sp.	Turritella Deshayesii, *Terq.*
Modiola producta, *Terq.*	Pleurotomaria, cast.
Gervillia?	Elysastræa Moorei, *Duncan.*

The *Elysastræa Moorei* is found also under the Sutton Stone. Below the beds with the above remains, to the east, is a very fine Liassic section, at the base of which, at low water, great numbers of *Montlivaltiæ* may be noticed on the waterworn surfaces of the beds, and also sections of large *Cerithiadæ.* The Lias in this direction has fewer fossils than towards Southerndown and Sutton.

c. *The* Ammonites-Bucklandi *beds.*—Leading down to the beach from Southerndown the beds are seen to belong to this group. On the edge of the cliff on the Down, towards Sutton, there is a small section, where the higher members given in Mr. Tawney's diagram may also be examined. Those last mentioned are a Pentacrinital limestone precisely like that upon the horizon of the coralliferous conglomerate at Brocastle. *Gryphæa incurva*, as in the beds below, abound in it, associated with *Ammonites angulatus*, *A. Bucklandi*, *A. Conybeari*, and *A. semicostatus*, with *Belemnites acutus* and the phragmacone of a Belemnite of great size, previously mentioned as containing *Discina Davidsoni* in its chamber, identical with those found in the chambers of the *Nautilus* and *Cerithium nodulosum* at Shepton. On the weathered surface of these beds the shells stand out in considerable variety; for, although collected from a small area, they have yielded about fifty species. Except traces of *Montlivaltia*, the coral-fauna is here wanting. A comparison of the others with those of Sutton and Brocastle shows that they are more immediately allied to the latter than the former, and manifests the great preponderance of an "Infralias fauna," again associated with *Gryphæa incurva* and Ammonites from a supposed higher horizon.

In a wall on the Down above this section, I found a block of reddish slightly conglomeratic limestone, in its matrix not unlike Dolomitic conglomerate, which is evidently very fossiliferous. I obtained from it the only specimen yet found of *Neritina Hettangiensis*, Terq.; and in the same block were fragments of fish-remains. I have been unable to find the locality whence it came. The following are from the beds at the top of the cliff:—

List of Organic Remains from the Ammonites-Bucklandi *beds.*

Cidaris, spines &c.
Ophioderma, joints &c.
Pentacrinites tuberculatus, *Mill.*
Serpula strangulata, *Terq.*
——, sp.
Discina Davidsoni, *Moore.*
Rhynchonella variabilis.
Avicula Buvignieri, *Terq.*
Gervillia acuminata, *Terq.*
Gryphæa incurva, *Sow.*
Lima gigantea, *Sow.*
—— duplicata, *Sow.*
—— Hermanni, *Sow.*
Ostrea irregularis.
Pecten sublævis.
Pinna semistriata, *Terq.*
Arca pulla.
Astarte cingulata, *Terq.*
——, sp.
Cucullæa similis, *Terq.*
Cardinia elongata.
——, sp.
Cardita (sulcata) Heberti, *Terq.*
Cypricardia compressa, *Terq.*
—— tenera, *Terq.*
Tancredia.
Lucina arenicola, *Terq.*
Modiola minima, *Sow.*
Mytilus Sinemuriensis, *Martin.*
Nucula.
Cerithium Semele, *Martin.*
—— verrucosum.
——, n. sp.
—— gratum, *Terq.*
Dentalium.
Pleurotomaria Mosellanus? *Terq.*
Turritella Humberti, *Martin.*
—— Dunkeri, *Terq.*
—— Jenkeni, *Terq.*
Melania Theodori, *Martin.*
—— nodulo-carinata, *Moore.*
Turbo liassicus, *Martin.*
Ammonites angulatus.
—— Johnstoni.
—— Bucklandi.
—— Conybeari.
—— semicostatus.
Belemnites acutus.
—— elongatus?
Drift wood.

———

Neritina Hettangiensis, *Terq.*

10. *Langan Lead-mine, Sutton Stone, and Conglomerates.*—It has been stated that there are thick conglomerates interposed between the Sutton Stone and the Carboniferous Limestone. Though not visible in the Sutton quarries, it has been pointed out that they are present under the Sutton Stone, when the base of the cliff section is examined at low water, though no evidence of their thickness can thus be arrived at. Under the Sutton stone at Dunraven they are also to be recognized. The Lias at Langan is deposited in a deep basin in great part surrounded by Carboniferous Limestone. The lead-mine at this place, mentioned by Mr. Tawney, is about a mile and a half north-east of Brocastle, and considerably below the horizon of its coralliferous conglomerates.

The sinking was commenced in a Liassic vein; and as the "country" had to be removed, by which the miners mean the stratified or other deposits on each side of the vein, these were proved to the bottom of the shaft. At the surface were regularly bedded, but finely conglomeratic, dense limestones with thin intervening beds of marl. Although fossils are plentiful on their weathered edges, but few could be extracted. In the marls, *Pollicipes rhomboidalis*, Moore, and Pentacrinites are frequent. Following the above limestones, the Sutton Stone was passed through, from which were obtained *Patella Dunkeri*, Terq., and *Pecten Pollux*, Taw.

Immediately below the Sutton Stone unstratified conglomerates were found, and passed through to the depth of 150 feet, and still continued when the mine was abandoned. No organic remains could be detected in them. All these conglomerates are therefore clearly interposed between the Sutton Stone and the Carboniferous Limestone, which no doubt forms the bottom of the basin at Langan*. In the stratified beds above the Sutton Stone, there are many species of *Cardinia* and *Pentacrinus*; and I also obtained the following:—

Ammonites angulatus.
Lepidotus-scales.
Pollicipes rhomboidalis, *Moore.*
Entomostraca, 2 spp.
Astarte irregularis, *Terq.*
Ostrea arietis.
Anomia irregularis, *Terq.*
Cardita tetragona, *Terq.*
Orthostoma avena, *Terq.*
Pleurotomaria lens, *Terq.*
Turbo rotundatus, *Terq.*
Trochus Juliani, *Terq.*
—— Langanensis, *Moore.*
Trochotoma clypeus, *Terq.*
Astrocœnia gibbosa, *Martin.*
Thecosmilia Michelini, *Terq.*

11. *Inadmissibility of the term "Infralias."*—For a considerable time all the beds at the base of the Lower Lias, below the "White Lias," including the bone-bed and the *Avicula-contorta* series, were oscillating between a classification by some authors with the Keuper and by others with the Liassic series. The indefinite term "Infralias" was then introduced, and has begun to be recognized in geological nomenclature. In my paper on the "Zones of the Lower Lias, &c.," I pointed out the marked distinction these beds presented from the Keuper at their base on the one hand, and the Liassic beds above, and proposed that, including the "White Lias," they

* As these conglomerates both at Sutton and Langan follow immediately below the Sutton Stone and graduate into it, there appears little doubt that they must be assigned to the Liassic period.

should be recognized as the "Rhætic Series," the propriety of which, when the vertebrate remains from the latter beds are described, will be more clearly seen.

M. Jules Martin, in his 'Paléontologie Stratigraphique de l'Infralias de la Côte-d'Or, recognizes the above term, and also M. Terquem for beds in Luxembourg and Hettange, and M. Deslongchamps for those of the "calcaire de Valogne."

Dr. Duncan follows them when he notices the Corals and other remains with which I have supplied him in his "Madreporaria of the Infralias of South Wales." Commencing the Lower Lias with the beds containing *Ammonites Bucklandi* and *Gryphæa incurva*, between these and the Keuper three zones are proposed for the Infralias,—the upper including the coralliferous deposits of Brocastle &c., in South Wales, and also the horizon of *Ammonites angulatus*. The second includes the zone of *Ammonites planorbis* and the "White Lias" in part (Wright); whilst in the lower zone he gives the "White Lias" in part (Moore), and the other beds to the Keuper,—all of which I propose to include in the Rhætic series. My proposal always was to include the whole of the "White Lias" with the latter. They are a compact mass of limestones, as a reference to my sections will show, with the same lithological and palæontological conditions throughout; and as there is no possibility of separating them into horizons, they must all be classed together; and I think I have shown sufficient reason, when describing the Camel and other sections, why my classification is to be preferred. I do not agree with Dr. Duncan's horizons for the South Wales coralliferous deposits, since those of Laleston, Cowbridge, and Llanbethian are in the Ostrea-beds and below the *Ammonites-planorbis* zone, whilst that of Brocastle, from its containing an abundance of *Gryphæa incurva*, must, I think, be placed above the horizon to which he has assigned it.

It is very certain, from the descriptions given by the above authors of the several continental "Infralias" deposits, that the beds are very feebly represented when compared with the Lower Lias of this country. In the district of the Côte-d'Or, they are deposited unconformably upon, or within the influence of, a granitic coast-line, and not only is there much unconformability, but the beds are much mineralized and metamorphosed, those of Nolay and Thorte being sufficiently ferruginous for the manufacture of iron, whilst galena, manganese, and other minerals are at times present. The greatest thickness described by M. Martin at Pouillery for the "Infralias," including the Rhætic beds, is but 10 feet, many of the sections being still thinner.

M. Terquem, in his description of the beds of Hettange and Luxembourg, also points out the presence of much unconformability. In the direction of Loevelage to d'Arlon, the "Infralias" beds are wanting, and the *Gryphæa incurva* or *Ammonites-Bucklandi* beds repose upon the Keuper; and he also states that in the Moselle, though not in Luxembourg, the "Infralias" begins with the bone-bed, from which it appears that, though so persistent in this country, the Rhætic beds are wanting in some of the above districts. The Liassic beds of Hettange are calculated by the above author at 25 to 30 metres; but in Luxembourg, in which they are in a basin-shaped depression, they are thicker.

M. Deslongchamps, when speaking of the "Calcaire de Valogne," again refers to the Infralias. Like its equivalent deposits at Sutton, the beds are mostly unconformable, and are stated by that author to be deposited in two small basins of Silurian strata, in which they have a thickness of about 20 metres. The above basins have been partly occupied by Triassic strata; but towards Picauville where they pass beyond the basin, they rest immediately upon the granite.

It is thus clearly shown, not only that the Lower-Lias deposits meet or repose upon an ancient coast-line in South Wales and Somersetshire, but that precisely similar conditions prevail in the continental districts just referred to, and that throughout their entire length they are much metamorphosed and unconformable, whilst at the same time, where the deposits are beyond the influence of these interrupting conditions, they assume the normal characters of the Liassic beds, and attain great thickness.

It is under these circumstances that our continental friends have adopted the division "Infralias" for the beds between the horizon of *Gryphæa incurva* and the Keuper. To this arrangement I think there are many objections, which will justify me in still retaining the old landmarks for the Liassic series. The proposed division is based upon deposits which are local and abnormal (and must therefore necessarily be more or less arbitrary), instead of upon such sections as those of Camel and Beer, in which there are types of the ordinary succession and the general condition of the formation over a widely extended area in the South-west of England; and the result of the adoption of their proposed classification would be that we should probably have to remove three-fourths of the English Liassic series from the Lower Lias to that of the "Infralias."

Not only will there be many physical difficulties, but the palæontological conclusions upon which this division is based do not hold good with the more extensive development of the Lias in this country, where the series from above the "White Lias" are seen to be parts of a connected whole.

The proposed division of the "Infralias" from the Lower Lias has been suggested by the above-mentioned authors from the fact that with them the *Gryphée arquée* (*Gryphæa incurva*) is not seen to commence with their "Infralias" fauna, and also that in these lower beds they have a special fauna which does not apparently pass up into those containing this shell. On the contrary, at Sutton and Southerndown, and at Bridgend, the shell is found abundantly with their "Infralias" fauna, whilst at Brocastle, where that fauna is the most varied, *Gryphæa incurva* is the commonest bivalve, and I cannot have collected less than fifty examples within a space of two or three yards. It is found also at Willsbridge and throughout the Bath district; and at the same time a very large percentage of the whole fauna is in actual association with *Ammonites Conybeari*, *A. angu-*

latus, and *A. Bucklandi*, and in part also even with *A. Sauzianus* and *A. semicostatus*.

M. Martin, in his Table of the "Infralias" deposits, gives, in the whole, 213 species, including those of the Rhætic Beds, which I have not classed with the Lias. Of these, 176 are found on the horizon of the *Ammonites angulatus* (*A. Moreanus*), only 45 of which in the districts he notices pass into beds with *Gryphæa incurva*. In this country nearly the whole fauna is in association with that shell: I recognize 69 more of the continental species in association with that shell, making 114 in the whole. Many other species have not yet been found common to both; but, as far as they have been recognized, nearly the whole of the continental fauna of the "Infralias" are in association with *Gryphæa incurva* and are found also in the chambers of *Ammonites Bucklandi*.

In Dr. Duncan's paper "On the 'Infralias' Corals," he has inferred that the Brocastle, Ewenny, and other deposits have no stratigraphical succession, and that most of the sections from which I obtained the coral-fauna are on the same horizon; but in this I am compelled to differ from him. Where the beds are removed from the metamorphosing influence of the Carboniferous Limestone, their correlation with the Camel section is quite clear, and their horizons can generally be recognized. Thus at Stormy is seen the passage from the Keuper into the Rhætic beds, and from these again into the Ostrea-beds, with the *Ammonites planorbis* still higher. The same horizon is clearly defined in the Church quarry at Laleston, though here the Sutton-Stone mineralogical character is assumed by the beds at the base of the quarry, instead of on the higher horizon at Sutton. In Dr. Pritchard's quarry at Laleston, the Ostrea-series is present, quite as regularly bedded as at Camel. The same occurs also at Llanbethian, where above the Ostrea-beds those with *A. planorbis* occur. The above represent the beds of the Camel section to the *A.-planorbis* zone. The only corals to this point are *Thecosmilia Michelini*, a flat *Montlivaltia*, and very fragmentary evidences of *Astrocœnia*. *Gryphæa incurva* has not yet appeared; and its presence so abundantly on the horizons of Sutton, Brocastle, &c. would imply that they are still higher in the Liassic series.

Next I should be disposed to place the Sutton Stone proper, and its equivalent at Windsor Hill, Shepton, in which occur *A. Conybeari* and *A. Bucklandi*; whilst above this, if not parallel with it, the normal conditions of the latter beds appear.

Mere lithology is of no value in comparing these peculiar deposits; nor is the presence or absence of certain species always a safe guide; for although, from the general facies of the fauna as well as from their lithological similarity, the horizons of the Sutton and Shepton beds are seen to be the same, yet not a single Sutton coral is present in the latter, and a species of *Montlivaltia*, which does not occur at Sutton, takes their place.

Although there are certain species of corals and mollusca common to Sutton and Brocastle, my view is that the latter are on a higher, and probably the highest horizon of any Liassic deposits in the district, since many of the Brocastle fossils appear only in the *Ammonites-Bucklandi* zone at Southerndown, or in the upper beds at Bridgend, with *A. semicostatus* and *Sauzianus*. The great abundance of *Gryphæa incurva*, both at Brocastle and at Southerndown, will at least remove these deposits from the so-called "Infralias."

VII. Conclusion.

From the peculiar character of the deposits of which I have treated, their study has been attended with much labour and difficulty, and has afforded occupation for several years. Mr. Godwin-Austen, in his elaborate theoretical paper on the extension of the Coal-measures under the South-eastern counties, alluded to the probable presence of an old land-area, of which Frome might occupy the central axis. In confirmation of his view, I am enabled to point not only to the axis of elevation in the basaltic dyke of Eastend, beyond Frome, on the Mendips, but also to produce Mammalia, Reptilia, and terrestrial Mollusca which were the inhabitants of this area within Rhætic and Liassic times, and from these and other physical reasons to infer that possibly the Mendips have seldom, or perhaps never, been again entirely submerged, or, if so, that it has been during the latter period. It has been shown that the barrier they have thus interposed has to a great extent modified the physical features of the whole line of country, from Frome through a great part of South Wales, and shut out the Secondary deposits from the Coal-basin, within which unconformability very generally prevails, and that the Secondary beds are very insignificant when compared with their equivalent deposits beyond. The mineral veins of the district show most conclusively that the Carboniferous Limestone must for a very long-extended period have been within the influence of the Liassic seas, and that from the latter have been derived most, if not all, of their mineral treasures, whether iron, or lead, or calamine; and it will have been seen that whenever the edges of the Lias have met the Carboniferous Limestone, or have been deposited within any of its basins, an altered mineralogical character is always present, which beds on the same horizon lose when beyond its influence. The correct succession from the Keuper, through the Rhætic, to the Liassic beds, and the precise divisions of the latter, have been pointed out, as well as the palæontological and lithological break indicated by the Rhætic White Lias, from which deposit the entire absence of Vertebrata and Cephalopoda has been shown, as well as its probable littoral character. In connexion with the Sutton Stone, it will have been seen that its peculiar lithology is only local, and that these beds are truly Liassic, whilst many of the shells it contains pass into the higher members of the Liassic series. Many points of palæontological interest will have been noticed, especially the wonderfully rich fauna of Brocastle, from which, including the corals, I have obtained nearly 200 species. The curious fossiliferous deposit in the Mendip mine has revealed the presence of a Liassic fauna, of a date prior to the deposition of the minerals therein, which is evidently contemporaneous with that of Brocastle and the *Ammonites-Bucklandi* beds of Bath. For the first time in this country there will have been recognized the interesting fauna of Fontaine-étoupe-Four, and to some extent that of the Hierlatz beds. Exception has been taken to an "Infralias" division; and its inapplicability to the larger and more complete development of those beds in this country has been pointed out.

Lastly, in connexion with his investigations, the author will have indicated a most varied and interesting fauna, including the Corals described by Dr. Duncan, and the beautiful Gasteropoda of Brocastle, the new Brachiopoda of Whatley, and the numerous microscopic Foraminifera with which the Liassic beds were at times crowded.

The list which will be given, with perhaps the exception of some from Holwell, Whatley, and Munger, is entirely confined to species from the Lower Lias. It does not profess to be complete, but contains only such as have been referred to in this paper; and yet these amount to not less than 429 species, and are in great part new to the fauna of this country.

The fauna of the Middle and Upper Lias have been shown by the author, in the 'Proceedings of the Somersetshire Archæological and Natural History Society' for 1865–66, to number 580 species; so that the whole Liassic series yields about 1000 species.

VIII. Descriptions of the Species.

1. Chara liassica, spec. nov.

A single seed-vessel of this freshwater plant is associated with the Liassic remains from the Charterhouse mine. It is not in the best condition, from having been slightly abraded; but by a close examination with the lens the spiral striations on its surface can be detected. When connected with the terrestrial and fluviatile remains to be hereafter noticed, its presence affords additional evidence of a Mendip land-area, and of a connexion subsisting between its streams and the Carboniferous limestone fissures before the deposition of the minerals therein. No remains of *Chara* having been found below Purbeck strata, this will be the oldest known example.

2. Grantia antiqua, spec. nov. Pl. XVI. figs. 33, 34.

Spicules triradiate, calcareous, of different lengths, springing at varying angles from a central calcareous base.

In some instances I have obtained the triradiate spicules entire, and free from the matrix. The presence of these Amorphozoa may be detected in almost every block in the Liassic conglomerate of Brocastle, though they are to be recognized generally in straight, detached, or single spicules. They are in such numbers as to show that they have added materially to the composition of the Liassic rocks in some of the South Wales sections. They may be detected abundantly not only at Brocastle, but on the weathered surfaces of the Liassic rocks at Cowbridge, Southerndown, and Shepton Mallet.

The genus is in existence as a British marine form, and has been found fossil in the Red Crag of Walton. Dr. Johnston, in his 'History of British Sponges,' remarks that the species of *Grantia* are properly littoral, growing between tide-marks or in shallow water within the lowest ebb. This also appears to have been strictly the case with this ancient representative of the genus, as it is found at Brocastle and other places immediately skirting the Carboniferous Limestone coast-line, or in shallow basins along its margin washed by the Liassic seas. It is interesting to be able to connect this recent genus with one of so remote an age, and at the same time to be able to realize its growth under similar physical and zoological conditions.

3. Serpula strangulata, Terq. Pl. XVI. fig. 32.

Shell thick, elongated, curved, ornamented by numerous raised, sharp, and regular annular rings, in the concave interspaces between which are fine encircling striæ.

M. Terquem mentions that this species is found in the lower beds of the Lias at Zetrich, and also in the Middle Lias of the Moselle. In like manner I possess it from the Lower Lias of Bridgend, Stout's Hill, and Southerndown, in some blocks of which are many examples, and also from the Middle Lias of Camerton, where it is not uncommon.

4. Pollicipes rhomboidalis, spec. nov. Pl. XVI. fig. 31.

Scutum thick, convex, rhomboidal or subquadrate; under and basal margin slightly rounded, divided by an obtuse carina, crossed by strongly marked lines of growth; surface with fine longitudinal striæ; inner surface concave, with corresponding lines of growth and longitudinal striæ. The carina elongated, triangular, with raised rounded parallel ridges.

Many fragmentary specimens of this species occur in the clays intervening between the beds of Lias at Ewenny and at Langan. The figured specimen is from the Sutton Stone of Shepton Mallet. I have already described a species from the Rhætic beds; and the genus is now recognized for the first time in the English Lias.

5. Belemnites elongatus?, Mill.

This genus is represented in the Lower Lias at Southerndown by a very large phragmacone, the chambers of which measure $2\frac{1}{2}$ inches in diameter. At first I was disposed to consider it an *Orthoceras*, and that the *Discina* which occupies the centre of one of the chambers had passed into it through the siphuncular orifice. To settle this point I had sections prepared; but having been unable to detect the presence of the siphuncle, it will be safer to consider that it belongs to *Belemnites*, though no Belemnite of such large proportions has before been found so low down. *Belemnites acutus* occurs rarely in the same section.

6. Crania liassica, spec. nov.

Shell rather small, subquadrate, concave, with a rather elevated obtuse vertex, shell-structure smooth; surface with a very irregular wrinkled aspect.

Fragments of this little *Crania* are not uncommon; but I have only one moderately perfect, showing the exterior, which is from the Brocastle Liassic conglomerate. It occurs also (but fragmentary) in the Charterhouse Liassic mine, and in the Lower Lias at Stout's Hill.

7. Discina Davidsoni, spec. nov. Pl. XVI. fig. 29.

Shell small, rather elongate, ovate, conical; vertex much elevated, almost central; anterior margin and sides rounded; posterior margin rather truncated; surface of the shell covered by very fine concentric lines.

In general form this shell is not unlike *D. Sandersii*, Moore, from the Upper-Lias Leptæna- and fish-beds; but the encircling striæ are much finer. This species is widespread, and evidently not uncommon. It is usually found attached to the interiors of dead shells. In this way I have it in the body-whorl of a large *Cerithium nodulosum*, Moore, from the *Ammonites-Bucklandi* beds of Shepton Mallet, and also attached to the internal chambers of several *Nautili*, their casts having been retained on the inner stony matrix. It occurs also in the metamorphosed bed on shells at Windsor Hill. Another instance is in the phragmacone of a very large Belemnite at Southerndown, where its concave side occupies the centre of the chamber, giving it at first sight the appearance of the siphuncle of an *Orthoceras*. The only free specimen, though not perfect, is from the Lower Lias of Bedminster Down.

It is named after my friend T. Davidson, Esq., F.R.S., whose noble work on the Brachiopoda does him so much honour.

8. Zellania obesa, spec. nov. Pl. XVI. fig. 28.

Shell minute, longitudinally ovate, much inflated; margin rounded; deltidium triangular, widely gaping, and encroaching, as is usual with this genus, on both valves; surface smooth.

Only one example of this shell has been found. Its very oval and inflated character distinguishes it from the other three Liassic species I have described. But for its very wide deltidium it might have been mistaken for a species of Entomostraca.

Locality. The Lower Lias of Stout's Hill.

9. Avicula nuda, spec. nov. Pl. XVII. fig. 19.

Shell quadrate, oblique; umbones much raised, anterior, and curving over the hinge-line; anterior side most convex; posterior side angulated from the umbo towards a rounded posterior and ventral margin; surface smooth, with faint, irregular, concentric lines of growth; hinge-line shorter than the shell.

From a Liassic conglomerate resting immediately upon Carboniferous limestone on the Marston road at Holwell, which appears to represent an horizon at the junction of the Lower with the Middle Lias, and of the age of the Hierlatz beds. I have some difficulty in separating this shell from the *Avicula quadrata* of Dr. von Dittmar, from the Alpine Upper Trias of Hallstadt.

10. CYPRICARDIA WINWOODII, spec. nov. Pl. XVI. fig. 27.

Shell ovately oblong, moderately convex, smooth, inequilateral; umbones anterior; anterior side rounded towards the ventral margin, posterior side produced, angular; a well-defined rib or carina passes from the umbones to the posterior ventral margin, beyond which there is an angulated area.

It is named after my friend the Rev. H. H. Winwood, F.G.S., the Hon. Sec. of the Bath Naturalists' Club.

Locality. The Sutton Stone of Sutton.

11. OPIS TRIANGULARIS, sp. nov. Pl. XVII. fig. 20.

Shell small, subtrigonal, thick, much longer than wide; umbones prominent and but slightly curved outwardly, terminal; an obtuse carina from the umbones passes to the posterior ventral margin, which is produced, and divides the dorsal surface from a very angulated area; surface covered with numerous straight lines of growth, which, on crossing the carina, pass obliquely to the anterior margin; anterior side slightly rounded; lunule not exposed.

It is from the Liassic conglomerate of Holwell; from the Hierlatz beds on the same horizon Dr. Stoliczka has described the *Opis clathrata*, from which this species is to be distinguished by its more triangular form.

12. LIMA DESLONGCHAMPSII, Stol. Pl. XVII. fig. 21.

Shell convex; broader than long, transversely oval; ventral margin and sides regularly rounded; surface with faint concentric lines of growth and very fine longitudinal striæ, which are most distinct on the younger shells. In certain conditions of the test it also possesses fine punctations.

It occurs in the Liassic conglomerate of Holwell, and also in the thin bed of Lias at Whatley, in both cases immediately upon Carboniferous Limestone. It has been found in the Hierlatz beds by Dr. Stoliczka, and at Fontaine-étoupe-four by M. Deslongchamps. It does not attain the size of *L. gigantea*, and is generally much more oval transversely than that shell.

13. LIMA DENSICOSTA, Quenst. Pl. XVII. figs. 23, 24.

Shell rather small, convex, obliquely ovate; anterior side and margin rounded; posterior side extended, round; auricles small, nearly equal; lunule small; surface with longitudinal costæ.

Locality. The Liassic conglomerate of Holwell. It occurs also on the Hierlatz.

The following species also occur with the above at Holwell; but, owing to the density of the matrix, none have yet been obtained in very good condition:—

Pecten palosus, Stol. Pl. XVII. fig. 27.
Pecten Rollei, Stol. Pl. XVII. fig. 25.
Pecten verticillus, Stol. Pl. XVII. fig. 26.
Lima scrobiculata, Stol. Pl. XVII. fig. 22.

14. Alaria rudis, spec. nov. Pl. XIV. fig. 24.

Shell turreted, fusiform; whorls 5–6, convex, obtusely carinated on the middle portion, rather flat below and angulated above; suture indistinct; last whorl extended; aperture oblong.

The surface of the only example I possess appears smooth; but probably it had originally fine transverse striæ, which may have been abraded. The outer lip is concealed, so that it cannot be seen whether it possessed digitations. For this reason it is, with a little hesitation, placed in this genus.

Loc. The coralliferous Liassic conglomerate of Brocastle.

15. Alaria fusiformis, spec. nov. Pl. XIV. fig. 25.

Shell fusiform, small; spire elevated; whorls 5–6, convex, angulated and divided by a deep suture; towards the base of the whorls are two distinct, slightly nodulated carinæ; surface ornamented by faint longitudinal striæ; canal short, straight. On the back of the body-whorl are three more-elevated carinæ; but, as the lip and mouth of the shell are not exposed, the character of the digitations are unknown.

It is from the coralliferous conglomerate of Brocastle, the lowest bed in which this genus has yet been recognized.

16. Cerithium pentacostæ, spec. nov. Pl. XIV. fig. 13.

Shell rather small, pyramidal; whorls short; longitudinal costæ seven in number, straight, strongly marked and elevated, and continuing to the base of the shell; whorls but slowly increasing, and crossed by encircling striæ; mouth small, rounded; lip folded; no canal.

This shell is not uncommon, though not often perfect. It is from the Liassic conglomerate of Brocastle.

17. Cerithium planicostatum, spec. nov. Pl. XIV. fig. 10.

Shell conical, regularly tapering; apex subacute; whorls 8, flattened, or slightly convex, and separated by a slight suture. In its younger stage the whorls are most convex and possess a slight carina on the middle, which becomes obsolete on the lower ones. The surface is ornamented by numerous, close-set, depressed, curved, longitudinal costæ; base flattened, with faint striæ; aperture not well exposed.

Of this pretty species I possess but one example. It approaches nearest the *C. Henrici* of M. Martin, but may readily be distinguished from that species by its less convex volutions, its more angulated or flattened base, and by its finer and more numerous costæ.

Loc. The coralliferous Liassic conglomerate of Brocastle.

18. Cerithium pellucidum, spec. nov. Pl. XIV. fig. 11.

Shell thin, small, cylindrical, rather pellucid; whorls slowly increasing, smooth, narrow and convex, divided by a rounded suture, which is bounded by an encircling depressed striation; aperture not exposed.

I possess but one example of this shell, which wants one or two of the upper chambers.

Loc. The coralliferous Liassic conglomerate of Brocastle.

19. Cerithium nodulosum, spec. nov. Pl. XIV. fig. 9.

Shell very large; spire turreted and much elongated, convex, angulated; whorls spirally coiled, elongated; the upper portions regularly angulated towards a well-marked concave suture. Towards the base of the volutions there occurs a single row of very prominent and rather widely separated nodulations; aperture longitudinally ovate.

Of this fine species I possess only one example showing the test; but this is lost on the lower whorl, and several of the upper ones are wanting. My specimen consists of five whorls, which measure 4 inches in length; and it is probable the shell must have been about 5 inches long when perfect.

It is from the Lias with *Ammonites Bucklandi* and *A. angulatus* at Shepton Mallet, and is represented, at Southerndown, Sutton, and Dunraven, by the large sections of its shells, which are there seen on the surfaces of the beds.

The outer chamber of my specimen contains a *Discina Davidsoni*, Moore.

20. Cerithium spiratum, Moore. Pl. XIV. fig. 12.

Shell spiral, narrow and very elongate; apex acute; possessing 14–15 very slowly increasing volutions, which are divided by a small angulated encircling suture; the surface of the whorls ornamented by close spiral striæ, which are crossed by six or seven raised oblique longitudinal costæ. Aperture rather ovate.

This pretty species does not appear to attain any considerable size, and, though it is not uncommon, it is rarely found quite perfect.

Locality. The coralliferous conglomerate of Brocastle.

21. Chiton radiatum, spec. nov. Pl. XVI. figs. 25, 26.

Shell elliptical or transversely oval, flattened; dorsal surface convex, smooth, possessing a central, broadly grooved, slightly raised apex, with lateral depressed areas; anterior convex, divided into two areas by a curved or folding line, the surface presenting radiations passing from beneath the umbo.

I possess four examples of this shell, only one of which is in good condition. I have previously found this genus in the Middle and Upper Lias, and also in the Rhætic beds, this being the first instance in which it has been recognized in the Lower Lias. Although comparatively rare, the genus has now been found in every geological stage down to the Lower Silurian. The same species also occurs in the Liassic lead-mine of Charter House and the Lower Lias of Bedminster, the figured specimen being from the coralliferous conglomerate of Brocastle.

22. Delphinula nuda, spec. nov. Pl. XVII. fig. 10.

Shell turbinated; spire elevated; volutions five, oblique, much rounded or convex, and slightly angulated on their upper margins. Surface of the shell smooth and without ornamentation; mouth only partly exposed, exhibiting on its inner margin a thick reflected lip. I have hitherto found only a single specimen, which is from the Liassic vein in the Carboniferous Limestone at Holwell.

23. Delphinula reflexilabrum, Horne. Pl. XVII. figs. 8, 9.

Shell small, discoidal, truncate; spire depressed; apex obtuse; body-whorl smooth, slightly depressed on the under surface, very rounded and convex on the margin; aperture very large, circular, and surrounded by a very wide reflected lip. Umbilicus and base not exposed.

This shell appears to have some affinity to *Rotella macrostoma*, Stol., which that author states to be common on the Hierlatz, but which he separates from the above, from its not possessing the reflected lip, which, in our specimen, acquires nearly one-third of the width of the last whorl.

Loc. The Liassic vein in the Carboniferous Limestone at Holwell.

24. Amberleya alpinus. Pl. XVII. fig. 7.

Eucyclus alpinus, Stoliczka.

Shell turreted; of 4–5 rounded volutions, which are divided by a deep angular suture. Each whorl possesses three or four tuberculated carinæ, and in the basal angle another somewhat smoother. The base of the body-whorl has many encircling striæ. The mouth is large, somewhat square; outer lip thin, but thickening at the base, where it is slightly reflected. My examples of this shell are not in good condition, though sufficiently so to mark the species. The figure is a restoration after Dr. Stoliczka's.

Loc. The Liassic vein in the Carboniferous Limestone at Holwell.

25. Fusus Terquemi, spec. nov. Pl. XIV. fig. 8.

Pteroceras? Terq.

Shell rather small, fusiform; spire produced; volutions 6–7, angulated; surface ornamented with fine concentric striæ, which continue to the base of the columella, and with elevated costæ which cross the angulated base of the whorls; aperture longitudinally ovate; columella extended, slightly folded, with narrow canal.

M. Terquem, in his account of the geology of Luxembourg and Hettange, has referred this shell with some doubt to *Pteroceras*, but states his example to have been imperfect.

As my specimens show the columella, and are otherwise complete, there can be no doubt that they belong to *Fusus*, though the genus has not been recognized so low. I name it in honour of M. Terquem, whose work on the Lower Lias has greatly assisted me in gaining my knowledge of the palæontology of that formation.

Loc. The coralliferous conglomerate of Brocastle, where it is not uncommon, though rarely perfect.

26. Fusus Jenynsii, spec. nov. Pl. XIV. figs. 6, 7.

Shell elongate, fusiform; whorls 7–8, angulated, bounded on the lower margin by an elevated obtusely nodulated carina; angulated surface of the whorls covered by very close encircling striæ, which are decussated by equally faint lines, giving the shell, by aid of the lens, a finely reticulated aspect; columella moderately extended, lip thick, and at the base rather folded over the canal; mouth rather small, ovate.

This shell is one of the commonest Gasteropods at Brocastle, whence I have examples of all ages. It does not appear to have attained any considerable size, my largest specimen being about half an inch in length. It is named after the Rev. Leonard Jenyns, F.G.S., the President of the Bath Naturalists' Club, and an earnest worker in natural science.

27. Helix Dawsoni, spec. nov. Pl. XV. figs. 1, 2.

Shell small; spire but slightly elevated, with about four apparently small convex volutions divided by a slight sulcus.

The base of the shell is slightly crushed, but it is seen to be flattened and to possess a deep and rounded umbilicus with a rounded aperture. The somewhat imperfect condition of this shell, of which I have but one specimen, renders it rather difficult to determine it with precision; but its generic determination is facilitated by its being found in association in the same deposit with the land and freshwater genera I have previously enumerated.

It is from the Charter-House Liassic lead-mine, and is named after Dr. Dawson, the discoverer of a still older land-shell in the Coal-measures of Nova Scotia.

28. Hydrobia, sp.

This genus is represented in the Charter-House Liassic mine, by a single somewhat imperfect specimen, to which, being of young age, I have not considered it desirable to give a specific determination, a course the less to be regretted from my possessing examples from the mines of other districts, which will be noticed on another occasion.

29. Littorina ovalis, spec. nov. Pl. XIV. figs. 17, 18.

Shell thick, ovate, convex; spire rather short; volutions 4–5, the body-whorl being convex, longitudinally ovate, and inflated. The body-whorl has numerous regular, obtuse, encircling striæ, which continue on the base, but which are less distinct on the upper whorls; these are decussated by close, rather curved, longitudinal striæ.

Loc. The coralliferous conglomerate of Brocastle, whence I have obtained two specimens.

30. Littorina circularis, spec. nov. Pl. XIV. figs. 15, 16.

Shell small, turbinated; spire acuminated; volutions 4–5, convex, and divided by the suture; whorls ornamented by regular encircling striæ, about nine in number on the last whorl, which are followed by others on a slightly angular or rounded base. Between the striæ are very fine longitudinal lines. Aperture large, rather ovate; lip slightly extended at the base, and folding over a small umbilicus.

Loc. The Liassic coralliferous conglomerate of Brocastle, where it is not uncommon.

31. Melania acuta, spec. nov. Pl. XIV. figs. 20, 21.

Shell turreted; spire extended; apex acute; volutions 5–6, the upper convex, the body-whorl rather inflated and extended, slightly angulated, and with an obtuse carina; sutures distinct. On the surface are depressed transverse striæ. Aperture longitudinally ovate, with a broad shallow sinus.

I possess several examples of this species from the Brocastle conglomerate, where it is associated with *M. abbreviata* and *M. usta*, described by M. Terquem, from the Lower Lias.

32. Melania Dunravenensis, spec. nov. Pl. XIV. fig. 19.

Shell elongated, turreted; whorls 6-7; spire elevated, acute, with an acute apex; volutions convex, rather spirally winding, aperture longitudinally ovate.

This shell occurs very abundantly in the raggy beds I have referred to under the cliff at Dunraven; but generally they only show sections of the chambers, or have their surfaces much abraded. For this reason the character of the test is rather uncertain; but I think the shell was ornamented with rather fine encircling striæ. I have noticed imperfect examples of the same shell in the Lias of Bridgend, at Shepton, and near Bath. Imperfect specimens and casts associated with it lead me to suppose that there are several other species.

33. Melania nodulo-carinata, spec. nov. Pl. XV. fig. 18.

Shell large; spire pyramidal; whorls broad, rather convex or angulated, the base surrounded by a line of large nodulations (about twenty in number) on the circumference of each whorl; base roundly obtuse; inner lip thick, folded, and slightly sinuous; aperture large, but not fully exposed.

Of this fine shell I possess but one specimen, in which only the lower whorl is complete, above which there is only a section of the chambers. On the underside, where it has not been abraded, the shell appears to have a finely waved or striated character. The transverse diameter of the whorls is much greater than their length; a small portion of the apex is wanting; but the shell must have been about four inches in length.

Loc. The Lower Lias, with *Gryphæa incurva* &c., at the top of the Southerndown Cliff.

34. Nerinæa acuminata, spec. nov. Pl. XIV. fig. 22.

Shell small, elongated, cylindrical; whorls rather long and separated by a concave sinus; centre of the whorls most convex and ornamented with longitudinal costæ, and with very fine encircling striæ. At the base of the whorls is a transverse, rather elevated, smooth rib. Aperture longer than wide, ovate; columella with slight fold; canal short.

This pretty little species is not uncommon, though rarely found perfect. It is from the Liassic conglomerate of Brocastle.

35. Nerinæa Horneri, spec. nov. Pl. XVII. fig. 12.

Shell conical, composed of six convex, rapidly increasing whorls; spire rather depressed; aperture rhomboidal; columella thick, with two folds upon its inner margin; no umbilicus.

The surface of the volutions is ornamented with numerous encircling nodulated costæ, which continue to the base of the shell in the interspaces, between which are numerous perpendicular striæ.

This pretty shell in its general contour is more depressed than is usual with *Nerinæa*. Several specimens of it are attached to the fossiliferous Liassic block extracted from the vein at the base of the Carboniferous Limestone quarry at Holwell, the matrix in which represents in this country the horizon of the Hierlatz beds.

36. Nerinæa Mendipensis, spec. nov.

Shell small, cylindrical; upper part of the whorls flattened, rather convex towards their base.

This shell is not perfect, and is otherwise in bad condition, but it is sufficiently distinct to be separated from *N. acuminata* of Brocastle. As this is the only specimen of the genus which I possess from the Charter-House lead-mine, I notice it chiefly to record its presence at that place.

37. Nerinæa rudis, spec. nov. Pl. XIV. fig. 23.

Shell turreted, cylindrical; whorls flattened, with a small but well-marked suture and with encircling but faint striæ, which are continued on the base; aperture large and longitudinally ovate; columella with a short canal.

I possess two examples of this shell, neither of which has the test well preserved, and the apex of one is concealed whilst the other is imperfect.

They are from the coralliferous conglomerate of Brocastle, and are, with a little hesitation, referred to this genus.

38. Neritopsis lævis, Stol. Pl. XVII. figs. 3, 4.

Shell small, depressed; whorls convex, rapidly increasing, and ornamented with very fine encircling striæ; aperture quite circular, and large in proportion to the shell; outer lip thin, but thickening towards the base. One example of this shell is in my possession, attached to the block from the Liassic vein in the Carboniferous Limestone at Holwell. It is stated by Dr. Stoliczka to be rare in the Hierlatz.

39. Neritopsis exigua, Terq. Pl. XV. fig. 19.

Shell moderately large, thick, neritiform, ovately globose; spire small; volutions four; upper part of the last whorl flattened, crossed by large, rounded, oblique costæ, which continue on the margin of the whorl to its base.

The costæ are crossed by transverse, rounded striæ, which, on the convex margin of the large whorl, are about thirty in number, becoming closer at the base. Aperture large, subquadrate. Specimens of this genus are abundant in the Brocastle Liassic conglomerate, but they present so much variety, probably owing to age and the condition of the test, that it is with much difficulty I can arrive at specific distinctions. Examples in their young state, with the exception of a few longitudinal costæ, are quite smooth, whilst others are highly ornamented.

40. Neritopsis cancellatus, spec. nov. Pl. XV. fig. 20.

Shell ovately globose; spire small; apex rather acute; whorls four; upper area of the whorls angulated, and crossed by acute longitudinal costæ, which, on the side of the body-whorl, are decussated by coarse encircling striæ, which become nodulated at their junction. Aperture rather ovate.

This species is more globose than *N. exigua*, and by its less numerous and coarser costæ may readily be distinguished from it.

Loc. The coralliferous conglomerate of Brocastle.

41. Patella ornata, spec. nov. Pl. XV. fig. 13.

Shell rather small, ovate, conical; apex acute, slightly anterior to the centre; anterior and posterior margins rounded; sides flattened and more compressed; surface ornamented by rather widely separated, somewhat irregular radiating ribs, which are less prominent on the sides; these are decussated by numerous fine lines of growth, which, where they cross the ribs, particularly towards the margin, give them a nodulated appearance.

This pretty species is found in the coralliferous conglomerate of Brocastle and in the Sutton Stone at Sutton. At Brocastle it is accompanied by *P. Schmidti*, Terq., and at Sutton by that shell and *P. Dunkeri*, Terq. This species is rare, and does not attain the size of those mentioned. Owing to an accident to a perfect example, I am unable to give a better figure.

42. Planorbis Mendipensis, spec. nov. Pl. XV. fig. 10.

Shell minute, discoidal, depressed; spire obtuse; volutions nearly horizontal, increasing rather rapidly, divided by a canaliculated suture, and slightly angulated.

I possess but one specimen of this shell, which is from the base of the Charter-House Liassic lead-mine, and is found in association with the other terrestrial and marine remains which I have shown to have been introduced therein. It is obvious that the ancient freshwater species, for the first time discovered, owe their presence in the mineral veins to the connexion of the latter with freshwater streams or lakes of the Liassic period. In the Charter-House mine individual specimens are very rare. I shall, on another occasion, show that their presence under such circumstances is not an isolated case, and that in some other districts freshwater remains occur abundantly in some of our mineral veins.

43. Proserpina Lyelli, spec. nov. Pl. XV. figs. 3, 4.

Shell small, smooth, discoidal, depressed: spire rather depressed; volutions about four; the upper whorls rather convex, the body-whorl flattened and more rapidly increasing; margin obtusely angulated; base slightly convex; umbilicus large, deep, and rounded; aperture large, circular; peristome rather thick, the inner margin of the outer lip with three oblique projecting teeth.

Owing to a fragment of some foreign substance covering a part of the mouth of the shell towards the umbilicus, it is not completely exposed.

Of this very interesting terrestrial shell I have discovered but a single specimen.

Pterocheilos, gen. nov.

44. Pterocheilos primus, spec. nov. Pl. XIV. figs. 4, 5.

Shell very thick, small, general contour angulated or rhomboidal; spire short, depressed, and angulated; surface of the shell smooth; whorls 4-5; the body-whorl centrally carinated, dividing its upper surface from a very angulated base. The carina terminates in a small, triangular, wing-like boss or projection on the centre of the outer lip. Aperture round; peristome thick, circular, and entire, bounded towards the columella by a slightly raised rim; columella very thick, folded, subumbilicated, greatly extending beyond the peristome, and possessing a wide but shallow sulcus towards its base.

Of this very peculiar shell, for which I propose the above generic designation, I possess but a single specimen. It is from the Brocastle Liassic conglomerate, and is associated with the numerous species of corals from my collection, described by Dr. Duncan, and the many other beautiful gasteropods for which this deposit is so remarkable.

Pleuratella, gen. nov.

45. Pleuratella prima, spec. nov. Pl. XIV. figs. 1, 2, & 3.

Shell rather small, thick, rotelliform, discoidal; spire much depressed; apex subacute; volutions 4-5, increasing rapidly and encircling; surface of the shell quite smooth and without ornamentation; margin of the whorls convex; aperture very large, rounded or slightly ovate; outer lip crescent-shaped, thinnest in the centre, but thickening as it passes down and meets the base of the columella: columella short, thick, terminating below in a folding or incurved boss, in the centre of which there is a distinct sulcus or excavation.

The upper surface of this shell so much resembles some of the rotelliform species of *Pleurotomaria* that it might readily be mistaken, were its base concealed, for that genus. I possess five examples of this shell, four of which are from Brocastle, the other from the

Charter-House lead-mine. They probably represent several species; but my material is not sufficiently complete for distinctive comparisons. In one example the shell is slightly angulated, with a more acute apex than the above, and possesses a slight carina on the upper whorl, which becomes obsolete as it increases in size.

46. Phasianella turbinata, Stol. Pl. XVII. fig. 6.

Shell conical, moderately elongate; volutions six, which are slightly convex in the centre of the whorl, but slightly flattened or angulated in their upper portions; surface of the shell smooth, without ornamentation.

My example does not show the mouth, which Dr. Stoliczka states is elongated and pointed towards the lip, the inner portion of which is thin. It has been found on the Hierlatz, and more rarely on the Gratzalp.

Locality. The Liassic vein in the Carboniferous Limestone of Holwell.

47. Pleurotomaria Mendipensis, spec. nov. Pl. XVI. fig. 24.

Shell small, turbinated, convex; apex subacute, whorls four, sutures distinct.

Just under the suture, above the body-whorl, are two rather close raised striæ, below which succeeds a concave encircling depression or canal; following this the rounded margin of the whorl is also finely striated; base rather convex or angular. The striæ are costated by equally fine equidistant lines, which give the shell, under the lens, a very pretty reticulated appearance.

It was obtained from the Charter-House Liassic lead-mine.

48. Pleurotomaria Buchi, Deslongchamps. Pl. XVII. figs. 13, 14.

Shell small, discoidal; apex depressed; volutions rather convex; upper surface of whorls flattened or slightly angulated towards the suture, and ornamented by numerous costæ, beyond which are encircling striæ, which are continued on the rounded margin of the larger whorl and on the base, where they surround a deep umbilicus, the striæ being decussated by finer striæ longitudinally; aperture round*.

It is from one of the Liassic veins in the Carboniferous Limestone at Holwell. It has been found by M. Deslongchamps at Fontaine-étoupe-four; and Dr. Stoliczka mentions its occurrence on the Hierlatz and in the Lias of Schwaben. I am not acquainted with M. Deslongchamps's figure; my example is rather more depressed than that given by Dr. Stoliczka.

49. Pyrula liassica, spec. nov. Pl. XVI. fig. 30.

Shell small, inflated, globose; spire depressed; the body-whorl much enlarged; columella extended, tapering. The surface of the

* In the figure prominence is given to what I believe is an accidental slit or fracture of the fissural band, and which otherwise would connect this shell with *Scissurella*.

large whorl possesses distant, longitudinal, curved costæ; and by aid of the lens concentric striæ may be recognized; aperture not exposed.

One of the peculiarities of the Liassic deposit at Brocastle, whence this shell comes, is, that many of the genera have hitherto not been found so low down; and in this instance we have a genus that has not been recognized below the Greensand, and is still to be sought for in the intervening strata.

50. Rimula liasina. Pl. XV. figs. 14, 15.

Emarginula liasina. Terq.

Shell rather small, oblique; apex posterior, curved; surface with numerous raised, longitudinal, radiating ribs, decussated by finer transverse lines; interspaces with numerous punctations; foramen near the anterior margin.

There appears to be little doubt that the species is that figured as *Emarginula* by M. Terquem, who states he possessed only a cast, and that imperfect. Numerous examples in my possession show, from the position of the foramen, that the species must be referred to *Rimula.*

It is rather plentiful, and usually attached to the coralliferous blocks in the Liassic conglomerate at Brocastle. The *Pileopsis nuda,* Terq., probably belongs to the same genus.

51. Rimula elegans, spec. nov. Pl. XV. figs. 16, 17.

Shell rather small, conical, ovate; apex posterior; sides rather flattened and acute, ornamented by numerous, close-set, regular, longitudinal striæ, which are crossed by numerous other transverse striæ.

This shell is readily separated from *R. liassina* by its finer and less-produced striæ, and by its generally compressed or longitudinally ovate form.

It is also from the coralliferous conglomerate of Brocastle, and more rare than the former species.

52. Discohelix cornucopiæ, spec. nov. Pl. XVI. figs. 1, 2, 3.

Shell discoidal; spire depressed, concave; volutions 5–6; upper margin of each whorl bounded by a depressed, transverse, rounded rib, which, on the outer margin of the larger whorl, passes into a very extended carina or encircling wing. The underside of this winged area is angulated or convex, and is separated from a very large and deep umbilicus by two carinæ, within which is a rounded furrow or canal; sides of the umbilicus angulated. The winged area, the carinæ, and the umbilicus are covered with longitudinal striæ, giving the under surface a very ornate appearance. Aperture roundly ovate; inner lip reflected. These shells are left-handed. In one or two specimens the larger whorl has a tendency to leave its usual plane and to become somewhat oblique. The chambered portion of the shell occupies only about one-half the dimensions of its dorsal surface.

Locality. The Liassic coralliferous conglomerate of Brocastle.

53. Discohelix fimbriatus, spec. nov. Pl. XVI. figs. 4, 5.

Shell discoidal, depressed; whorls 5–6, on the same plane, or but slightly raised, moderately convex. Surface of the shell covered by very close, regular, encircling striæ, which cross irregular, flattened costæ, or lines of growth, giving a wavy appearance to its ornamentation. The costæ terminate on the inner margin of the whorl in very depressed nodules, and on its outer margin in an elevated nodulated carina, which extends far beyond the chambered portion of the shell—the carina sometimes occupying about a third of the diameter of the shell. The back is angulated and retreating towards the umbilicus, and is covered, like the upper surface, with regular striæ, but which are waved as they approach the carina. Umbilicus deep, very large; aperture not exposed.

Of this very pretty and remarkable shell I possess but one example showing the upper surface and the back, and a second giving a section of the chamber.

They are from the Brocastle conglomerate.

54. Solarium lunatum, spec. nov. Pl. XVII. fig. 15.

Shell small, discoidal; whorls four, the upper convex, rounded, and slightly raised; surface ornamented by regular curved lines, which are bounded on the side of the body-whorl by a sinus, which becomes obsolete in its younger condition; beneath the sinus is an acute encircling carina; underside not exposed.

Of this pretty shell there are two examples attached to the block extracted from the Liassic vein at Holwell.

55. Trochotoma Brocastellensis, spec. nov. Pl. XV. fig. 29.

Shell turbinated, concave; apex obtuse; whorls five, having on their surfaces depressed transverse striæ; base of the whorls bounded by an encircling rib, on which are three close-set striæ, immediately beneath which is a slight sinus. The whorls are angulated (the upper portion of the body-whorl most so), and are ornamented by curved or oblique, depressed costæ.

This species is rare, as I possess only one other imperfect example. The base of the shell is surrounded by the matrix.

It is from the Liassic conglomerate of Brocastle, and the largest species yet obtained from that locality.

56. Trochotoma Lycettii, spec. nov. Pl. XV. figs. 27, 28.

Shell discoidal, depressed; spire flattened; apex rather acute; whorls five, with numerous encircling striæ, those in the centre and at the base of each volution being most elevated; the upper margin of the whorls flattened or angular, with irregular curved or almost obsolete lines of growth. The basal margin of the shell is surrounded by a raised rim composed of three or four slightly nodulated striæ. Base of the shell and umbilicus deeply excavated and surrounded by very distinct encircling striæ.

From the Brocastle Liassic conglomerate, where it is rare. It is named after my friend Dr. Lycett, to whose researches we are indebted for the separation of this genus from the *Pleurotomariæ*.

57. Trochus apicalis, spec. nov. Pl. XVI. figs. 20, 21, 22.

Shell pyramidal, regularly tapering; apex acute; volutions eight, narrow, very closely encircling; base of the volutions carinated; suture almost obsolete; surface smooth. The bottom of the shell is smooth, discoidal, rather concave; aperture very narrow, transverse; outer lip curved and folding round a truncated columella, which terminates in a central boss.

Of this species, which does not appear to attain a large size, I possess four examples from the Brocastle Liassic conglomerate.

58. Trochus gradatus, spec. nov. Pl. XVII. fig. 5.

Shell conical, thick; apex rather obtuse; volutions 4–5, slightly convex, and separated by a very slight concave suture; whorls very slowly increasing; surface smooth.

At first this shell looks not unlike the *T. aciculus*, Horn., often found on the Hierlatz; but it does not possess the distinct encircling suture between the whorls of that species, which also possesses a more acute spire.

This shell is not uncommon, as portions of several are to be detected, partly concealed by the matrix, in the block from the Liassic infilling in the Carboniferous-limestone quarry at Holwell.

59. Trochus Deslongchampsii, spec. nov. Pl. XVI. fig. 15.

Shell turbinated, trochiform; apex subacute; whorls 5, step-like, the upper flattened, the surface of the body-whorl more angulated, and surrounded on its margin by two very produced rounded carinæ, which are slightly nodulated towards the aperture, between which there is a very distinct and deep transverse canal; aperture subquadrate. The surface of the shell possesses very close angulated striæ.

The species is rare. I possess three examples, all of which are from the Brocastle Liassic conglomerate. It is named after my friend M. Deslongchamps, whose investigations have added much to our knowledge of Liassic Gasteropoda.

60. Trochus Langanensis, spec. nov. Pl. XVI. fig. 18.

Shell rather small, discoidal, depressed; apex rather acute; volutions 4–5, rather convex.

On the angulated margin of the shell are two depressed transverse carinæ, between which is a flattened or slightly concave area. The volutions have very fine concentric or transverse striæ. Aperture subquadrate.

This little shell is rare, and has only been found in the Lower Lias of Langan. It is readily distinguished from *T. Deslongchampsii* by its more convex volutions and its more obtuse carinæ, which become obsolete on the upper whorls. The beds of Langan, whence it comes, are on the same horizon as those of Southerndown.

61. Trochus Holwellensis, spec. nov. Pl. XVII. figs. 1, 2.

Shell turreted, conical; apex acute; spire extended, composed of ten angulated volutions; surface of the whorls ornamented by elevated oblique costæ, which are largest at the base of each whorl, and are continued upwards on its angulated surface; the costæ are decussated by three encircling striæ, which give the former a slightly nodulated character. The costæ at the base of each whorl are expanded, forming a carina over the succeeding whorl, the edge being fringed by prominent bosses from the termination of the costæ. Aperture not exposed.

This pretty species is very rare. I possess but two specimens, which are from the Liassic vein in Carboniferous Limestone at Holwell.

62. Trochus latilabrus? Stol. Pl. XVII. fig. 11.

Shell turbinated, inflated, depressed; volutions 4–5, conical, separated by a slight sulcation, the body-whorl increasing rapidly and much enlarged. The upper whorls are covered by encircling striæ, which by aid of the lens are seen to be very finely granulated. On the body-whorl of the only example I possess the striæ become almost obsolete. The base and mouth are not visible; the former is stated by Dr. Stoliczka to possess spiral furrows, and the inner portion of the lip to be a little thickened.

Loc. The Liassic vein in the Carboniferous Limestone at Holwell.

63. Trochus Elizæ, Moore. Pl. XVI. figs. 16, 17.

Shell conical; spire elevated; whorls six, rather convex; sutures slightly angulated; surface ornamented by four or five regular transverse striæ, which are decussated by faint longitudinal striæ, giving the shell a generally reticulated appearance; base discoidal, slightly convex; aperture oblique, small; columella small, slightly folded.

It is from the Liassic conglomerate of Brocastle.

64. Turbo solidus, spec. nov. Pl. XVII. fig. 18.

Shell conical, rather thick; volutions 5; base of the whorls somewhat acute, above which they are angulated to the suture. Surface of the shell smooth, with very faint curved lines of growth on the last whorl. Aperture not exposed.

This shell is from the Liassic fissure in the Carboniferous Limestone at Holwell.

65. Turbo Brocastellensis, spec. nov. Pl. XVI. 13 *a*, 13 *b*.

Shell small, turbinated, discoidal; apex obtuse; volutions 4–5; upper portion of the whorls flattened, below which the body whorl is convex or slightly angulated. Surface encircled by numerous regular striæ, very finely costated longitudinally. Aperture rounded; base not exposed.

From the coralliferous conglomerate of Brocastle, where it is rather rare.

66. Amberleya apicalis, spec. nov. Pl. XVI. figs. 7, 8, 9, 10.

Shell turreted, fusiform, elongated; spire tapering; apex very acute; volutions 9–10, angulated, their surfaces ornamented by three encircling nodulated carinæ, the tubercles on the first and second being tooth-like and depressed, the latter, which occupies the centre of the whorl, being most elevated; the third is formed of small rounded tubercles immediately at the base of the whorl, just above and slightly projecting beyond the suture; springing from the tubercles are very fine reflected bifurcating striæ; aperture lengthened, ovate.

The figures 9, 10 appear to be younger forms of this species, in which state the nodulations on the carinæ are very prominent and almost spinose, and, like some others of the group ranged under *Amberleya*, possess mouths less longitudinally ovate than in the more adult specimens.

Of this pretty species I possess several examples from the Liassic coralliferous conglomerate of Brocastle; but, like most other shells of any size, they are partly concealed by the matrix.

67. Amberleya grandis, spec. nov. Pl. XVI. fig. 6.

Shell pyramidal; spire extended, composed of 6-7 deep, convex, regularly increasing volutions; surface richly ornamented with seven or eight transverse nodular striæ, the three lowest being most elevated; crossing the transverse striæ and between their channelled interspaces are numerous faint longitudinal striæ, which give the surface a somewhat crenulated aspect. The whorls are winding, and separated by a deep suture. Aperture not visible.

We possess three examples of this shell on the same block, but they are partly concealed by the matrix, or imperfect. They are from the Brocastle Liassic conglomerate.

68. Turbo nodulo-carinata, spec. nov. Pl. XVII. figs. 16, 17.

Shell rather small, turreted; apex acute; spire produced; whorls 5, convexly angulated, and separated by a well-marked angular suture. The middle of the upper whorls is crossed by two depressed nodulated carinæ, which increase in number on the body-whorl; they are decussated by numerous oblique longitudinal striæ, which give the shell a very ornate appearance.

It is rare, and found hitherto only on the surface of the block extracted from the Liassic fissure in the Carboniferous Limestone of Holwell.

69. Turbo reticulatus, spec. nov. Pl. XVI. figs. 11, 12.

Shell turbinated; spire rather elevated; apex acute; whorls 4–5, convex, the lower rather inflated, and ornamented by prominent transverse striations, which are decussated by others longitudinally, giving the surface a reticulated aspect. Sutures distinct.

This is a very pretty species; but in the only example I have, the lower part of the body-whorl is concealed.

From the coralliferous conglomerate of Brocastle.

70. Turbo tumidus, spec. nov. Pl. XVI. fig. 14.

Shell turbinated, rather small, convex; spire and apex obtuse; whorls 4, with very fine transverse striæ; the body-whorl inflated and convex.

Several examples of this shell occur in the Brocastle conglomerate; and I have a specimen from the Charter-house lead-mine, 270 feet from the surface.

71. Amberleya turrita, spec. nov. Pl. III. fig. 19.

Shell small, turreted; spire elevated; apex acute; volutions 5, divided by a deep angulated suture. In the centre of each whorl there is an elevated carina with rather distant but regular nodulations, above which is an angulated area with longitudinal costæ. At the base of the whorl there is a small encircling finely nodulated rib. Columella extended; aperture large, rather ovate.

From the Brocastle conglomerate, which has yielded only one specimen.

72. Turritella Howsei, spec. nov. Pl. XIV. fig. 14.

Shell small, turreted, elongated; apex acute, volutions 9–10, spiral, slowly increasing, divided by a distinct angulated encircling suture; surface ornamented with faint transverse striæ. Aperture roundly ovate.

I possess two examples of this shell, both of which are rather abraded. They are from the Charter-house lead-mine, and belong to the Lower Lias.

73. Valvata anomala, spec. nov. Pl. XV. figs. 7, 8, 9.

Shell small; apex slightly raised, volutions narrow, convex, thickening towards the aperture, and divided by a rounded or slightly angulated suture; aperture rather ovate; lip slightly reflected over a circular deep umbilicus.

This shell is from the Liassic deposit at the bottom of the Charter-house mine, and belongs to the age of the Lower Lias. At present the species is represented by a single specimen.

I give below another species; and I possessed a more turbinated, trochoidal form, which was unfortunately lost. I possess numerous specimens of the same genus from some of the Yorkshire Carboniferous-Limestone-mines; we therefore have the interesting fact of the appearance of this freshwater genus in Liassic times, and probably in the Yorkshire mines much earlier, and its apparent absence until the deposition of the Crag and the fluviatile deposits above, which connect it with living species.

74. Valvata pygmæa, spec. nov. Pl. XV. figs. 5, 6.

Shell small, discoidal, depressed; whorls almost on the same plane, or slightly raised at the apex, rounded, and separated by a round suture; aperture rounded, umbilicus large, shallow.

This shell is very small, and I possess but one specimen of the species. It also is from the Charter-house mine, and of Liassic age. It is to be distinguished from *V. anomala* by its more depressed form, and by its more circular aperture.

75. Vertigo Murchisonæ, spec. nov. Pl. XV. figs. 11, 12.

Shell very small, thick, cylindrical; apex obtuse; 4–5 narrow, spirally winding, convex volutions, separated by a winding suture; surface with very faint longitudinal striæ; aperture reversed, longitudinally ovate, rather narrow; peristome continuous.

Of this terrestrial genus I possess two examples, both having been obtained 270 feet from the surface in the Liassic deposit in the Charter-House mine. They are associated with the marine and fluviatile genera previously enumerated; and their presence is no doubt due to their having been carried into the Carboniferous-Limestone fissures by the action of water derived from a terrestrial area. The genus is represented in the present day by about twelve species, my examples being the first evidence of its previous existence.

Table of Species and Localities.

	Camel.	Laleston.	Sutton Stone.	Do., Shepton.	*A.-Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter-House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Chara liassica, *Moore*	...	...	...	...	...	...	...	...	1						
Araucarites peregrinus, *Sternb.*	1	...	...	...	...	...	...	...	...	...	1				
Grantia antiqua, *Moore*	...	...	...	...	...	...	...	1							
Spongia, sp.	...	...	...	1	...	...	...	1							
Cristellaria costata, *D'Orb.*	1	...	...	...	...	...	...	...	1	1	...	...	...	1	
— crepidula, *F. & M.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
— cultrata, *Mont.*	...	...	...	...	...	...	...	...	...	1	...	...	...	1	
— lituus	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
— rotula, *Lam.*	...	...	...	...	...	...	...	...	1	1	...	...	...	1	1

	Camel.	Laleston.	Sutton Stone.	Do., Shepton.	*A.-Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter-House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Dentalina communis, *D' Orb.*	1	...	...	...	...	...	...	...	1	1	...	...	...	1	
— interrupta, *D' Orb.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
— obliqua, *Linn.*	1	...	...	...	...	...	...	...	1	1	...	...	...	1	
— ovicula, *D' Orb.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
— obliquestriata, *Reuss.*	...	...	...	...	...	...	...	...	1	1	...	...	...	1	
— pauperata, *D' Orb.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
Frondicularia complanata, *Mont.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
— striatula, *Reuss*	...	...	...	...	...	...	...	...	1	1	...	...	...	1	
Involutina liassica, *Jones*	...	...	...	...	1	...	...	...	1	1	1	...	...	1	
—, sp.	...	...	...	...	...	...	...	...	1						
Lingulina carinata, *D' Orb.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
— tenera, *Born*	1	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Marginulina lituus, *D' Orb.*	...	...	...	...	...	...	...	...	1	1	...	...	...	1	
— raphanus, *Linn.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
Nodosaria fasciæ, *Linn.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
— paucicostata, *Rœm.*	...	...	...	...	...	...	...	...	1	...	...	...	...	1	
— radicula, *Linn.*	...	...	...	...	...	...	...	...	1	1	...	...	...	1	
— raphanus, *Linn.*	...	...	...	...	...	...	...	...	...	1	...	...	...	1	
— raphanistrum, *Linn*	...	...	...	...	...	...	...	...	1	...	...	...	...	1	
— Zippei, *Rol.*	1	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Planularia Bronni, *Rœm.*	...	...	...	...	...	...	...	...	1	1	...	...	...	1	
— cornucopiæ, n. sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
— longa, *Cornuel*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
—, sp.	...	...	...	...	...	...	...	1							
Trochammina incerta, *P. & J.*	1	...	...	...	...	1	...	...	...	1	1	...	...	1	
Vaginulina legumen, *Linn.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
— lævigata, *Rœm.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
— striata, *D' Orb.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	
Astrocœnia costata, *Duncan*	...	...	...	...	...	...	...	1							
— dendroidea, *Dun.*	...	...	...	...	...	...	...	1							
— favoidea, *Dun.*	...	...	...	...	...	...	...	1							
— gibbosa, *Dun.*	...	...	1	...	...	...	...	1							
— minuta, *Dun.*	...	...	...	...	...	...	...	1							
— plana, *Dun.*	...	...	1	...	...	...	...	1							
— pedunculata, *Dun.*	...	...	...	...	...	...	...	1							
— spinigera, *Dun.*	...	...	...	...	...	...	...	1							
— reptans, *Dun.*	...	...	1	...	...	...	...	1							
— parasitica, *Dun.*	...	...	1												
Cyathocœnia dendroidea, *Dun.*	...	...	...	...	...	...	...	1							
— costata, *Dun.*	...	...	...	...	...	...	...	1							
— incrustans, *Dun.*	...	...	1												
Elysastræa Moorei, *Dun.*	...	...	1	...	...	1									
— Fisheri, *Laube*	...	...	1												
Isastræa globosa, *Dun.*	...	...	...	...	...	...	...	1							
— Sinemuriensis, *De From.*	...	...	...	...	...	...	...	1							
Latimæandra denticulata, *Dun.*	...	...	...	...	...	...	...	1							
Montlivaltia brevis, *Dun.*	...	...	...	...	...	...	...	1							
— Brodiei, *Dun.*	...	...	...	...	...	...	...	1							
— Murchisoniæ, *Dun.*	...	...	...	...	...	...	...	1							
— polymorpha, *Terq. & Piette*	...	...	1	...	...	...	...	1							
— pedunculata, *Dun.*	...	...	1	...	...	...	...	1							

	Camel.	Laleston.	Sutton Stone.	Do., Shepton.	*A.-Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter-House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Montlivaltia parasitica, *Dun.*			1												
— simplex, *Dun.*								1							
— Walliæ, *Dun.*								1							
— Sinemuriensis, *D'Orb.*			1								1				
—, sp.		1	1	1	1		1								
Rabdophyllia recondita, *Laube*			1												
Septastræa excavata, *De From.*								1							
Thecosmilia affinis, *Dun.*								1							
— dentata, *Dun.*								1							
— irregularis, *Dun.*								1							
— Michelini, *Terq. & Piette*						1	1	1		1					
— Martini, *De From.*								1							
— plana, *Dun.*								1							
— mirabilis, *Dun.*			1												
— serialis, *Dun.*			1												
— Walliæ, *Dun.*								1							
— Terquemi, *Dun.*								1							
— rugosa, *Laube*			1												
— Suttonensis, *Dun.*			1												
Apiocrinus Amalthei, *Quenst.*													1		
Cidaris Edwardsii						1		1	1	1	1	1	1	1	
Cotylederma fistulosa													1		
— vasculum, *Desh.*													1		
Cidaris, sp.	1	1		1	1	1	1	1	1	1	1	1	1	1	1
Hemipedina Bowerbankii, *Wright*	1	1							1						
Ophioderma, sp.	1	1			1	1	1	1	1	1	1	1	1	1	1
Pentacrinus tuberculatus, *Müll.*	1				1	1	1	1	1	1	1	1	1	1	1
— robustus, *Wright*													1		
Plicatocrinus Mayalis, *Desh.*													1		
Tropidaster pectinatus, *Forbes*															1
Serpula strangulata, *Terq.*						1				1				1	1
— socialis					1	1	1	1		1	1				
—, sp.					1	1		1					1	1	
Pollicipes rhomboidalis, *Moore*				1					1						
Bairdia plebeia, *Jones*								1	1						
— brevis, *Jones & Kirkby*									1						
Cythere bilobata, *Münst.*									1						
— æqualis, *Jones*, MS.									1						
— spinifera, *Jones*, MS.									1						
— fabulina ?, *Jones & Kirkby*								1	1						
— Kutorgiana, *Jones*, MS.								1							
— curva, *Jones*, MS.								1							
— intermedia, *Münst.*									1						
— ambigua, *Jones*, MS.									1						
— Thraso, *Jones*									1						
Cytherella aspera, *Jones*	1				1					1	1				
Kirkbya plicata, *Jones*									1						
Moorea tenuis, *Jones*									1						
— obesa, *Jones*, MS.								1							
Normania mundula, *Jones*	1				1					1	1				
Eryon Wilmcotensis, *Woodw.*	1														

	Camel.	Laleston.	Sutton Stone.	Do., Shepton.	*A.-Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter-House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Scapheus, spec. nov.	...	...	...	...	...	...	...	...	...	...	1				
Coleoptera, sp.	1														
Orthoptera, sp.	1														
Berenicia Archiaci, *Haime*	...	...	...	...	...	...	...	...	...	...	...	...	1		
Neuropora Haimii, *Desl.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
—, sp.	...	...	...	...	...	...	...	...	...	...	...	...	1		
—, mammillata	...	...	...	...	...	...	...	1							
—,	...	...	...	...	...	...	...	...	1						
Stomatopora, sp.	...	...	...	...	...	...	...	...	...	1					
Argyope liassina, *E. Desl.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— Perieri, *E. Desl.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— Suessei, *E. Desl.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
Crania Gumberti, *E. Desl.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— liassica	...	...	...	...	...	...	...	1	1	1					
Discina Davidsonii, *Moore*	...	...	...	1	1	1	...	...	...	...	1				
Leptæna rostrata, *E. Desl.*	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1
— Bouchardii, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1
— Davidsonii, *Bouch.*	...	...	..	...	...	...	...	...	...	...	...	...	1		
Lingula, sp.	...	...	...	...	...	...	...	1	1	1	1				
Rhynchonella concinna, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	1			
— egretta, *Desl.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— fallax, *Desl.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— furcillata, *Theod.*	...	...	...	...	...	...	...	...	...	...	...	1	1		
— rimosa, *Ziet.*	...	...	...	...	...	...	...	...	...	...	...	1	...	1	1
— variabilis, *Schloth.*	1	...	...	...	1	1	1	1	1	1	1	1	...	1	1
— subvariabilis, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	1			
Spirifera Walcottii, *Sow.*	...	...	...	...	1	...	...	...	1	1	1	1	1	1	
— oxygona, *Desl.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— Muensterii	...	...	...	...	...	...	...	...	...	...	...	1			
— Deslongchampsii, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— verrucosa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Suessia, sp.	...	...	...	...	...	...	...	...	...	...	...	...	1		
Terebratula punctata, *Sow.*	...	...	...	...	1	...	...	1	1	1	1	1	1	1	1
— Waterhousei, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	1			
Terebratulina Deslongchampsii, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
Thecidium Bouchardii, *Dav.*	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1
— granulosum, *Moore*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— Moorei, *Dav.*	...	...	...	...	...	...	...	1	1						
— rusticum, *Moore*	...	...	...	...	...	...	...	1	...	...	...	...	1		
— triangularis, *D'Orb.*	...	...	...	...	...	...	...	1	1	1	1				
Zellania Davidsonii, *Moore*	...	...	...	...	...	...	...	1	1						
— Laboucherei, *Moore*	...	...	...	...	...	...	...	...	1						
— obesa, *Moore*	...	...	...	...	...	...	...	...	...	1					
Anomia irregularis, *Terq.*	...	...	...	...	...	...	...	1	...	1	1				
— pellucida, *Terq.*	...	...	..	...	...	...	...	...	...	1	1				
Avicula Alfredi, *Terq.*	...	...	...	...	...	...	...	1	...	1					
— Buvignieri, *Terq.*	...	...	...	...	...	1	...	1							
— Dunkeri, *Terq.*	...	...	...	...	...	...	...	1	...	1					
— Deshayesii	...	...	...	...	...	...	...	1							
— decussata, *Goldf.*	1	...	...	1	1										

	Camel.	Laleston.	Sutton Stone.	Do., Shepton.	*A.-Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter-House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Avicula inæquivalvis, *Sow.*	...	...	...	...	1	...	...	...	...	1	1	1	1	1	1
— infraliassina, *Martin*	...	...	...	...	...	...	...	1	...	...	1	1			
— nuda, *Moore*	...	...	...	...	...	...	...	...	...	...	...	1			
—, sp.	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1
Gervillia acuminata, *Terq.*	...	...	...	...	...	1	...	1							
Gryphæa incurva, *Sow.*	1	...	...	1	1	1	1	1	...	1	1	1	1	1	1
— depressa, *Phillips*	...	...	...	...	...	...	...	...	...	...	...	1			
Hinnites, sp.	...	1	1	1	1	...	...	...	...	...	1				
— liassicus, *Terq.*	...	...	...	...	...	...	...	1							
Inoceramus, sp.	...	...	...	...	...	...	...	...	...	1	1				
Isodonta Engelhardti, *Terq.*	...	...	...	...	...	...	...	1							
Lima gigantea, *Sow.*	1	1	1	1	1	1	1	1	...	1	1	...	...	1	
— amœna, *Terq.*	...	...	...	...	...	...	...	1							
— dentata	...	...	...	...	...	..	...	1	...	1					
— Deslongchampsii, *Stol.*	...	...	...	...	...	...	...	...	...	...	...	1	1		
— densicosta, *Quenst.*	...	...	...	...	...	...	...	...	...	...	...	1			
— duplicata	1	...	1	1	1	1	1	...	...	1	1	...	...	1	
— Haueri, *Stol.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— Hermanni, *Voltz*	1	...	...	1	1	1	1	...	...	1	1	...	...	1	
— Hettangiensis, *Terq.*	...	...	...	...	...	...	...	...	...	1					
— scrobiculata, *Quenst.*	...	...	...	...	...	...	...	...	...	...	...	1			
— tuberculata, *Terq.*	1	1	1	1	1	...	...	1	...	1	1				
— punctata, *Sow.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
Ostrea arietis, *Quenst.*	1	1	1	1	1	...	...	1	...	1	1				
— intusstriata, *Em.*	1	1	1	1	1	...	...	1	...	1	1				
— irregularis	1	...	1	1	1	1	1	1	..	1	1				
— liassica	1	1	1	1	1	1	1	1	...	1	1	...	...	1	
— monoptera, *Desl.*	...	...	...	...	...	...	...	...	...	...	1	...	1		
— ocreata, *Desl.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
Pecten æquiplicatus, *Terq.*	...	...	...	...	...	...	...	...	...	1					
— palosus, *Stol.*	...	...	...	...	...	...	...	...	...	...	...	1			
— Pollux, *D'Orb.*	1	...	1	1	1	...	...	1	...	1	1				
— sublævis, *Phil.*	1	1	...	1	1	1	1	1	...	1	1	1	...	1	
— verticillus, *Stol.*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— Etheridgei, *Taw.*	...	...	1	1											
— textorius, *Schloth.*	...	...	...	...	...	...	.	...	...	...	...	...	1		
— Thiollieri, *Martin*	...	...	...	...	...	1									
— Whatleyensis, *Moore*	...	...	...	...	...	...	...	...	...	...	...	...	1		
—, sp.	...	...	...	...	...	...	...	1	...	...	...	...	1		
— dispar ?	...	...	...	...	...	1									
— Rollei, *Stol.*	...	...	...	...	...	...	...	...	...	..	...	1			
Placunopsis	...	...	...	...	...	...	...	1	...	...	...	1			
Pinna folium, *Phil.*	...	...	...	...	...	...	1	...	...	..	1				
— semistriata, *Terq.*	...	1	1	1	1	1	1	...	...	1	1				
Plicatula Hettangiensis, *Terq.*	1	...	...	...	1	1	...	1	...	...	1				
— acuminata	...	1	1	1											
— pellucida, *Terq.*	...	...	...	...	...	...	...	...	...	1					
— spinosa, *Sow.*	...	...	...	...	...	...	...	...	1	...	...	...	1	...	1
— sarcinula, *Goldf.*	...	...	...	...	...	...	...	1	..	...	...	1	...	1	1
— Baylii, *Terq.*	...	...	...	...	...	...	...	1							
Spondylus liassicus, *Terq.*	...	...	...	...	1										

	Camel.	Laleston.	Sutton Stone.	Do., Shepton.	A.-*Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter-House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Arca Collenoti, *Martin*															
— pulla, *Terq.*	...	1	...	...	...	1	1	1	...	...	1				
— Sinemuriensis, *Martin*	...	...	...	...	...	...	...	1							
Astarte cingulata, *Terq.*	...	1	1	...	...	1	...	1							
— exigua, *Terq.*	...	...	...	...	...	...	...	1							
— acuta, *Moore*	...	...	...	...	...	...	...	...	...	...	...	...	1		
— psilonoti, *Quenst.*	...	...	...	...	...	...	...	...	...	1					
— irregularis, *Terq.*	...	...	...	...	...	...	...	...	...	1					
Cardinia elongata, *Stutch.*	...	...	...	...	1	1	...	1							
— exigua, *Terq.*	...	...	...	...	...	...	...	...	...	1					
— Listeri, *Sow.*	...	1	...	...	1	...	...	1	...	...	1				
— Morisi, *Terq.*	...	...	...	...	...	...	...	1							
— Moreana, *Martin*	...	...	1												
— sublamellosus, *Martin*	...	...	...	...	...	...	1								
Cardita tetragona, *Terq.*	...	...	1	...	...	...	1	1							
— Heberti, *Terq.*	...	1	...	...	1	...	1	1	...	1					
Cardium Heberti, *Terq.*	...	...	...	...	...	...	...	...	...	1					
— Phillppianum, *Terq.*	...	...	...	...	...	...	...	...	...	1					
— Terquemi, *Martin*	...	...	...	...	...	...	...	1	...	1					
Cucullæa Hettangiensis, *Terq.*	...	1	...	...	...	...	1	1	...	1					
— similis, *Terq.*	...	1	...	...	...	1	...	1	...	...	1				
Cypricardia Bronni, *Martin*	...	...	...	...	...	...	...	...	...	1					
— compressa, *Terq.*	...	...	1	...	...	1									
—, sp.	...	...	...	...	...	...	...	1							
— inclusa	...	...	...	...	...	...	...	1							
— Winwoodii, *Moore*	...	...	1												
Gastrochæna liasina, *Terq.*	...	...	...	...	...	...	...	1							
Leda Heberti, *Martin*	...	...	...	...	...	...	1	...	1	1					
Lithodomus arenicola?, *Terq.*	...	...	1	...	...	1	1	1	1	1	1	1			
Lucina arenicola, *Terq.*	...	...	...	...	...	1									
Modiola producta, *Terq.*	...	1	...	1	1	1	...	...	...	...	1				
— minima, *Sow.*	1	1	...	...	...	1	...	...	...	1					
— Hillana, *Sow.*	...	...	...	1	1										
Mytilus arenicola, *Terq.*	...	...	...	...	...	...	...	1							
— lamellosus, *Terq.*	...	...	...	...	...	...	...	1							
— liassicus, *Terq.*	...	...	...	...	...	...	...	1							
— Simoni, *Terq.*	...	...	...	...	...	...	...	1							
— Sinemuriensis, *Martin*	...	...	...	...	...	...	...	1							
Myacites, sp.	...	...	...	...	1	...	...	...	...	1	1				
Nucula, sp.	...	...	...	...	...	1	1	...	1	1	1				
Mya, sp.	1	...	...	...	...	...	...	...	...	1					
—, sp.	1	...	...	...	...	...	...	...	...	1					
Opis triangularis, *Moore*	...	...	...	...	...	...	...	...	...	...	...	1			
—, sp.	...	...	...	...	...	...	...	...	1						
Pholadomya ambigua, *Sow.*	...	...	...	...	1	...	1	...	...	1	1	...	...	1	
— arenacea, *Terq.*	...	...	...	...	...	...	...	1							
Saxicava Sinemuriensis, *Martin*	...	...	...	...	...	...	...	...	...	1					
— arenicola, *Terq.*	...	...	...	...	...	...	...	...	...	1					
— Bronni, *Martin*	...	...	...	...	...	...	...	1							
Tancredia securiformis, *Terq.*	...	...	...	...	...	...	...	1	...	1					
— tenera, *Terq.*	...	...	...	...	...	1									

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Unicardium cardioides, *Phil.*	1				1					1	1				
Actæon angulifer, *Martin*							1								
— Simemuriensis, *Martin*										1					
Alaria rudis, *Moore*								1							
— fusiformis, *Moore*								1							
Amberleya Alpinus, *Stol.*												1			
— apicalis, *Moore*								1							
— grandis, *Moore*								1							
— turrita, *Moore*								1							
Ampullaria carinata, *Terq.*		1													
— planulata, *Terq.*		1						1							
— angulata, *Desl.*							1								
Cerithium acuticostum, *Terq.*							1	1		1					
— Collenoti, *Martin*										1	1				
— Dumortieri, *Martin*							1								
— Henrici, *Terq.*							1			1					
— gratum, *Terq.*							1	1	1	1	1				
— Jobæ, *Terq.*								1							
— nodulosum, *Moore*					1	1									
— pellucidum, *Moore*								1							
— pentacostæ, *Moore*								1							
— planicostatum, *Moore*								1							
— paludinare, *Terq.*					1		1	1	1	1					
— porulosum, *Terq.*							1								
— pupa, *Martin*								1							
— rotundatum															
— Semele, *D' Orb.*						1	1	1	1	1	1				
— spiratum, *Moore*								1							
— Sinemuriensis, *Martin*								1		1					
— trinodulosum, *Martin*										1	1				
— verrucosum						1									
Chemnitzia Oppeli, *Martin*								1							
— polita, *Martin*								1		1	1				
Chiton bilobatum, *Desl.*													1		
— radiatum, *Moore*								1	1						
Delphinula nuda, *Moore*												1			
— reflexilabrum, *Horne*												1			
Dentalium, sp.					1	1	1	1		1					
Fusus Jenynsii, *Moore*								1							
— Terquemi, *Moore*								1							
Helix Dawsoni, *Moore*									1						
Hydrobia, sp.									1						
Littorina circularis, *Moore*								1							
— ovalis, *Moore*								1							
— clathrata					1	1					1				
Melania acuta, *Moore*								1							
— abbreviata, *Terq.*		1	1	1				1	1	1	1				
— crassilabrata, *Terq.*						1									
— dubia (Pterocera), *Terq.*		1		1				1							
— nodulo-carinata, *Moore*						1									
— Dunravenensis, *Moore*						1									

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Melania Dunravenensis, *Moore*					1	1	1				1				
— Theodori, *Martin*						1									
— usta, *Terq.*								1							
Nerinæa acuminata, *Moore*								1							
— Horneri, *Moore*												1			
— Mendipensis, *Moore*									1						
— rudis, *Moore*								1							
Neritina arenacea, *Terq.*								1							
— canalis, *Terq.*								1							
— Hettangiensis, *Terq.*						1									
Neritopsis exigua, *Terq.*		1	1					1							
— cancellatus, *Moore*								1							
— lævis, *Stol.*												1			
Orthotoma avena, *Terq.*							1	1							
— frumentum, *Terq.*								1	1						
— oryza, *Terq.*								1		1					
— triticum, *Terq.*									1	1					
—, sp.										1					
Patella ornata, *Moore*			1					1							
— Dunkeri, *Terq.*			1					1							
— Schmidti, *Terq.*								1							
Phasianella liasina, *Terq.*								1		1					
— turbinata, *Stol.*												1			
— nana, *Terq.*								1							
Planorbis Mendipensis, *Moore*									1						
Proserpina Lyelli, *Moore*									1						
Pterocheilos primus, *Moore*								1							
Pleuratella primus, *Moore*								1							
Pleurotomaria concava, *Martin*							1								
— anglica, *Sow.*											1			1	
— expansa, *Sow.*					1				1	1	1			1	
— Mendipensis, *Moore*								1							
— densa, *Terq.*					1										
— Hettangiensis, *Terq.*				1											
— Buchi, *Desl.*												1			
— Mozellanus, *Terq.*						1									
— nucleus, *Terq.*										1					
— Hennocquii, *Terq.*										1					
— Henrici, *Martin*								1							
— lens, *Terq.*								1							
— rotelliformis, *Dunk.*								1							
— trocheata, *Terq.*											1				
Purpurina tricarinata, *Martin*										1					
Pyrula liassica, *Moore*								1							
Rimula elegans, *Moore*								1							
— liasina, *Terq.*								1							
—, sp.									1						
Solarium lunatum, *Moore*												1			
— lenticulare, *Terq.*					1			1	1						
Discohelix cornucopiæ, *Moore*								1							
— fimbriatus, *Moore*								1							

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Straparollus Oppeli, *Martin*	...	...	...	...	...	...	...	1	1						
— tricarinatus, *Terq.*	...	...	...	...	...	...	...	...	1	1					
Trochotoma Brocastellensis, *Moore*	...	...	...	...	...	...	...	1							
— Lycettii, *Moore*	...	...	...	...	...	...	...	1							
Trochus apicalis, *Moore*	...	...	...	...	...	...	...	1							
— Deslongchampsii, *Moore*	...	...	...	...	...	...	...	1							
— epulus, *Stol.*	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1
— gradatus, *Moore*	...	...	...	...	...	...	...	...	...	...	...	1			
— Juliani, *Terq.*	...	...	...	...	...	1									
— Langanensis, *Moore*	...	...	...	...	...	1									
— nitidus, *Terq.*	...	...	...	...	...	...	...	1							
— latilabrus, *Stol.*	...	...	...	...	...	...	...	...	...	...	...	1			
— Elizæ, *Moore*	...	...	...	...	...	...	...	1							
— Holwellensis, *Moore*	...	...	...	...	...	...	...	...	...	...	...	1			
— tubicola, *Terq.*	...	...	...	...	...	...	...	...	...	1					
— Piettei, *Martin*	...	...	...	...	...	...	...	...	...	...	1				
— sinistrorsus	...	...	1												
Turbo solidus, *Moore*	...	...	...	...	...	...	...	...	...	...	...	1			
— apicalis, *Moore*	...	...	...	...	...	...	...	1							
— Brocastellensis, *Moore*	...	...	...	...	...	...	...	1							
— costellatus, *Terq.*	...	...	...	...	...	...	...	1	...	1					
— gemmatus, *Terq.*	...	...	...	...	...	...	...	1	...	1					
— liassicus, *Martin*	...	...	...	...	...	1	...	...	...	1	1				
— nodulo-carinatus, *Moore*	...	...	...	...	...	...	...	...	...	...	...	1			
— nanus, *Martin*	...	...	...	...	...	...	...	...		1					
— Orion, *D' Orb.*	...	...	...	...	...	...	...	...	...	...	...	1			
— striatus	...	...	...	...	...	...	...	1							
— reticulatus *Moore*	...	...	...	...	...	...	...	1							
— tumidus, *Moore*	...	...	...	...	...	...	...	1							
— triplicatus, *Martin*	...	...	...	...	...	...	1								
— Pietii, *Martin*	...	...	...	...	...	...	...	1	1	1					
— Martini, *Terq.*	...	...	...	...	...	...	...	...	1						
Tornatella Buvignieri, *Terq.*	...	...	...	...	...	...	1	1							
— secale	...	...	...	...	...	...	...	1							
Turritella Dunkeri	...	...	...	...	...	1									
— Deshayesi, *Terq.*	...	...	...	...	1	1	1								
— Howsei, *Moore*	...	...	...	...	...	...	...	1	1						
— Humberti, *Martin*	...	...	...	...	...	1	1	...	1	1	1				
— Jenkeni, *Terq.*	...	...	...	1	...	1	1	...	...	1					
Valvata anomala, *Moore*	...	...	...	...	...	...	...	...	1						
— pygmæa, *Moore*	...	...	...	...	...	...	...	...	1						
Vertigo Murchisonæ, *Moore*	...	...	...	...	...	...	...	...	1						
Ammonites planorbis, *Sow.*	1	1	...	...	...	...	...	...	...	1					
— Johnstoni	1	...	1	...	1	1									
— angulatus	1	...	1	...	1	1	1	...	...	1	1	...	...	1	
— Bucklandi, *Sow.*	...	...	...	1	1	1	1	...	...	1	1	...	...	1	
— Conybeari, *Sow.*	...	...	...	1	1	...	...	...	...	1	1	...	...	1	
— Sauzianus, *D' Orb.*	...	...	...	...	...	1	1								
— semicostatus	...	...	...	...	...	1	1	...	...	...	...	...	...	1	
— Turneri, *Sow.*	...	...	...	...	...	...	...	...	...	...	1	...	...	1	
— obtusus	...	...	...	1	1										

	Camel.	Laleston.	Sutton Stone.	Do., Shepton.	*A.-Bucklandi*, do.	Southerndown, do.	Bridgend.	Brocastle.	Charter-House.	Stout's Hill.	Weston, Saltford.	Holwell.	Whatley.	Camerton.	Munger.
Ammonites, young form	...	...	...	...	...	1	1	1	1	1	1				
Belemnites acutus, *Mill.*	...	...	...	...	...	1	1	...	1	1	1	...	1	1	1
— clavatus	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1
— elongatus ?, *Mill.*	...	...	...	...	...	1									
Nautilus striatus, *Sow.*	1	...	...	...	1	...	...	...	...	...	1				
— intermedius, *Sow.*	1	...	...	...	1	...	...	...	...	1	1	...	...	1	
—, young sp.	...	...	...	...	...	...	...	1							
Geoteuthis	...	...	...	...	...	...	...	...	...	...	1				
Fish-remains of many species															
Ichthyosaurus platyodon															
Plesiosaurus rugosus															

EXPLANATION OF PLATES XIV.–XVII.

(*Illustrative of Fossils from the Lower Lias.*)

Plate XIV.

Fig. 1. *Pleuratella prima*, spec. nov.: front view, enlarged.
2. —— ——: back view, enlarged.
3. —— ——: upper surface, enlarged.
4. *Pterocheilos primus*, spec. nov.: front view.
5. —— ——: back view.
6. *Fusus Jenynsii*, spec. nov.: back view.
7. —— ——: front view.
8. —— *Terquemi*, spec. nov.: front view.
9. *Cerithium nodulosum*, spec. nov.: natural size.
10. —— *planicostatum*, spec. nov.; front view.
11. —— *pellucidum*, spec. nov.
12. —— *spiratum*, spec. nov.: front view.
13. —— *pentacostæ*, spec. nov.: front view.
14. *Turritella Howsei*, spec. nov.: front view.
15. *Littorina circularis*, spec. nov.; front view.
16. —— ——: back view.
17. —— *ovalis*, spec. nov.: back view.
18. —— ——: front view.
19. *Melania Dunravenensis*, spec. nov.: front view.
20. —— *acuta*, spec. nov.: front view.
21. —— ——: back view.
22. *Nerinæa acuminata*, spec. nov.: front view.
23. —— *rudis*, spec. nov.: back view.
24. *Alaria rudis*, spec. nov.: front view.
25. —— *fusiformis*, spec. nov.: back view.

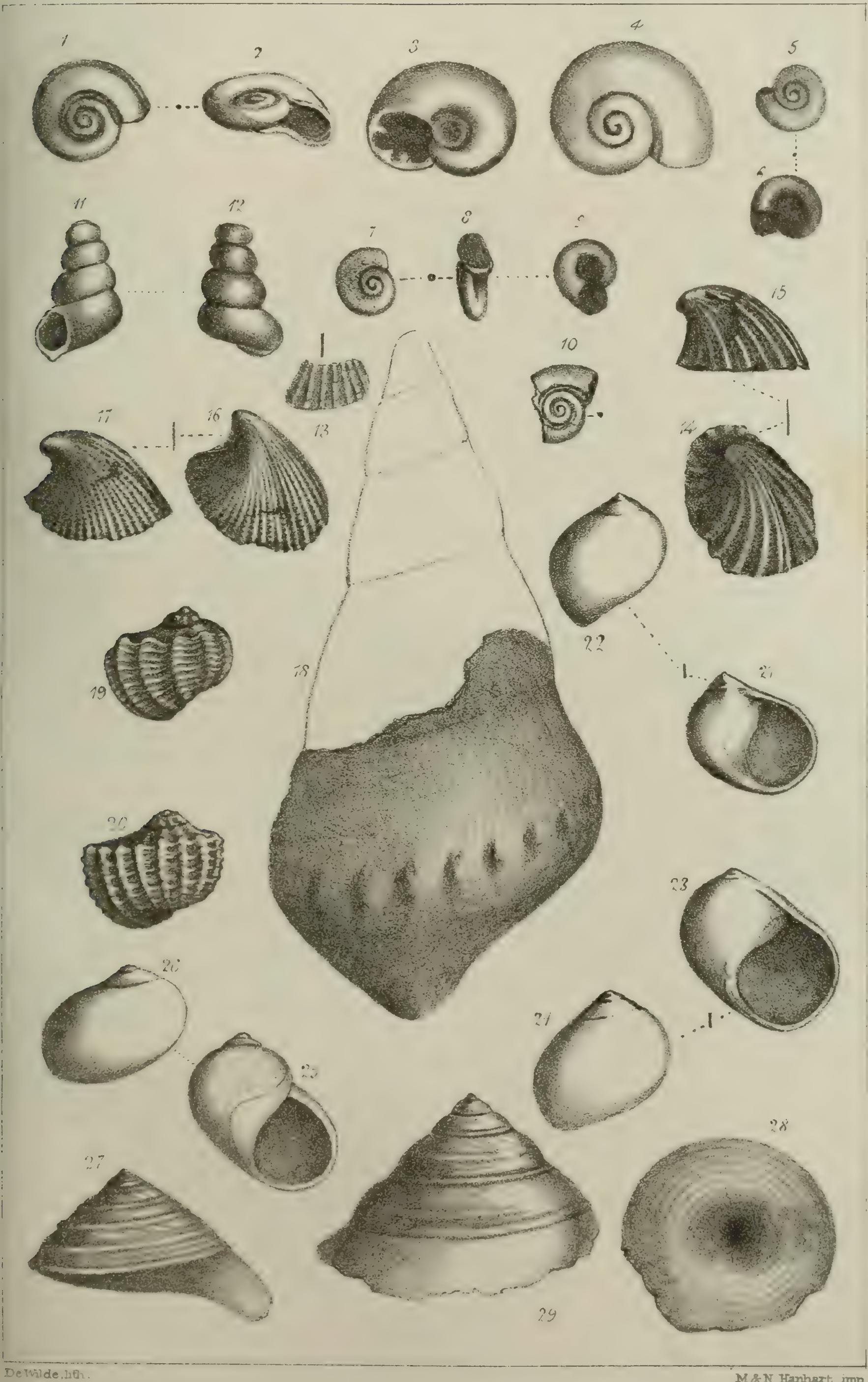
Plate XV.

1. *Helix Dawsoni*, spec. nov.: upper surface, enlarged.
2. —— ——: profile, enlarged.
3. *Proserpina Lyelli*, spec. nov.: base, showing aperture and teeth on lip, much enlarged.
4. —— ——: upper surface, much enlarged.

De Wilde lith.

M & N Hanhart imp.

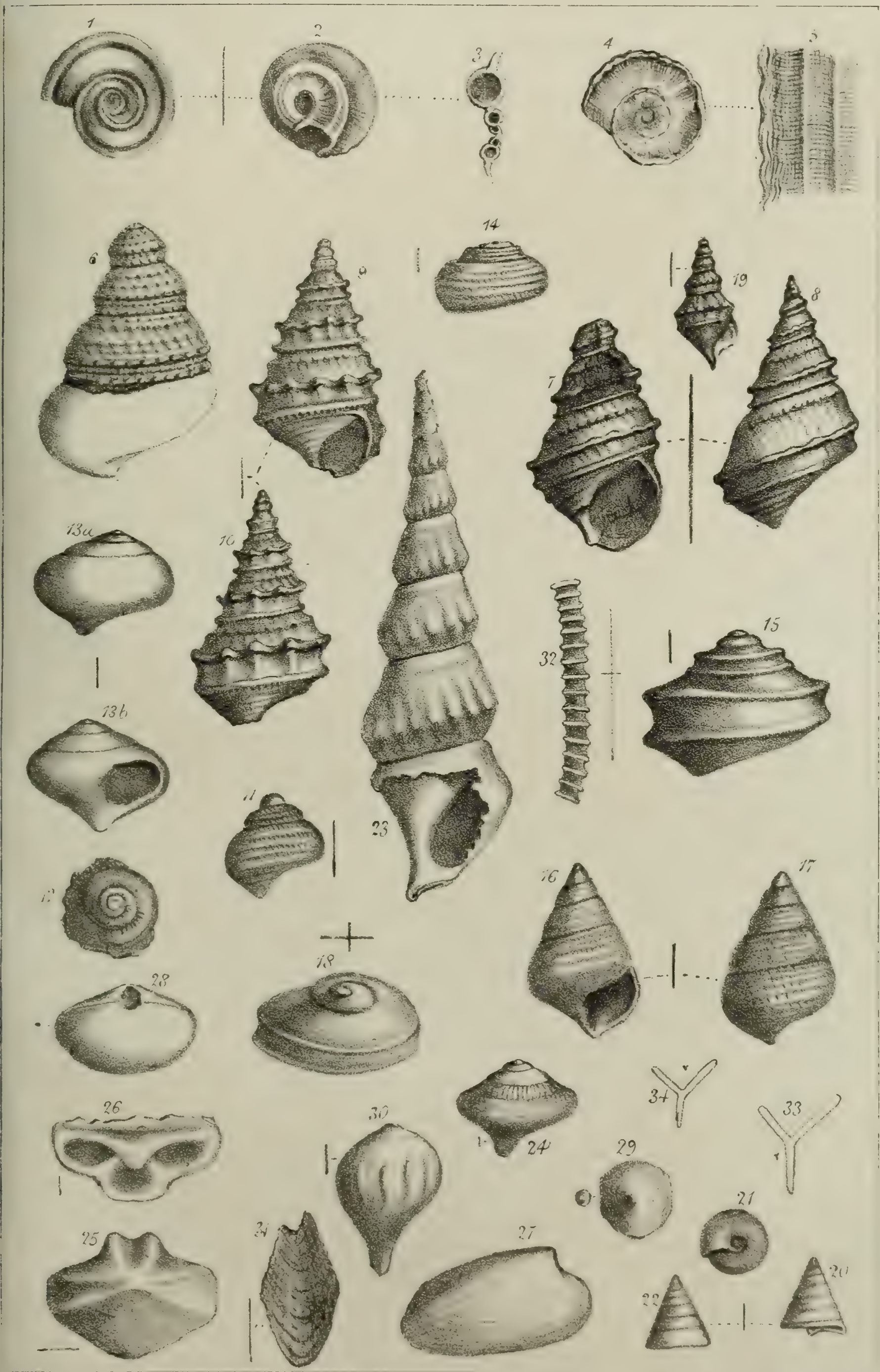
FOSSILS FROM THE LOWER LIAS.



De Wilde, lith.

M & N Hanhart imp

FOSSILS FROM THE LOWER LIAS



De Wilde lith.

M & N. Hanhart imp

FOSSILS FROM THE LOWER LIAS

5. *Valvata pygmæa*, spec. nov.; upper surface.
6. —— ——: under surface.
7. —— *anomala*, spec. nov.: upper surface.
8. —— ——: profile.
9. —— ——: under surface.
10. *Planorbis Mendipensis*, spec. nov.: upper surface.
11. *Vertigo Murchisoniæ*, spec. nov.: front view.
12. —— ——: back view.
13. *Patella ornata*, spec. nov.
14. *Rimula liasina*, Terq.: upper surface.
15. —— ——: side view.
16. —— *elegans*, spec. nov.: upper surface.
17. —— ——: side view.
18. *Melania nodulo-carinata*, spec. nov.: back view.
19. *Neritopsis exigua*, Terq.: back view.
20. —— *cancellatus*, spec. nov.: back view.
21. *Neritina canalis*, Terq., front view.
22. —— ——: back view.
23. —— *arenacea*, Terq.: front view.
24. —— ——: back view.
25. —— *Hettangiensis*, Terq.: front view.
26. —— ——: back view.
27. *Trochotoma Lycettii*, spec, nov.: front view.
28. —— ——: base view.
29. —— *Brocastellensis*, spec. nov.: back view.

Plate XVI.

Fig. 1. *Discohelix cornucopiæ*, spec. nov.: upper surface.
2. —— ——: base, showing umbilicus, aperture, and winged area.
3. —— ——: section of chambers.
4. —— *fimbriatus*, spec. nov.: upper surface.
5. —— ——: view of back.
6. *Amberleya grandis*, spec. nov.: back view.
7. —— *apicalis*, spec. nov.: front view.
8. —— ——: back view.
9. —— ——: front view of young age, enlarged.
10. —— ——: back view of young age, enlarged.
11. *Turbo reticulatus*, spec. nov.: back view.
12. —— ——: top view.
13. —— *Brocastellensis*, spec. nov.: top view.
14. —— *tumidus*, spec. nov.: top view.
15. *Trochus Deslongchampsii*, spec. nov.: back view.
16. —— *Mariæ*, spec. nov.: front view.
17. —— ——: back view.
18. —— *Langanensis*, spec. nov.: upper view.
19. *Amberleya turrita*, spec. nov.
20. *Trochus apicalis*, spec. nov.
21. —— ——: view of base.
22. —— ——: back view.
23. *Cerithium verrucosum*, Terq.: front view.
24. *Pleurotomaria Mendipensis*, spec. nov.: back view.
25. *Chiton radiatum*, spec. nov.: dorsal surface.
26. —— ——: under side.
27. *Cypricardia Winwoodii*, spec. nov.: dorsal surface.
28. *Zellania obesa*, spec. nov.
29. *Discina Davidsoni*, spec. nov.: upper surface.
30. *Pyrula liassica*: back view.
31. *Pollicipes rhomboidalis*, under side.
32. *Serpula strangulata*, Terq.
33. *Grantia antiqua*, spec. nov.
34. —— ——.

PLATE XVII.

(*The species figured in this plate have all been obtained from Holwell.*)

Fig. 1. *Trochus Holwellensis*, spec. nov.: back view.
2. —— ——: base, enlarged.
3. *Neritopsis lævis*, Stol.: front view.
4. —— ——: top view.
5. *Trochus gradatus*, spec. nov.: enlarged.
6. *Phasianella turbinata*, Stol.: back view.
7. *Amberleya alpina*, Stol.: front view.
8. *Delphinula reflexilabrum*, Horne: front view.
9. —— ——: top view.
10. —— *nuda*, spec. nov.: back view.
11. *Trochus latilabrus?*, Stol.: back view.
12. *Nerinæa Horneri*, spec. nov.: front view.
13. *Pleurotomaria Buchi*, Desl.: front view.
14. —— ——: surface view.
15. *Solarium lunatum*, spec. nov.: top view.
16. *Turbo nodulo-carinatus*, spec. nov.: back view.
17. —— ——: front view.
18. —— *solidus*, spec. nov.: front view.
19. *Avicula nuda*, spec. nov.
20. *Opis triangularis*, spec. nov.: dorsal surface.
21. *Lima Deslongchampsi*, Stol.
22. —— *scrobiculata*, Stol.
23. —— *densicostata*, Quenst.
24. —— ——.
25. *Pecten Rollei*, Stol.
26. —— *verticillus*, Stol.
27. —— *palosus*, Stol.

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2. *On the* PHYSICAL STRUCTURE *of* WEST SOMERSET *and* NORTH DEVON, *and on the* PALÆONTOLOGICAL VALUE *of the* DEVONIAN FOSSILS. By ROBERT ETHERIDGE, Esq., F.G.S., F.R.S.E., Palæontologist to the Geological Survey of Great Britain.

CONTENTS.

De Wilde, lith.

M & N Hanhart imp

FOSSILS FROM THE LIAS OF HOLWELL

I. Introduction.

It seems almost superfluous that another paper should be written upon the structure and succession of the Rocks of "West Somerset and North Devon;" but of late their position or place in the geological series has been questioned in an able paper by Professor Jukes*, in which he endeavoured to prove that the entire series of slates, sandstones, and limestones of the North Devon and West Somerset area belong partly to the Old Red Sandstone and partly to the Carboniferous rocks, rather than to the so-called Devonian Group, to which they have hitherto been considered to belong. In other words, Professor Jukes has propounded views as to the relative succession and physical structure of North Devon diametrically opposed to those held by most geologists, and based upon the investigations of Sir Roderick Murchison and Professor Sedgwick, Professor John Phillips, De La Beche, Weaver, and others; and he distinctly states that they have "all misunderstood the structure of the country," and this arising chiefly from their having been previously unacquainted with the structure and succession of the lower members of the Carboniferous group of rocks, and with the upper series of the Old Red Sandstone, as shown in the South of Ireland (*the Irish Old Red Sandstone*).

Professor Jukes also disputes the *reality* of the "time" succession (not the apparent) of the rock-groups of North Devon, *i. e.* those grits, slates, and sandstones which occur (in the Lynton area) from Lynton or the Foreland, on the north, to the base of the Pickwell Down or Morte sandstones, on the south, or more extendedly to Barnstaple, which is the extreme southern part of the North Devon

* Quart. Journ. Geol. Soc. vol. xxii. p. 321. August 1866.

group under examination. This area is occupied by varied rock masses (three well-defined groups), consisting at the base of red sandstone and slates with gritty and subcalcareous bands, which form the Lynton or Lower Devonian series; succeeding these are red sandstones and slates, well-defined calcareous masses, and bands of limestone, which constitute the Middle Devonian or Ilfracombe group; these are surmounted by a thick zone of red sandstones (the Upper Old Red), which are again overlain by a great series of slaty subcrystalline arenaceous limestones and shales, brown sandstones and grits, which constitute (with the red sandstones below) the Upper Old Red Sandstone or Upper Devonian Series, partly the equivalents of those beds which occur in the Cork district, and termed by the Irish geologists Carboniferous Slate, Coomhola Grits, and *Old Red Sandstone*. It will be my object to endeavour to show that this succession in North Devon and West Somerset is one unbroken and continuous series, existing in both districts, and proved by physical as well as palæontological data. It will also be my endeavour to prove that the hypothetical fault which Professor Jukes has stated to range from Morte Bay on the west to Wiveliscombe and the Quantock Hills on the east has no existence through the centre of North Devon,—and also to show that there is no evidence of a concealed anticlinal (of the nature demanded) with a northern inversion, through the agency of which, and the concealed fault with a supposed northerly downthrow of some 4000 or 5000 feet, we are asked to believe that the Lynton sandstones, grits, and slates, and the Middle or Ilfracombe Series in the north part of the county, are upon the same general horizon as those (similar, not identical) rock-masses comprising the structure of Baggy Point, Marwood, Sloly, Croyde, Braunton, Pilton, &c., on the south, and *above* the Pickwell Sandstones. From these views I entirely dissent on the grounds above stated; and a careful examination of the West Somerset and North Devon areas during the past autumn (1866) now enables me to lay before the Society the results of that investigation.

II. History and Literature.

It is necessary to my purpose that a condensed history of the literature of the Devonian Rocks, with their groupings &c., should be understood, and that our British series, with their continental equivalents and their correlation generally, should be paralleled; we shall thus be enabled to trace the history of the question, and aided in coordinating the views held by those geologists and palæontologists who have, both in this country and on the Continent, since the year 1837, adopted the nomenclature proposed by Murchison and Sedgwick in their elaborate memoir upon "the Physical Structure of North Devon and the Rhenish Provinces"*, in which they endeavoured to assign a position and sequence to those slates, sandstones, and limestones which are so conspicuously and extensively developed in North and South Devon and Cornwall. Their views

* Geol. Trans. vol. v. 1840; and Proceedings, vol. iii. 1839.

were ably substantiated by Mr. Lonsdale, by his careful investigation of the fossils, to which he assigned an intermediate and distinct position (to the corals, &c.), showing, with the authors of that memoir, that the stratified rock-masses of that extensive area and their fossil contents hold a position, physically and palæontologically, between the great mass of the Silurian deposits, already definitely determined, and those of the Carboniferous series succeeding them, which are developed on a grand and extensive scale in the culm-trough that occupies the region between Barnstaple, in North Devon, on the north, and Brocastle and Petherwin, in North Cornwall, on the south.

1836. *Sedgwick and Murchison.*—These authors, in a communication to the British Association*, were the first to accurately determine the place of the carbonaceous deposits of North and Central Devon, which had previously been classed with the lowest portions of the Grauwacke; they described the structure of the county in ascending order, and divided the whole series into five groups; they, however, then misunderstood the group of rocks that repose upon the Morte slates and sandstones in North Devon, referring the Upper Devonian or Barnstaple series to the Silurian system, and placing the Carboniferous upon them, which in stratigraphical succession was correct, the *underlying* group being referred to a *wrong* age. In 1839 this error was corrected†.

1837. *Williams, Rev. D., F.G.S.*‡—A section accompanies this paper, giving the author's views of the general succession of the rock-masses of West Somerset and North Devon, in which he places the Cannington-Park Limestone at the base, and below the Foreland and Dunkery sandstones, and Lynton slates; he divides the rocks into nine groups in ascending order—the carbonaceous strata and their flora being erroneously placed below the Old Red Sandstone and the Carboniferous Limestone.

1837. *Austen.*—R. Godwin-Austen, Esq., in a masterly paper "On the Geology of the South-east of Devonshire"§, discussed the structure of the rock-masses of that area generally, and, after describing the succession of the Tertiary deposits and Secondary formations, also noticed the culmiferous or Carboniferous series, its position and succession, and then remarked upon the Transition System (then so called), believing that the culm-measures rested unconformably upon them. He divided this series into five groups, also noticing the igneous and trap rocks.

1838. *Weaver.*—Thomas Weaver, Esq., communicated to the Geological Society an important paper on the "Geological Relations of North Devon"||, in which he describes the structure of that area, from Bideford, on the south, to the Foreland, east of Lynton, on the

* Report, 1836.

† "On some fossil wood, &c., low down in the Grauwacke of Devon, &c."

‡ I do not purpose commenting upon the views held by any of the older authors in this notice of the History of the Devonian Rocks.

§ Proc. Geol. Soc. vol. ii. 1833–38, p. 584.

|| Proc. Geol. Soc. 1838, vol. ii. p. 589.

north, and employed a nomenclature derived from those localities where the strata were best developed or exhibited, in ascending order, from the Foreland to the culmiferous beds south of Barnstaple; he believed the whole series to be connected and to pass from one to the other, showing one general sequence with a southern dip. The term "transition" was adopted by him for the rocks subsequently called "Devonian." This paper was a valuable contribution to the then state of our knowledge upon this area.

1838. *Austen.*—Mr. Godwin-Austen, in another paper, "On the origin of the Limestones of Devonshire"*, clearly showed their origin to be due to the laws of organic life, and drew comparisons between them and the modern coral-reefs. The localities and facts mentioned are important as bearing upon the question of the Middle Devonian limestone.

1839. *Williams.*—The Rev. D. Williams communicated to the Geological Society his paper upon the "Transition or Grauwacke System as exposed in the Counties of Somerset, Devon, and Cornwall"†. This was also a valuable paper, and a correction of former views held by him. The upper members of the North Devon Rocks are the only series commented upon, the lower rocks being reserved for a subsequent notice.

1839. *Sedgwick* and *Murchison.*—"Classification of the Older Rocks of Devon and Cornwall"‡. The rocks of North Devon and Cornwall are described in this paper in descending order in four groups; and a nomenclature is proposed differing from that formerly propounded at the meeting of the British Association held at Bristol in 1836. They held that the succession of the rocks in North Devon was complete and conformable, from the carbonaceous series to those of Baggy and Marwood, which succeed them, and thence to the Ilfracombe and Lynton beds below; and they associated the Quantock series with the oldest or Lynton slates and sandstones. The authors showed the same succession for South Devon and North Cornwall; they also proposed to substitute the term "Devonian" for "Old Red Sandstone," as suggested by Mr. Lonsdale, after his examination of the fossil contents of the slates and limestones of South Devon.

1839. *Austen.*—"On the structure of South Devon." This paper was supplementary to the memoir read in 1837 (Proc. Geol. Soc. vol. ii. p. 584), and in it the author showed the general relations of the various bands of slates, limestones, and sandstones in South Devon. Six important considerations and conclusions are here given; and Mr. Austin then considered that the carbonaceous rocks of Central Devon formed no part of the older deposits named therein.

1839. *Williams, Rev. D.*—"On the Great Graywacke System, as is comprised in the Group of West Somerset, Devon and Cornwall." The author wrote this paper as a supplement to his former communication in 1839 (Proc. Geol. Soc. vol. iii. 1839, p. 115). In it

* Proc. Geol. Soc. 1838, vol. ii. p. 669. † Ibid. vol. iii. 1839, p. 115.
‡ Ibid. vol. iii. 1839, p. 121.

he corrects certain errors, and gives much valuable research bearing upon the succession of the whole series in West Somerset and Devon. In the history of the Devonian controversy it is important, but needs no special comment here. The author, however, states his opinion that ten consecutive series occur in and occupy the whole country from Cannington Park and the Quantock Hills in West Somerset to the Land's End in Cornwall. (Proceed. Geol. Soc. vol. iii. 1839, pp. 158–162.)

1839. *De La Beche.*—'Report on the Geology of Cornwall, Devon, and West Somerset'*. In this important memoir the author discusses the above three areas in all their aspects, still retaining the term "Greywacke" for the whole of those rocks below the carbonaceous deposits. In the 5th chapter (pp. 127–155) these two groups receive important notice, and the views and opinions of continental authors, both physical and palæontological, are given as bearing upon the relation of the two systems. Accompanying, or as part of, this work, appeared in the year 1841 Prof. Phillips's 'Palæozoic fossils of Devon, Cornwall, and West Somerset,' being a description of all the then known organic remains of the Devonian rocks, to be noticed hereafter.

1840. *Sedgwick* and *Murchison.*—"On the Physical Structure of Devonshire, &c."†. In this elaborate paper, which at the time exhausted the subject, the five regions into which the authors divided Devonshire are graphically and clearly described, their views upon the geological structure of which was received then, and cannot now be controverted. The chapters descriptive of the succession of the deposits in North Devon between the north coast and the culmiferous series, and of those between Dartmoor and the south coast in South Devon, should be read and consulted by all who would seek to understand the physical structure of Devon. The second part of their paper, "On the Classification of the older stratified Rocks of Devonshire and Cornwall, &c."‡, contains much information upon the organic remains, and their distribution through the divisions therein proposed.

1840. *Lonsdale.*—"On the Age of the Limestones of South Devon" §. This paper was intended to show again that the author was the first to infer from zoological evidence that the Limestones of South Devon would prove to be of the age of the Old Red Sandstone. It is a complete résumé and summary of the opinions previously entertained respecting the age of the limestones which are associated with the slates, &c., of Devon and Cornwall. The older authors had placed these Limestones in the Primary-transition or Greywacke and Carboniferous series, though Mr. Prideaux had previously assigned them in part (or in mineral characters) to the Old

* Published by order of the Lords Commissioners of Her Majesty's Treasury, 1839.

† Trans. Geol. Soc. 2nd series, vol. v. p. 633.

‡ Ibid. p. 688.

§ Proc. Geol. Soc. 1840, vol. iii. p. 281. Trans. Geol. Soc. 2nd series, vol. v. p. 721, &c.

Red Sandstone*; and Prof. Phillips† would not confidently place them in a definite position in consequence of the resemblance of their fossils to many of the species occurring in the Mountain-limestone. The labours of other authors are commented upon in this paper, and comparisons are made with other systems‡.

1841. *Phillips.*—"Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and West Somerset."§ This volume accompanies Sir H. De la Beche's Report, and contains accurate descriptions and figures of all the species of Devonian fossils then known; and when we consider the fragmentary nature and unsatisfactory condition of the fossils that occur in these slates and limestones, and the materials out of which Professor Phillips compiled his work, it is one of the highest classical value, which we must ever apply as our standard of reference. The divisions and sequence therein adopted require little or no change at my hands, and have been fully confirmed by recent investigations.

1842. *Sedgwick and Murchison* ||.—"On the Distribution and Classification of the Older or Palæozoic Rocks of North Germany and Belgium, &c."; accompanied by a description of the Fossil Mollusca, &c., by Viscount d'Archiac and M. E. de Verneuil. The Carboniferous rocks of Westphalia, as well as the Devonian limestones and shales of Mettmann, Elberfeldt, Hagen, and Iserlohn, and the calcaceous rocks of Pfaffrath, Refrath, &c., on the right bank of the Rhine, are elaborately described in the first part of this paper. The second part contains an explanation of the structure of the country on the left bank of that river, comprising the rocks of the Eifel and the older rocks of the Moselle and the Rhine, with the formation of the Hundsrück and the Taunus. Part the third embraces descriptions of the Devonian rocks which constitute the Thüringerwald, Upper Franconia, and the Fichtelgebirge, and descriptions of Hof, Elbersreuth and Gerolsgrün, &c.

In this important memoir the authors with much detail describe the whole of the Devonian deposits, occupying a large portion of the Rhenish province and Belgium. It is followed by a long and important memoir by Viscount d'Archiac and M. Edouard de Verneuil descriptive of the organic remains which occur in the rock-masses, commencing with a general survey of the fauna of the Palæozoic rocks known at that date. Pp. 336–410 are occupied by carefully detailed descriptions and notices relative to the species and their distribution through the Lower, Middle, and Upper divisions of the Devonian rocks; and the paper is concluded by a table showing the ranges, and giving other important information relating to the British and Rhenish fossils.

* Trans. Plymouth Instit. pp. 36-43, 1828, 1830.

† Encyclop. Metropolitana, 1836.

‡ This paper by Mr. Lonsdale contains a complete list of authors and their opinions, extending from the time of Woodward in 1729 to those of Sedgwick and Murchison in 1839.

§ Published by order of the Lords Commissioners of Her Majesty's Treasury.

|| Geol. Trans. 2nd series, vol. vi. 1842. (Paper read May 13th and 27th, 1840.)

1846. *De la Beche.*—"On the Formation of the Rocks of South Wales and South-western England, &c."* This remarkable memoir enters fully into the question of the structure and succession of the Devonian rocks of the West of England; pages 65 to 105 are devoted, with others, to their consideration. It is too long for more than mere notice, and is replete with important matter. The author refers to the labours of those who have investigated the structure of North and South Devon, especially Mr. Godwin-Austen, from whose researches, and those of Prof. Phillips, the materials are largely drawn.

1848. *Peach, C. W.*—"On the Fossiliferous Strata of part of the South-east Coast of Cornwall" †. This paper has reference to supposed fish-remains in the region mentioned, and is the first notice of ichthyic remains in the Devonian rocks; *Onchus,* and an *Asterolepis* are stated to occur at Lentivet Bay and Pencarra. Many important facts are communicated in this notice.

1848. *Pattison, S. R.*—"On an insulated patch of Devonian strata in the parish of St. Stephen by Launceston" ‡. Notice of the Yealmbridge flagstones and other rocks, with fossils from the Upper Devonian beds, with a list of the few species found.

1850. *Pattison, S. R.*—"On the Petherwyn Beds" §. This paper contains a concise, but clear, description of the strata at Petherwyn, their economical uses, relation to other deposits, and a copious list of organic remains, compiled chiefly from Prof. Phillips's 'Palæozoic Fossils of Devon and Cornwall,' 1841. Mr. Pattison here mentions the coarse unfossiliferous sandstones that underlie the Upper Devonian rocks in North Cornwall. I believe them to be the equivalents of the Pickwell Down sandstones in North Devon.

1850. *Pengelly.*—"On the Ichthyolites of East Cornwall" ||. An important communication upon these obscure, yet valuable, remains at Looe Island and Harbour, St. Veep, &c. Subsequent research has revealed other and better specimens of the genus *Onchus,* &c., which are now in the possession of Mr. Pengelly.

1851. *Sedgwick.*—"On the Slate Rocks of Devon and Cornwall" ¶. This paper is of great value, especially so as relating to Cornwall, the slates of which are correlated with those of Devon. The position of the Petherwyn and Baggy Point, Marwood, and Barnstaple beds are noticed here, and also the overlying Posidonia-shales and limestones, with the succeeding Culm-measures. The results of much physical research are given in this memoir.

1853. *Sharpe, D.*—"Review of the Classification of the Palæozoic Formations, &c. &c." **. Much important matter is contained in this paper, in which are compared the equivalent strata of Belgium &c.; reasons are given by the author for considering that much of the so-called Devonian should be classed with the Carboniferous (or

* Mem. Geol. Surv. of Great Britain, 1846. Vol. i.

† Royal Geol. Soc. Cornwall, 35th Annual Report, p. 57, 1848.

‡ Royal Geol. Soc. Cornwall, 35th Ann. Rep. p. 63.

§ Royal Geol. Soc. Cornwall, Ann. Rep. 1850, p. 132.

|| Royal Geol. Soc. Cornwall, Ann. Rep. 1850, p. 116.

¶ Quart. Journ. Geol. Soc. vol. viii. pp. 1–19. 1852.

** Quart. Journ. Geol. Soc. vol. ix. p. 18.

système Condrusien of Dumont); and the South Devonian Limestone, with peculiar modifications, is made to succeed the Old Red Sandstone, or Rhenane series, and the Old Red Sandstone to overlie the Ilfracombe or calcareous group of North and South Devon.

1853. *Godwin-Austen.*—"On the series of Upper Palæozoic groups in the Boulonnais." This remarkable district is ably deciphered by Mr. Austen. The author divides the series into two divisions—(1) the limestones above and below the Cove, and (2) the Yellow Sandstone group; he subdivides the two into seven series, showing succession of beds and conditions indicated. A note accompanies this paper from Mr. D. Sharpe (p. 246), containing a list of the organic remains; this note is of much value, though I cannot agree with the author's conclusion relative to the position of the Petherwyn beds, or fossils.

1854. *Siluria, Murchison, Sir R.*—Noticed under the third edition, in 1859.

1855. *Jukes and Salter.*—"Notes on the Classification of the Devonian and Carboniferous Rocks of the South of Ireland" *.

1855. *Murchison and Morris.*—"On the Palæozoic and their associated Rocks of the Thüringerwald and the Harz." In the first part of this memoir reference is repeatedly made to the Devonian series of Thüringerwald. The Upper Devonian, "Younger Greywacke" of Credner and Richter, consists of the Upper Devonian and Lower Carboniferous, united by these authors into one subgroup, which appears to constitute one physical mass covering over, or abutting against, the Lower Silurian rocks.

In part ii. the Devonian Rocks of the Harz, as well as on the Rhine, are shown to be composed chiefly of the Spirifer- or Coblentzian sandstone and slates, which contain the same characteristic fossils as the rocks of the same age in Devonshire. The deductions bearing upon the distribution and condition of the Devonian series throughout the communication should be consulted, as they are additional to, and confirmatory of, the views propounded by Sedgwick and Murchison in 1842.

1856. *Godwin-Austen.*—"On the possible Extension of the Coal-Measures beneath the South-eastern part of England." Speculative as this paper is, and necessarily must be, the generalizations and philosophical and suggestive views put forward by the author are of the highest and most important order; they relate to the Devonian as well as to the Carboniferous Rocks and their distribution. The lacustrine condition of the Old Red Sandstone and the area occupied by that formation are discussed, and the physical conditions of the old land-surface, &c., are carefully noticed. Those details in the paper bearing upon the condition of England and Europe during the deposition of the Old Red Sandstone, Carboniferous Limestone, and the growth of coal, are important, and command the attention of all the physicists.

1859. *Murchison, Sir R.*—'Siluria' †. The third edition (in-

* Dublin Geol. Journ. vol. vii. June, 1855.

† History of the oldest Fossiliferous Rocks, and their Foundations, &c. 1859.

cluding the 'Silurian System') of this elaborate work, descriptive of the Silurian deposits of the world, embraces much information, if not the most complete *résumé* known of the Devonian and Old Red Sandstone systems, leaving, for the purposes of generalization, little to be done. Pp. 269 to 292 are descriptive of the Old Red Sandstone of England, Wales, and Scotland; they are succeeded at p. 292 by a masterly description of the Devonian Rocks in Devon and Cornwall, and Ireland; pp. 405 to 410 are devoted to the Devonian rocks of Saxony &c., and pp. 417 to 471, inclusive, to those of the Rhenish Provinces, Belgium, France, America, and Spain. The literature of the Devonian question is here nearly exhausted.

1860. *Pengelly.*—"On the Chronological and Geographical Distribution of the Devonian Fossils of Devon and Cornwall" *. Important tables accompany this paper, as well as a *résumé* of the views held by earlier authors; and Mr. Pengelly in the latter part of his communication discusses the relations existing between the Silurian and Devonian, and between the Devonian and Carboniferous species.

1861. *Pengelly.*—"On the Devonian Age of the World" †, the substance of six lectures delivered at the Royal Institution, in which much valuable matter is brought together relative to the whole Devonian question. The distribution of groups and species is detailed, &c.‡, and elaborated into a commentary upon their peculiarities, forming a digest of the subject.

1862. *Pengelly.*—"On the Geological and Chronological Distribution of the Devonian Fossils of Devon and Cornwall" §. This is a more detailed account of the distribution of the Devonian fossils than that given in the 'Brit. Assoc. Report,' Oxford, 1860; numerous tables, showing relative and absolute distribution, and the value of the several species, as well as calculated deductions, and data *for future labours yet*, upon the Devonian fauna of Devon and Cornwall. These two papers should be consulted by all students of Devonian geology.

1863. *Salter, J. W.*—"On the Upper Old Red Sandstone and Upper Devonian Rocks" ‖.—An important communication upon the Upper Old Red Sandstone and Upper Devonian beds, in which the author clearly establishes the value of this division. He describes the South Pembrokeshire Old Red Sandstone generally, especially those beds at Drinkim Bay in Caldy Island, where it is shown, as in the Avon section at Bristol, that the Old Red is definitely distinct from the overlying Lower Limestone Shales in every particular, especially so in the total absence of fossils. The author, however, notices a bed of *Serpulæ* some fifty feet down in the Old Red Sandstone, which perhaps is the only marine form known in this

* Brit. Assoc. Report, 1860.

† Six Lectures delivered at the Royal Institution, in May and June 1861.

‡ Published in the 'Geologist,' vol. iv. p. 332.

§ Geologist, vol. v. p. 10; and Brit. Assoc. Report, Oxford, 1860; also Royal Geol. Soc. Cornwall, Report 1860, p. 388. Earlier notice.

‖ Quart. Journ. Geol. Soc. vol. xix. 1863.

upper part of the series. North Devon is then described, so far as concerns the area south of Pickwell Down, which region is occupied by the Upper Old Red and Devonian rocks; these are compared with the South Wales beds. The Petherwin and Land-lake series are carefully noted, and their position below the Marwood, Pilton, and Barnstaple group established. Mr. Salter then notices the Old Red Sandstone of Somersetshire, Gloucestershire, and Shropshire, adding important matter relative to the South of Ireland, as regards the Carboniferous slate and the Coomhola series. The "Foreign Equivalents" of the Upper Devonian, with the results of his investigations, conclude this paper.

1864. *Jukes.*—"Memoirs of the Geological Survey of Ireland. Explanations of sheets 187, 192, 195, 196, 199, &c., with Palæontological Notes by W. H. Baily, F.G.S., &c." It is unnecessary to do more than mention that in the concise description of the country to which these "Explanations" refer, much valuable matter is contained relative to the Old Red Sandstone and Carboniferous beds of the South of Ireland; and in them (especially the memoirs upon sheets no. 187, 195, and 196 of those above enumerated) are embodied the views held by Prof. Jukes relative to the two formations, which are reproduced in his paper upon North Devon and Rhenish Prussia *, and also in his paper on the same subject in the Quarterly Journal of the Geological Society †.

1865. *Kelly.*—"Remarks on the Doctrine of Characteristic Fossils" ‡. The Table given in this paper, showing the distribution of the Pilton, Petherwin, and Newton-Bushel species, apart from theoretical views, and from the determinations of the Devonian and Carboniferous species, and as part of the literature of the Devonian series, may be consulted: its value must be determined by the reader, after careful and critical examination.

1865. *Jukes.*—"Notes for a Comparison between the Rocks of the South-West of Ireland and those of North Devon, and of Rhenish Prussia in the neighbourhood of Coblentz" §. This paper is a *résumé* of the two previously noticed, to which is added an account of the author's researches in Rhenish Prussia, chiefly in the neighbourhood of Coblentz. The South-Irish beds are briefly described here, followed by a statement of Professor Jukes's idea of the contemporaneity of the Carboniferous Slate and Carboniferous Limestone. North Devon is then cursorily noticed, especially Baggy, Croyde, Braunton, and Pilton. The Middle or Ilfracombe beds receive a passing notice only. Comparative lists of fossils from Ireland and North Devon are given from different localities ||, followed by those

* Notes for a comparison between the rocks of the South-West of Ireland and those of North Devon, and of Rhenish Prussia in the neighbourhood of Coblentz.

† "On the Carboniferous Slate (or Devonian rocks) and the Old Red Sandstone of South Ireland and North Devon" (Quart. Journ. Geol. Soc. Aug. 1866, vol. xxii. p. 321).

‡ Journ. of the Royal Geol. Soc. Ireland, 1865, vol. i. pt. 1. new ser.

§ *Loc. cit.*

|| I differ much from Prof. Jukes relative to the distribution of the species.

of the Carboniferous Slate. The Coblentzian beds are noticed, with Prof. Jukes's views upon them.

1865. *Pengelly*.—"On the Co-relation of the Slates and Limestones of Devon and Cornwall with the Old Red Sandstones of Cornwall" *. This paper refers particularly to the evidence of the fossil fishes in the Devonian strata, and is an endeavour to co-ordinate the Old Red and Devonian rocks.

1865. *Hall, T. M.*—"The Geology of North Devon"†. In this lecture on the "Geology of the country around Barnstaple, Bideford, Ilfracombe, Lynton, and Clovelly," &c., the author proposes a new nomenclature for the North Devonian rocks, which he divides into seven series—"the *Foreland Group*, *Lynton Zone*, *Martinhoe beds*, *Ilfracombe Group*, *Marwood Zone*, and *Pilton beds*." Whatever local value may be attached to these divisions, they, with his descriptions, clearly express their succession and position below the Carbonaceous series south of Barnstaple.

1866. *Jukes*.—"On the Carboniferous Slate (or Devonian Rocks) and the Old Red Sandstone of South Ireland and North Devon" ‡. The Introduction to this paper contains the sum of the differences that exist between Mr. Jukes and the older authors upon the physical structure of North Devon and West Somerset; and in it he endeavours to remove from the British rocks the Devonian series, as a system, altogether §. The author gives physical and palæontological reasons for his conclusions. The second part is devoted to the structure of South Ireland, as derived from his experience in that region; part the third to the geological structure of North Devon and West Somerset, in which are elaborated the distinctive views held by the author, and the reasons he assigns for his change of nomenclature, and the difference in the conclusions arrived at by him, as compared with those of other writers.

1867. *Jukes*.—"Additional Notes on the Grouping of the Rocks of North Devon and West Somerset, with a Map and Section"‖. This pamphlet, so far as regards the subject matter, is intended to supply the deficiency in the author's communication to this Society in 1866, relative to the more complete examination of the series of rocks below the Upper Old Red Sandstone of Pickwell, Devon; consequently the Wiveliscombe, Dulverton, Combe Martin, Dunster, Minehead, and Quantock region are partly described. This paper is accompanied by a map and section of North Devon and West Somerset.

III.—Structure and Succession of the Rocks of West Somerset.

1. *Cannington Park Limestone*.—In the midst of faulted ground the outlier of limestone at Cannington Park is a conspicuous feature.

* Royal Geol. Soc. Cornwall, 1865, p. 441.

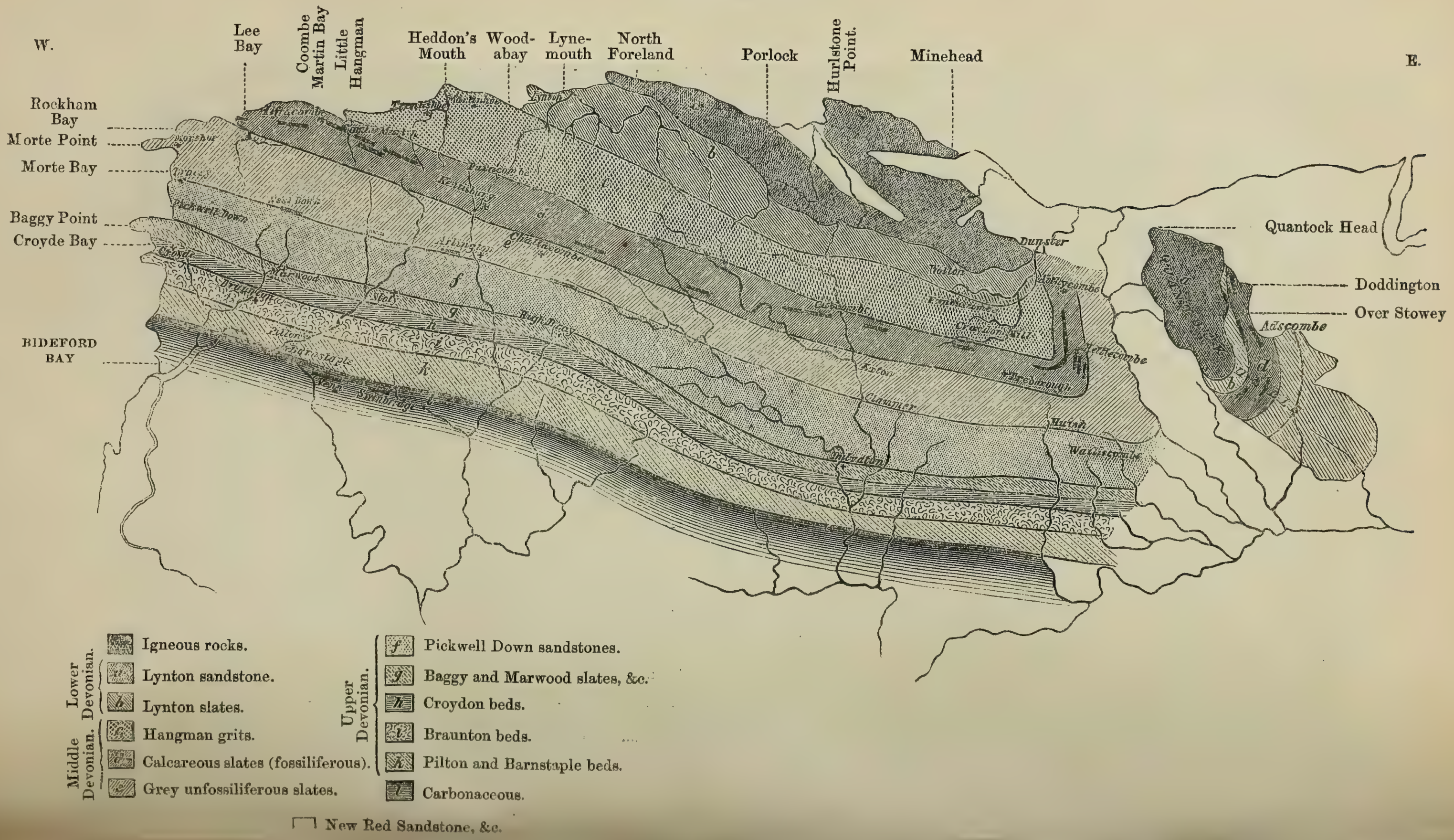
† A lecture delivered before the members of the Exeter Naturalists' Club, at "Westward Ho," Northam, Sept. 23rd, 1865.

‡ Quart. Journ. Geol. Soc. vol. xxii. March, 1866.

§ This view is discussed in my present paper.

‖ Printed for private circulation among the Fellows of the Geological Society of London, 1867.

Fig. 1.—*Geological Map of West Somerset and North Devon showing the divisions and succession of the Lower, Middle, and Upper Devonian and Carboniferous series.*



It is surrounded on all sides by the Lower New Red Sandstone ; and to the south and east there occurs a series of fissile, thin-bedded, chocolate-coloured slates, which agree in every particular with those on the eastern slopes of the Quantock Hills. These slates contain no fossils, so far as I was enabled to determine ; but that they are connected (beneath the thin covering of the New Red) with the main mass of the Quantock Hills is evident ; for exposed masses at Ashford, Radlet Farm, and Halsey Cross connect the slates of Nether Stowey (which are of Middle Devonian age) with those of the village of Cannington, between which, as before stated, and Cannington Park to the north, a considerable exposure of red slates takes place, which are again seen at Charlinch, two miles to the south-east, where an extensive fault brings them to the surface. Considerable doubt has arisen as to the age of the limestone of Cannington Park. It has generally been assigned to the Carboniferous period, but the almost total absence of fossils renders the task of fixing its true place extremely difficult ; if, however, position, lithological characters, what few fossils there are, and peculiarities of structure may be depended upon, it so strongly resembles the smooth blue, pink, grey, and red-veined argillaceous porcelain-like limestones of Torquay and Newton Bushel in South Devon, and those of Adscombe and Stowey on the Quantocks, that, to my mind, it cannot be distinguished from them : and, again, it has no resemblance to any division of the largely developed series of Carboniferous Limestone of the adjacent Mendip Hills, nor to any in the Bristol area. This limestone dips to the south-east ; and upon it rest the chocolate-coloured slates, which are rolled or contorted, but so masked by the overlying New Red Sandstone, that its *clear* connexion with the limestones and slates of the Quantock Hills cannot be satisfactorily traced ; nevertheless, from its character, position, and association with the slates, there is every probability that the limestone of Cannington is of the age of the slates amongst which it exists, and by which it is surrounded. It is the most easterly outlier of the Devonian rocks in West Somerset*.

2. *The Quantock Hills.*—This range of hills, which stretches across West Somerset from Quantock Head on the north-west to West Monckton on the south-east, is composed on the west side (or along its strike, which corresponds to its geographical bearing) of coarse and fine red and grey sandstones, which form the base of the series of rocks constituting the structure of the Quantock range. All the rock-masses beneath and to the west of Staple-Hill Foot, Bicknoller, Crowcombe, Bagborough, Cothelstone, Kingstone, &c. are covered by the Lower New Red Sandstone and Conglomerate, which occupy the valley from Williton and Stampford Brett on the north, to Stogumber, Lydeard St. Laurence, Milverton, and Taunton on the south.

* The section (fig. 2, p. 584) will show, through the patches of exposed slates between Cannington and the Quantock Hills and those that surround it on three sides, how these limestones by an opposite dip are related to those of Adscombe and Over Stowey to the west, all further evidence of them being lost to the east of Cannington, under the New Red sandstones and marls, and the alluvium of the Somersetshire marshes.

The base, therefore, of the Quantock series, as at Lynton, cannot anywhere be satisfactorily determined; but that the Red sandstone and grits before mentioned are of the same general horizon as those of Grabbist and Croydon hills, and partly also of the same red sandstone which occurs at the Hangman and Trentishoe, &c., to the west, I do not doubt. They occupy the same position, and have the same relation to the slates and limestones of Asholt, Adscombe, and Over Stowey on the eastern side of the Quantock range that the slates and associated limestones of Ilfracombe, Combe Martin, Twitchin, Simonsbath, Newland, Luckwell, Luxborough, Higher Broadwater, &c. do to the same sandstones above mentioned, which stretch from Croydon Hill on the east to the Little Hangman in Combe Martin Bay on the west. It is important that this should be understood, because whatever might have been the cause of the great bend, horizontal curve, or movement now hidden by the New Red series of the Stogumber Valley, it is clear that the succession of the Lower sandstone and grits, and that of the succeeding slates and limestones of the Middle group, are as complete in the Quantock Hills as those of Lynton or Combe Martin—a fact unmistakeably borne out by the lithological characters of the rocks as well as by the palæontological contents of the limestones and slates. The general dip of all the slates and associated coral-limestones on the eastern side of the Quantocks is to the east; the great limestone beds in the quarries at Adscombe and Over Stowey dip north-east 35°; at the former place they are in solid beds, from 4 to 9 feet in thickness, with partings of shale containing many corals. The character of the limestones in every particular closely resembles the hard crystalline grey and red-veined series of Torquay; they contain many of the same corals, viz. *Cyathophyllum cæspitosum*, *C. Hallii*, *Favosites cervicornis*, *Stromatopora concentrica*, all abundantly distributed, with *Heliolites porosus*, and many Polyzoa*.

At Ashholt-Wood and Lower-Ashholt quarries, thick-bedded limestones, interstratified with red slaty bands and red grits, are extensively worked. These beds occur on the same line of strike as those of Adscombe, but have a south or reversed dip S.S.W. 30°; they are lower in the series than those of Over Stowey and Adscombe; and, from compass-bearings taken at Cockercombe and to the west of the new court (where the great greenstone, or porphyritic felstone beds are so finely exposed), I have no doubt that a line of disturbance occurs from these latter places through Ashholt, thus reversing the dip in so short a distance. This felstone-porphyry is interstratified with the slates, to the thickness of 700 feet†.

* These limestones take the highest polish, are worked for statuary purposes, and are equal in every respect to those of Plymouth, Newton, Torquay, &c.; and Lord Taunton has extensively used them in the construction of his mansion at Adscombe, where they are worked into columns, pillars, mantel-pieces, &c.

† This pale-green porphyritic felstone has been extensively used by Lord Taunton in constructing the new court at Adscombe; it also takes a fine polish, and his lordship has used it in the construction of the fireplaces &c.

In the Ashholt, Adscombe, and Stowey quarries I obtained the following fossils:—

Alveolites suborbicularis.
Heliophyllum Hallii.
Endophyllum abditum.
Acervularia.
Favosites cervicornis.
—— reticulata.
Cyathophyllum cæspitosum.
Stromatopora concentrica.
Atrypa desquamata.
Petraia.
Heliolites.

The entire thickness of the limestones could not be determined, owing to their forming the base or floor of the quarry; but they are more massive and less regularly bedded than those of Adscombe and Over Stowey to the north. These slates and limestones belong to the Middle Devonian, or Ilfracombe, group, and are the same as those which range from Widmouth, Combe Martin, Lee under Nutcombe, and Westleigh &c., and then strike across the country south of Exhead, Dure Down, Black Barrow, and on to Treborough and Nettlecombe. They are the lowest limestones in the North Devon and West Somerset area; but it must be borne in mind that nowhere in North Devon are the limestones exhibited on so gigantic a scale as in South Devon, being, west of the Quantock Hills, chiefly, if not entirely, interstratified with the slates in thin lenticular masses and bands, but nevertheless always yielding the same corals, though apparently not so large an assemblage of mollusca.

A section crossing the Quantock Hills from the village of Crowcombe on the east, over the Fire Beacon to Over Stowey, Radlet, and Ashford, and thence to the slates and limestones of Cannington Park, will show the succession of the Lower red sandstone and grits, or the Lynton series, and the Middle, or Combe Martin and Ilfracombe slates and limestones; and if the higher members of the Middle group, or the equivalent of the Morte series, are present here, they are buried beneath the New Red Sandstone which abuts against the slates of Over Stowey, and which constitutes the plain surrounding the Devonian outliers at Radlet, Charlinch, Ashford, and Cannington. The annexed section (p. 584) will give the succession. I regard the structure of the Quantock Hills as essentially the same as that of the north part of North Devon. The base, or western side, or escarpment, is composed of coarse red, grey, green, and yellow saccharoid sandstones, flaggy and micaceous in places, which, as they ascend higher in the series, become slaty, being again succeeded by a higher series of red gritty sandstones and slates, agreeing in every particular with the higher portion of the grits and slates as exposed in the Lynton area above the Valley of Rocks, and at Woodabay, Trentishoe, Heddon's Mouth, and the Hangman, and with the beds occupied by Seven-Wells Wood. The limestones of Doddington, Adscombe, and Over Stowey represent the Combe Martin and Ilfracombe series, being, however, much thicker and more extensively developed than the limestones at Combe Martin, and rich in organic remains, although few have been obtained.

Whether the New Red series on the east, towards Bridgewater or

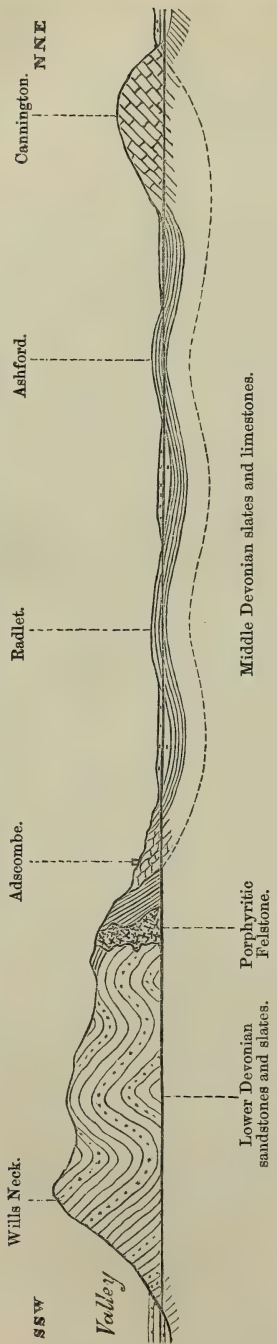


Fig. 2.—*Section from Wills Neck across the Quantock Hills to Cannington Park.*

Stockland, Bristol (the upper New Red Sandstone), covers still higher sandstones resembling the Morte-Bay and Pickwell-Down beds, I am not justified in asserting, though I see no reason why it should not occur. Similar arguments may be used relative to the connexion of the western side of the Quantock Hills with the eastern portion of the Exmoor range at Croydon and Brendon Hills, which are separated by the narrow valley, composed of the Lower New Red Sandstone and Dolomitic Conglomerates of considerable thickness, which extends to Carhampton, Dunster, Watchet, and Minehead, but which is separated from the deep valley of Luckham and Porlock by an isthmus of Old Red Sandstone connecting Croydon Hill and Dunster Park with Grabbist Hill and North Hill over Minehead. These two valleys, continuous in direction, though disconnected at Higher Kitswell, appear to occupy the line of a great fault, or they are in a trough or synclinal basin; the Great St.-Decumans and parallel faults at Watchet, Quantock Head, and Little Stoke, which extend for fourteen miles, are traceable by the depression of the Porlock valley and the reversed dips of the rocks into it. This line also corresponds with the anticlinal of the valley of the East Lynn, south of the Foreland, and the high coast-land from Porlock, the beds comprising the structure of which all dip continuously north (north of the anticlinal from 20° to 40°) to Culbone, Glenthorne, and on to Porlock, thence through North Hill to Minehead, south of the anticlinal, or the gorge of the East Lynn, from Lynton to Lucott Hill, Stoke Pero, and Timberscombe, south-east of Dunster. The grits, sandstones, slates, and limestones of the whole of North Devon and West Somerset have one universal general dip to the south, *i. e.* from Lynton or Ilfracombe on the west to Croydon Hill and the Quantocks on the east, to the Culm-measures south of Barnstaple, Dulverton, and Wiveliscombe; and I hope to show, both on physical and palæontological evidence, that the Lower, Middle, and Upper Devonian series are still the groups of rocks that occupy the area assigned to them by Weaver, Murchison, Sedgwick, Sharpe, Lonsdale, Phillips, and others.

3. *Dunster, Minehead, and Porlock Areas.*—West of the Quantock Hills and in the most northerly part of West Somerset is Grabbist Hill, and North Hill, also Porlock, Culbone, and Oare Hills, the three latter overhanging the Bristol Channel; and the lowest beds throughout all North Devon and North Somerset are exposed along their southern flanks. It is impossible not to believe that you are here examining the genuine Old Red Sandstone of Scotland, South Wales, and the Silurian area. Coarse red, grey, and pale-yellow, and mottled thick-bedded sandstone, with alternating fine-grained, flaggy beds, constitute the rock-masses of these hills; and the general dip is to the north-east from 15° to 50°; observations along their strike give the mean dip of 35°.

No organic remains whatever are known to occur in these sandstones. From the bent and contorted condition of the beds along a given line, *i. e.* from the Foreland through Desolation Point to Hurlestone and Greenlay Points on North Hill (over Minehead), it would appear that they are rolled from north to south, and thus are explained the reversed dips occasionally noticed along this line. At Hurlestone Point this rolling is well seen, the beds in the space of 50 feet being inverted, those seaward, and forming the north head of the Point, dipping 10° south-east, those immediately south dipping 55° north-north-west. The fault being a down-throw to the south, this line of disturbance is traceable from the Foreland on the west, to Quaytown and Minehead on the east, and perhaps passes into the *grand system* of faults that occupy the bay and shore of Watchet, Quantock Head, and Little Stoke. These red sandstones, on assuming their southern dip, constitute the base of the series of slates and grits that stretch across the country from Lynton to Timberscombe and Dunster Park; they underlie and are conformable to the Lower Devonian, Coblentzian, or Spirifer-grits, sandstones, and slates of West Somerset.

Along the summit of North Hill the coarse-grained micaceous Lower red sandstones dip north-north-east and north 18°; in a quarry near Woodcombe they dip due east 20°.

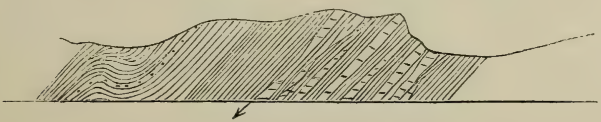
At Greenlay Point and Minehead the beds form an anticlinal and are faulted, dipping at opposite points, north 45° and south-west 15°, thus agreeing with, and showing the extension of, the east and west fault from Hurlestone Point to Quaytown. At Greenlay Point the rocks are alternating coarse and fine-grained red, green, grey, and yellow sandstones. Lower members of this red sandstone series appear to the south of the Minehead valley at Lower Hopcott, where they still dip north-east 15°; they are massive beds of red and grey crystalline grits, banded, and stained deep-red, from three to four feet thick, and much jointed; partings of falsely bedded clayey shale occur, and the whole quarry is apparently much disturbed.

South of Hopcott the red sandstones comprising the structure of Grabbist Hill all dip to the north and north-east, and continue to do so until they reach the deep Wotton-Courtney valley, between Grabbist and Croydon hills, where, along the course of the river, a reversion of dip takes place, either through faulting or a depressed anticlinal; this change is in a direct line with the St.-Decumans fault on to Quantock Head. This reversion and change is traceable from Dunster to the Foreland and Lynton; and the southern dip of these sandstones constitutes them the base of the *whole of the superincumbent Grits, Slates,* and *Limestones* of West Somerset and North Devon: in other words, these red sandstones underlie, and are conformable to, and form part of (the natural base) the Lower Devonian grits and slates of the North Devon area.

4. *Dunster to Dulverton.*—Having endeavoured to show along a given line that we have a natural and conformable base for the higher or succeeding series of grits and slates, I will now trace the junction and the changes of character on the line of dip in West Somerset, both as regards the physical structure of the rocks and the palæontological value of their fossils, and will do so over two areas, one south of Dunster, viz. from Dunster to Dulverton, and the other east of Dunster to the Brendon Hills, through Withycombe, Higher Roadwater, Nettlecombe, and Treborough. At Timberscombe, Bickham, and Oaktrow, south-west of Dunster, the sandstones and grits retain their character, but are more thinly bedded and more fissile than those to the north, and the partings are more slaty. These beds are an easterly extension of the second series of red grits exposed at Woodabay, Trentishoe, and the Hangman. Between Oaktrow and Ashwell a gradual change takes place in the lithological character of the sandstones; the grit beds become thinner, and give way to thicker masses of interstratified slaty rocks; and at Cutcombe the change becomes complete. We here lose the red grits and fine sandstones altogether; the passage from arenaceous to argillaceous rocks being complete. We have here, then, as at Combe Martin Bay, evidence of the grits, sandstones, and slates of the Hangman group passing insensibly into the second, or Ilfracombe series, and that in the clearest manner. South of Cutcombe, on the ridge at Wheddon Cross, we meet with the lowest series of limestones in the Ilfracombe group, which are here lenticularly arranged masses of calcareous matter, due chiefly to organic influence, and interstratified amidst the slate. In places these limestones are of considerable thickness, and are used both for building and agricultural purposes, especially at Newland, Court Hill, and Luckwell; they are also extensively developed to the east of Croydon Hill, at Higher Broadwater, Lod Huish, and Nettlecombe. *Favosites cervicornis, Stromatopora concentrica,* and *Cyathophyllum*, &c. occur in the limestone-bands at Wheddon Cross and Luckwell.

No mollusca were observed; their absence is somewhat remarkable. It is singular how destitute the slates of West Somerset are of molluscan remains and other associated life, though it may be accounted for from the fact that the largely developed series of argillaceous rocks of this region were accumulated in a deep sea, and probably in an area of depression, and hence the preponderance of *Cœlenterata* in the definitely marked line of limestones striking from Ilfracombe and Combe Martin to Nettlecombe and Withycombe; and, again, the persistency of the conditions under which these limestones were deposited, along so extensive a line, clearly indicates deep water, depression, and a fringing reef-like growth of coral-masses. Fourteen species of corals are known to occur in these lenticular bands of calcareo-argillaceous deposits in West Somerset, at Withycombe, Nettlecombe, Goldsoncot, Roadwater, and other places in that area; and the same facies is preserved in all the limestones.

Fig. 3.—*Section in a Quarry at Wheddon Cross, showing the lenticularly arranged limestone bands in the midst of the slates.*



At Wheddon Cross the beds dip 45° south; and this angle of dip appears to be general (south of Exton). Continuing our examination of the limestones and slates from Wheddon Cross and Luckwell, both along the road and down the valley of the Exe, beyond Eyeson Hill, we are still in the lower part of the Middle or Ilfracombe beds, or that division of them which rests upon the upper part of the series of red grits at the Little Hangman &c., and which is well seen in ascending order along the coast from West Challacombe through Combe Martin Bay, Watermouth, Widmouth, Helesborough, and Ilfracombe to Lee Bay, and upon which the Upper division, comprising the glossy slates of Morte Hoe (and Lundy), sets in. South of Eyeson Hill, the river- and road-sections give unmistakeable proof that we are in, and crossing the strike of, these grey glossy Morte-Hoe slates, their physical condition and marked characters being most prominent. In the gorge of the river, at the picturesque village of Winsford, two miles west of the main road to Dulverton, and near the bridge, fine sections occur, showing the dip of the same beds to be S. 60°, and the cleavage vertical. From this point south, through Exton and Clammer, and as far as Browford, the dip is in the same direction. These slates here are frequently folded, and exhibit a reversed dip, but no local dislocation or faulting between Browford and Oxgrove. This reversion therefore seems due to extensive undulations of the strata; for, west of Shircombe, these pale-grey fissile slates dip 65° S., at Browford S.E. by S. 50°, at Kent's mill the same, and 100 yards north of Chilly-Bridge gate they still dip S. 80°;

but close to the turnpike gate they appear to dip north, or are nearly vertical, and shortly regain their dip to the south at 80°, but again undulate and dip to the north as far as Oxgrove, where, on approaching the red grits and sandstones, they are again bent and folded, though not immediately in contact with them. These easterly extended Morte slates as clearly underlie the Dulverton or Pickwell-Down sandstone here as the same slates at Morte and Woolacombe clearly and unmistakeably underlie the Pickwell-Down sandstone in Morte Bay, hereafter to be described.

Between Oxgrove and Lousy Gate two distinct undulations and reversed dips take place in these Upper Old Red Sandstone beds. Below, or south of, Oxgrove they dip south-south-west 65°, and are thick-bedded, earthy, red, grey, and chocolate or purple gritty sandstones. Both roads were traversed from Exton to Dulverton, viz. that following the course of the river Exe, and the Exton Hill, Bromton Regis, and Lousy Gate road, and subsequently the courses of the three rivers—the Barle, the Exe, and the stream west of Haddon Down,—all with a view to determine if there existed any evidence of a fault, or other movement of sufficient magnitude (said to occur) to at all alter our reading and understanding the physical structure of North Devon and West Somerset. From the latitude of Morte Bay on the west to the southern part of the Quantock hills on the east of the county, no such movement, due to either fault or anticlinal, was I enabled to determine in all the traverses made. At Oxgrove, as above stated, the Morte slates are seen *in position below*, or underlying, the red Pickwell sandstones (third series)* (Upper Old Red Sandstone), which here dip south at 45°, but extensively undulate before reaching Barham Down and Lousy Gate, where they resume a steady dip south-west at 50°, and then pass under the conformable Upper Devonian, or Dulverton and Baggy slaty series to the south. The transition from the thick-bedded, many-coloured, gritty beds through the mottled micaceous softer grits and fissile marls &c. south of Lousy Gate, to the yellow and brown Baggy slates south of the town of Dulverton to Pixton Park, is complete, and without any disturbance whatever. No section can be clearer than that of the upper or superimposed series; nor is there a clearer or better base than that afforded by the Upper Old Red Sandstone (Upper Devonian) for the Lower Carboniferous rocks which lie to the south of Dulverton, at Brushford and East Anstey &c.; for imediately south of the thick-bedded red sandstones and shales at Lousy Gate, the fissile or slaty series set in, as at Vention, on the south side of Morte Bay, and, after continuing red for some distance, finally alternate with the pale-brown and greenish-yellow slates of Dulverton, where they are all of one character, again succeeded by the Pixton-Park (Marwood) and Brushford beds. It is clear, therefore, that here the upward succession is complete, and that the Upper Old Red Sandstone of Pickwell &c. determines the top of the Middle or Ilfracombe beds, and the base of the Upper Devonian series, the

* 1st, or lowest, the Foreland Lower Sandstones. 2nd, the Hangman, or Middle Sandstones. 3rd, the Pickwell-Down or Upper Sandstones.

higher divisions of which pass into the Carboniferous Slates of the Barnstaple and Bideford area, &c.; and in the traverses from Dunster to Dulverton, in which the entire series of the rocks of West Somerset are passed over in the direct line of their dip or deposition, I have been enabled to determine that the succession is complete. From Timberscombe through Oaktrow to Ashwell, the lower red sandstone and slates belong to the Lynton group, being immediately and conformably succeeded at Cutcombe and Wheddon Cross by the the grey gritty slates of the Ilfracombe series, the two divisions of which, the Ilfracombe proper and Mortehoe beds, occupy all the country to the latitude of Oxgrove, being here and there (as on the coast) in this distance rolled or undulated, but nowhere showing any evidence of an extensive fault or inverted order. At Oxgrove, as at Huish Champflower (Wiveliscombe) on the east, and Mortehoe on the west, they unmistakeably pass under the superincumbent Upper Old Red Sandstone of Pickwell, Dulverton, and Main Down &c., without any visible fault, or any evidence of a deep-seated one of sufficient magnitude to invert the order of the rock-masses of the two areas (that is, the south and north). This so-called (by Professor Jukes) "Old Red Sandstone" is the base of the upper division of the Devonian rocks, on which rest the slates of Baggy, George Ham, Marwood, Sloly, High Bray, &c., which constitute palæontologically the Upper Devonian series, and which are succeeded by the *probable* equivalents of the Irish Coomhola beds at Croyde, Braunton, Barnstaple, &c., and so on into the true Carboniferous series. Thus, in this, to me, highly typical inland succession, as contradistinguished from that seen on the coast, where the whole series may be determined *in situ* and their masses compared, we have no break or fault of any magnitude whatever, no movement of the strata to any extent, certainly not sufficient to cause inversion; for the undulations of the slates near the base of the thick red sandstones are such only as would occur in yielding and softer beds during either sudden or long-continued movements, especially when overlain by some 3000 feet of massive, thick-bedded sandstones, and along an extensive tract of country. The undulations and local reversions of dip in the slates of the Middle Devonian or Ilfracombe group are not of great magnitude throughout their entire strike. Its base rests upon the second series of sandstones, or the Hangman and Woodabay beds; and at its summit are the Pickwell and Dulverton Upper Old Red Sandstones, which are unfossiliferous throughout.

5. *Valley of the Barle and west of Dulverton.*—The valley which the river Barle traverses, and the rocks through which it passes, afford good sections of the "Old Red Sandstone." The country from Dulverton to Mauncy Castle is occupied by the Pickwell-Down (Dulverton) red grits and sandstones, which have reversed dips and undulations corresponding to those described on the Exe river, and on the roads east of Dulverton; but they are better shown here, on account of the greater exposure of the rock-masses. A little north of Dulverton, some 1500 feet of thick-bedded, highly

micaceous red sandstones, having erous partings of purple, grey, and red marly shale, dip south-east 50° to 60°, and in places near the town are much undulated; the cleavage imparts a peculiar feature and structure to both marls and sandstones, and is highly inclined to the north. At Northcombe Bridge hard gritty sandstones appear to dip north, or are rolled to the north and towards Ashwick; they appear in anticlinals from the undulations, as at Barlynch; to the east, at Ashwick, they again dip south-west 15°, are again rolled before reaching Mauncy Castle, where they continuously dip south, and are again succeeded to the north by the glossy grey Morte-Hoe slates, which conformably underlie them. In the deep valleys south of Ashwick Bridge and under Dulverton Common the features are the same, and show the rolling and the final south dip at East Lipscombe, where the Baggy slates set in. This area was searched expressly with the view of ascertaining if there existed marked evidence of either a fault or a depressed anticlinal, either of them of sufficient magnitude to support the hypothesis entertained by Professor Jukes, that the "Lynton, Baggy, and Marwood beds are on the same horizon, and thus accounted for," all evidence, however, nevertheless being to the contrary. *I failed to detect any evidence to support this view.*

6. *South of Dulverton.*—A line drawn east and west from North Anstey through the south part of the town of Dulverton, Hill Bridge, and Skilgate, defines the conformable upper junction of the "Upper Old Red Sandstone" grits and marls, with the fissile Baggy and Marwood slates and sandstones, which continue south to Brushford, and south of which the carbonaceous slates &c. of Barnstaple and Bideford commence, the impure

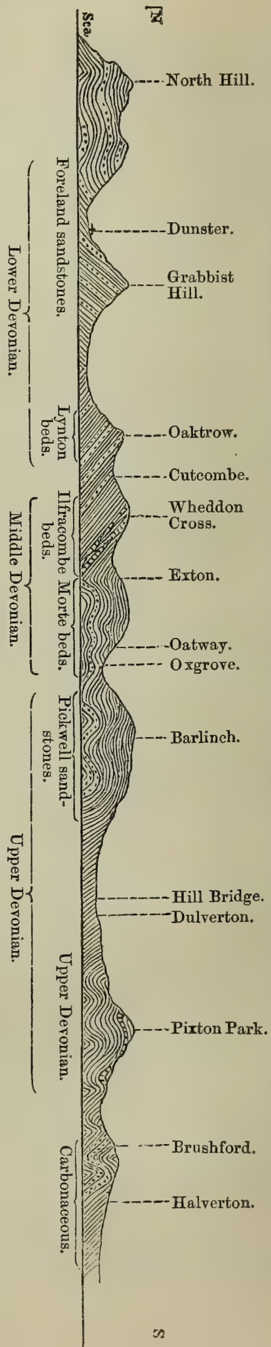


Fig. 4.—*Section across West Somerset from North Hill to Dulverton and Pixton Park.*

limestones of Pixton Park, Coombe, and Clayford being of the same age as the dark-grey limestone and brown sandstone series of Sloly and Marwood, which weather rusty, and then exhibit their fossil contents in the form of casts and moulds. At Combe, *Strophalosia productoides* and casts of *Petraia* and *Rhynchonella pleurodon* were observed.

The succession from the red grits and Lower sandstone of Timberscombe and Bickham, through the succeeding Middle sandstone and slates at Oaktrow and Cutcombe, with their associated coral-limestones at Wheddon Cross, and the succeeding mass of undulating Morte slates, to the base of the Upper Old Red Sandstones of Dulverton Down, is complete and continuous; neither is there any sign of unconformity between this sandstone band and the underlying slates; they constitute one complete and continuous series, with no break in the succession up to the Brushford beds on the south, where, both on physical and palæontological grounds, a marked change takes place, and we are fairly at the base of the Carboniferous (*carbonaceous*) series.

7. *Dulverton to Wiveliscombe.*—Immediately to the south of Haddon Down, at Hele, Ford, Upcots, Beckham, &c., the upper beds of the Upper Old Red Sandstone are visible in many places; they are red and chocolate-coloured, thin-bedded, slaty, micaceous, earthy sandstones, passing insensibly into the slates of the Baggy group; in the valley half a mile south-east of Upcots, they are well exposed in a quarry, as well as in natural sections, and dip south 45°.

The structure of Haddon Down is precisely the same as that of Dulverton Down and Hawkridge Common and all the range to the west; and traverses made on the route to Wiveliscombe, over Haddon and Heydon Downs, showed the same conditions; and the deep gorge of the river at Challick Farm, south of and under Main Down, and at Chipstable, proved the conditions to be the same as at Dulverton, the strike of the sandstone and slates and the conformity being evident from west to east (from Dulverton to Wiveliscombe). My attention here was chiefly confined to the northern side of Main and Heydon Downs, extending from the Oakhampton slate-quarries along the line of fault in Langley Marsh to Huish Champflower, Raddon, and Washbattle Mills, &c.

This point was selected as being the only place where a fault had been laid down by Sir H. De la Beche along the line of country which has been assigned to the *supposed* great east and west fault, having a downthrow to the north, and thus causing that ideal inversion of the rock-masses of North Devon which has been said to have placed the great band of sandstone striking from Pickwell Down to Main Down, Wiveliscombe, and the Quantocks, below the underlying Lower Devonian sandstones, grits, and slates of Lynton, placing the Foreland and Lynton group on the same horizon as that of Baggy and Marwood, &c. In other words, this fault admitted to the extent required, and according to the views advocated, the whole of the intervening slates and limestones of the Ilfracombe group and their underlying Hangman grits and sandstones, with the entire

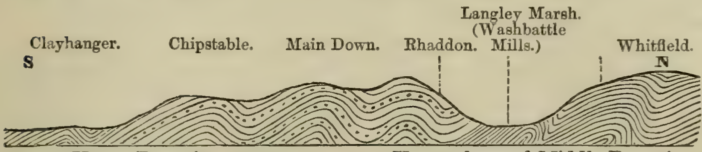
Lower or Linton slates to the north of the fault, to the extent of some 15,000 feet, would be the repeated equivalents of those beds to the south of this sandstone range, or the Baggy, Marwood, Croyde, and Pilton beds—the Upper Devonian of most authors, the Carboniferous Slate of Professor Jukes. Much care was taken in examining this fault, which is with difficulty traceable on the east in the slates, and along the marshy ground at Langley, and which appears to extend from Chapel Leigh to Langley Marsh, a distance of four miles east and west. From Hawkham through the Oakhampton-House Quarries, Whitfield, &c., we are unmistakeably in the grey fissile slates of Mortehoe and Morte Bay, which here dip south from 65° to 70°, with cleavage coincident, but in some places nearly vertical; the same system of quartz veins that occurs at Lee, Mortehoe, and Woolacombe occurs here—a circumstance, connected with other features, tending to clearly identify their position below the range of the Upper Old Red Sandstone before mentioned. The New Red sandstone and conglomerate of the lower members (Permian ?) abut against the fault, and conceal the continued strike of the Pickwell and Haddon-Down sandstones between Wiveliscombe and Kingston to the Quantock Hills on the east. At Langley Marsh, marshy ground only determines its position. West of that point all evidence is lost; it may be assumed, but cannot be proved. It may, however, be owing to the difficulty we have in tracing a fault through highly fissile and nearly vertical slates, without hard or interstratified masses to guide us; but there is no apparent break or unconformity between the slates of Clatworthy, Tuck Mill, and Huish Champflower.

With the overlying gritty, hard, red, micaceous sandstones of Main and Heydon Downs the passage and sections are complete, and may be examined in the brook from Tuck Mill to Washbattle Mills, and along the road above the mill, where the rocks gradually change colour from pale-grey to red, becoming marly and fissile gritty slates, and finally passing into the coarse sandstones of Main and Heydon Down. The brook passes over highly inclined slates, with cleavage 80° south, and the junction is clearly shown at the mill-bridge and in the road above it, and also in the gorge leading to Chalich.

The quarries at Higher and Lower Rhaddon, north of Main Down, situated in the lowest part of the Main Down beds, are opened in micaceous, mottled, marly, red and grey earthy sandstone, thick- and thin-bedded, dipping south from 45° to 60°; these conditions continue under the north flanks of Main, Heydon, and Haddon downs; and the sandstone graduates into the slates below through a gradual change of character, as at Woolacombe and Morte Bay.

At Withycombe, Wiveliscombe, and Main Down we have the same undulations and small anticlinals in the sandstone as seen east of Dulverton and the river Barle; but it regains its south dip south of Wiveliscombe, and this prevails all along the southern side or flanks.

Fig. 5.—*Section from Clayhanger over Main Down to Whitfield.*



8. *Dunster to the Brendon Hills and Nettlecombe.*—This route was selected for an examination of the Devonian beds in ascending order, especially those members of the Middle group that mantle and sweep round the southern and eastern flanks of Croydon Hill, where two, if not three, distinct series of succeeding limestone bands are well exposed. It is, indeed, a precise repetition of the conditions observable at Combe Martin and Ilfracombe on the west. Not only is the succession clear, but the relations of the slates to their accompanying coral-limestones can be well examined. A line drawn from Dunster Park, north of Langcombe, Lod Huish, and Croydon, and round to Treborough Wood, Drucombe, and Clicket, to Ashwell, before mentioned, will describe approximately the boundary between the red gritty sandstone series of Croydon (the Hangman and Trentishoe grits) and the succeeding slates and limestones of the Middle Devonian or Ilfracombe group, which conformably rest upon these upper red beds of the Hangman grits. All the band of country east and south of this line to the base of, or junction with, the great sandstone band described as striking from Morte Bay to Wiveliscombe is occupied by the Ilfracombe slates and limestones, and its higher member the grey, smooth, non-fossiliferous slates of Lee, Rockham, and Mortehoe. It is the lower calcareous and fossiliferous division, however, which we have chiefly to deal with.

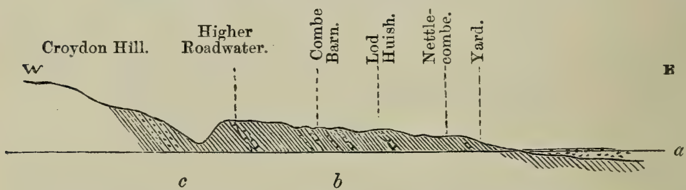
9. *Withycombe by Dunster.*—We have here the first exposure of a continuous band of limestone rich in corals, which can be traced round the Croydon promontory, to Treborough, the species occurring here being the same as those in the limestones at Newton Bushel, Torquay, and Plymouth in South Devon. From these limestones at Hill Farm have been obtained no less than fourteen species of Corals and Polyzoa, as well as Brachiopoda; and the same forms are distributed generally through these West Somerset Middle Devonian beds. The following are those that have been found by Spencer G. Perceval, Esq., of Severn House, Henbury, near Bristol:—Cœlenterata: *Favosites cervicornis*, Blainv.; *Favosites reticulata*, Blainv.; *Alveolites suborbicularis*, Lam.; *Cyathophyllum Damnoniense*, Lonsd.; *C. cæspitosum*, Goldf.; *C. Bolloniense*, Blainv.; *Cystiphyllum vesiculosum*, Goldf.; *Heliophyllum Halli*, M. Edw.; *Endophyllum abditum*, M. Edw.; *Amplexus tortuosus*, Phill.; and *Syringophyllum*. Polyzoa: *Fenestella antiqua*, Goldf. Amorphozoa: *Stromatopora concentrica*, Goldf. Six of the species here enumerated are abundantly distributed, and are all typical of beds of the same

age in South Devon*, a significant and important fact as bearing upon the physical structure and stratigraphical position of the rocks of West Somerset.

10. *Goldsoncot.*—On the strike of the same lower calcareous zone at Goldsoncot Farm quarry is another fine exposure of red, purple, and grey-veined variegated limestone in thick beds; a band about twenty feet thick occurs here, and is succeeded by others interstratified with the purple slates and indurated shaly and marly beds; the limestone is encrinital, containing also many corals, *Cyathophyllum cæspitosum*, *Favosites cervicornis*, *Stromatopora* and others resembling those from the Withycombe series; but the rock was too crystalline for me to be certain as to other species. The beds dip north-north-east 20°.

11. *Higher Roadwater, Traphole, and Lod Huish.*—The same zone of limestone and its associated slates and corals here regularly dip south and south-east 30°; the beds are massive and thick in places, but lumpy, or in hummocks, and lenticularly arranged in the slates. The corals, which are less abundant than at either Goldsoncot or Withycombe, can nevertheless be detected, on close examination, directly east of Roadwater; and higher in the series are the well-known quarries and limestones of Lod Huish and Nettlecombe. Upwards of 1000 feet of slates intervene between these two calcareous belts; and viewing this Huish and Nettlecombe group as one series of associated limestones and shales, it also cannot be less than 1400 feet thick. The following section will show their relative position.

Fig. 6.—*Section from Croydon Hill to Yard.*



a. New Red Conglomerate. *b*. Middle Devonian slates, with intercalated limestone (*c*).

IV. Structure and Succession of the rocks of North Devon.

A. Lower Devonian Group.

1. *Porlock to Lynton.*—The grand range of hills which at three points of the compass immediately surrounds the Porlock Valley, is apparently composed of one group of sandstones, all from the latitude of the Foreland, Countesbury, Oare, and Porlock Hills, dipping north-east, or towards the Bristol Channel. The same may be said of North Hill and Grabbist Hill to the east, which are cut off or separated from Croydon and Luccott Hills, and Dunkerry Beacon to the

* Mr. Perceval has presented a complete series of the species to the Museum of Practical Geology, Jermyn Street. I obtained several specimens from the same locality.

south by a deep depression in the Porlock valley, caused either by a great fault or depressed anticlinal. Whatever may be the cause, it is now hidden, and covered by red sandstone and conglomerate of Triassic age. This valley is continuous in direction with the Lynton anticlinal, and appears to be connected with the extensive east and west faults that traverse St. Decumans, Watchet, Quantock's Head, and Little Stoke, which are post-Liassic in time, and greatly disturb the country.

This range is the most elevated land in Somersetshire; and the entire mass is composed of hard red, grey, and variegated gritty sandstones (micaceous in places), having partings of compact or hard shales. The splintery nature of these grits and sandstones is peculiar, and unlike the general condition of the Old Red Sandstone of other areas in having a different fracture, and breaking up into smaller cubical fragments under atmospheric denudation or the hammer. They seem to have been deposited under different conditions from the normal Old Red; still they are the only members of the West Somerset Palæozoic rocks that at all resemble portions of the Lower Old Red Sandstone series of the Welsh, Hereford, and Gloucestershire areas.

Constant research has failed to detect any organic remains, if we except a few undeterminable plant-like remains (Fucoids), and, here and there, what appear to be Annelide-burrows. Many excellent sections are exposed between West Porlock and Culbone (the seat of Lord Lovelace), along the picturesque road overhanging the sea; and everywhere the beds dip north-east, at angles varying from 15° to 40°, or about a mean of 30°; their character is the same all the way to the Foreland. This strip of high land, about two miles wide, from Countesbury to Porlock Hill, is the northern face of the anticlinal, the axis of which is in the gorge and valley of the East Lynn; the course of the stream from Oare is nearly coincident with the direction of this anticlinal.

The lowest members of these lower red sandstones are nowhere exposed in this area; and they are not to be sought for either along this high ridge or in the elevated valley of the Lynn; as the anticlinal nowhere clearly exposes them, it may not affect the lowest beds. All that can be said is, that south of the gorge the Lynton or Lower Devonian slates and grits are nearly horizontal for a considerable distance; they then assume a southern dip, without inversion. The characters of these two masses, *i. e.* the lower red slaty sandstones and the grey slates that repose upon them, are marked and striking, structurally, physically, and palæontologically.

These are the sandstones, slates, and associated grits which Professor Jukes asserts to be the same (or on the same general horizon) as those of Pickwell Down, Baggy Point, Marwood, &c., ten miles to the south-west. This assumption is based upon the supposed existence of a great fault to the south with a northern downthrow of many thousand feet, or a concealed anticlinal rolling the beds on the south to the north, where they again appear, and thus placing these Foreland sandstones and grits in the same geological position as those of the parallel range of Pickwell, Dulverton, and Main Downs, &c.; and the Lynton and Ilfracombe slates, that rest upon the Foreland sandstones, are therefore made to be of the same age as those of Baggy, George Ham, Marwood, Sloly, and Brushford, &c., on the south of the upper range of Old Red Sandstone above mentioned. From these views of Professor Jukes I entirely differ, both as to his premises and his conclusions, relative to the Devonian question, differing from him in the reading of the structure of the typical Devonian country, and also upon palæontological grounds.

Similarity is not identity; and however much certain portions of these slates and grits may resemble each other in some few external features, yet between the Baggy and Croyde slates and those of Lynton and Ilfracombe there is on the whole a most strongly marked difference, both in physical structure and organic contents; indeed no two groups of slate rocks, when minutely examined, differ more, as a mass, or amongst themselves, than those under discussion, which occupy the country extending from Lynton on the north-east to Pilton and Barnstaple on the south-west; and no more striking contrast amongst a slaty group can be determined than between those fissile and calcareous sandstones that occur between the Lower red sandstones of the Foreland series and the Upper red sandstones of Pickwell Down (in Morte Bay), which continuously strike across the country to Wiveliscombe.

There is no resemblance between the fissile beds of the southern area and those of the northern, *i. e.* taking the line of Upper Red Sandstones of Pickwell as our east and west line of demarcation. The great group of unfossiliferous slates of Mortehoe, Lee, &c., of peculiar physical structure and some 5000 feet thick (and not known to the south), exists at the base of the Pickwell sandstones, and has to be accounted for through either of the hypotheses put forward, viz. that "of a downthrow fault to the north, or an anticlinal line across the country," neither of which can account for the total loss of these slates, or of the thick slates and associated limestone of the Ilfracombe series, or the second series of red sandstones below them, and capping the hills above the Valley of Rocks at Brendon, above Watersmeet, and constituting also the thick red and grey grits of Woodabay, Martinhoe, Trentishoe, Heddon's Mouth, and the two Hangman Hills, all on the north side of this supposed fault, and overlying the Lynton fossiliferous slates, which, as before stated, repose upon the Foreland and Countesbury red sandstones. In fossil-evidence, also, we have an equal discrepancy, or an amount of difference alone sufficient to cause a doubt respecting the identity of the age of the rocks of the two areas, and to show conclusively that there is an ascending order or sequence in the rock-masses of North Devon, as well as in their fauna, and that we should reasonably expect that many species occurring in rocks of older age, or in the Lower and Middle Devonian groups, should continue to live on, and either die out or migrate to other areas or provinces, if the conditions favourable to their prior existence changed.

2. *Foreland, east of the River Lynn.*—Immediately east of the river,

the beds of gritty slates are much disturbed, and dip at various angles, as well as being arched, rolled, or folded; but the talus on the steep slopes of the cliff prevents any accurate observation from being made as to the precise place where any junction of the slates and red sandstones occurs here, and any direct evidence from being obtained as to the cause of the disturbance; here commence the lowest slates of the Devonian series, which contain *Spirifera lævicosta*, Valenc. (*S. ostiolata*, Phill.), *Orthis arcuata*, Phill., and what I believe to be masses of *Steganodictyum* in the indurated slates, the two former being abundantly distributed. Large fallen blocks of grey indurated gritty calcareo-siliceous slates, with the planes of bedding full of fossils, occur on the shore on the east side of the Lynn, or between Lynmouth and the Foreland; it was, however, impossible to obtain specimens, owing to the extreme induration of the beds; but nests of *Favosites cervicornis*, *Fenestella antiqua*, and *Orthis arcuata* were readily detected. These beds on the east side of the river appear again on the west, where they dip at a low angle to the south, and also constitute the base of the succeeding mass of the Lower Devonian grey gritty slates which rise from the sea to the summit of the Valley of Rocks; these lower slates, &c., are about 1500 feet thick. A gentle dip and undulation enable us to trace them to Lee and Woodabay, where they dip south from 15° to 20°, and are then conformably overlain by a series of thick red grits and sandstones (the Hangman Grits, &c.).

The summit of the steep escarpment above the Devil's Cheese-ring is also composed of these red, grey, and pale-yellow grits and sandstones, which constitute the tableland above Lynton. These are a second series of red sandstone resembling both the lower at the Foreland, and the higher at Pickwell Down; and their conformable junction is well seen at Woodabay, resting upon the uppermost beds of the fossiliferous Lynton slates, which insensibly pass up into them; these red beds are not, in my opinion, a repeated series, or a repetition of the Foreland and Countesbury grits, caused by the anticlinal of the Lynn valley, but a higher and succeeding series of red sandstones, on which again rest the Middle or Combe Martin and Ilfracombe series south of the Hangman and stretching all across North Devon. The fossils occurring at Woodabay, as at Lee and the Valley of Rocks, are characteristic of these Lynton or Lower Devonian slates, and are the following:—*Fenestella antiqua*, *Megalodon cucullatum*, *Orthis arcuata*, *Orthis granulosa*, *Spirifera lævicosta*, *Pleurotomaria aspera*, *Bellerophon globatus*, *Orthoceratites*, with *Tentaculites* and numerous casts and remains of Crinoidea.

No one can fail to distinguish this division of the Devonian series, and the stratigraphical place it occupies; and it possesses so marked a marine fauna, that it shows a complete, if not an *absolute*, change from that of the Silurian series, which, I believe, it succeeds in time.

The gorges of both the east and west Lynns show the same succession of beds and physical changes on the line of dip; and the road- as well as the river-sections prove the position, flattening, and southern dip of the slates under the red sandstones south of Brendon at Barton, Cherriton, Sparhanger, and Farley, which are the Hangman red grits and sandstones of Woodabay, and the higher lands of Malacot, Trentishoe, Barrow, &c., and on to the Hangman; they are from 800 to 1000 feet thick, and completely exposed in the cliff-sections, and constitute the high Downs to the south and south-west.

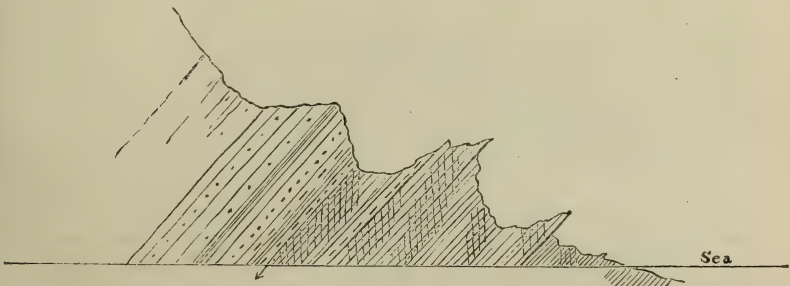
The slate rocks overhanging Watersmeet are extremely rich in fossils, some of the beds being entirely composed of one species of Orthis, *O. arcuata*, Phill. (*O. longisulcata*, Phill.), a form not known out of or above the Lower or Lynton group in North Devon, but every where found in the upper part of the series at Watersmeet, Lynton, Valley of Rocks, Woodabay, West Lee, Heddon's Mouth, &c., in some places profusely crowded, and usually distorted.

The entire succession of these lower slates is to be seen and examined in the cliffs west of Lynmouth, especially at and under the Castle Rock, Valley of Rocks, and its overhanging escarpment; nearly the whole series is fossiliferous, although the fossils are badly preserved. It is somewhat remarkable that out of the species of Brachiopoda known in the Devonian rocks one only, *Chonetes* (*Leptæna*) *sordida*, Sby. (*C. Hardrensis*, Phil.), is said to be common to these Lower or Lynton beds and to the Carboniferous rocks; in other words, only one species of this group passes up or ranges from the Devonian to the Carboniferous strata. Doubt has been thrown as to this form being the true *C. Hardrensis*, and also as to its occurrence in the Middle or Ilfracombe group. It is, however, an unsatisfactory and doubtful shell upon which to build any theory; but if it be not this species, we have none in common. Again, on following the series in an upward succession from Lynmouth to Lynton by the path overhanging Lynmouth, about 100 feet above the sea, and also up the main road, and along the north face of the cliff, the grey bands of hard crystalline limestone are seen weathering rusty and to be highly fossiliferous. In these beds occur *Spirifera hysterica*, Schloth., *P. lævicosta*, Valenc., *Orthis arcuata*, Phill., *Favosites cervicornis*, Blainv., *Alveolites*, crinoidal stems, &c.; and higher still (400 feet above the sea), immediately below the sharp bend in the road to Lynton, beds of grey limestone occur, from 20 to 40 feet thick, containing casts of numerous fossils; these are immediately succeeded by thick grey slaty beds much cleaved; and it is in the upper part of these slates, at Watersmeet and the Valley of Rocks, that the *Orthides* and *Spiriferæ* &c. occur.

3. *Woodabay and Heddon's Mouth.*—As the strike of the Lower or Lynton slates at Lynmouth is E. by S. and N. by W., and the coast-line bears east and west, it is clear that we have not their base exposed, forming as they do the foreshore, and below low-water mark; and, as before mentioned, the very disturbed nature of the same beds east of the river, near the anticlinal, forbids our satisfactorily obtaining it there; so that the whole series of slates is not seen, either under the North Cliffs on the precipitous face of the Castle Rock, or on the eastern side of the river under Countesbury Hill; and it is the southern recession and indentation of the coast-

line a little westward, and the continued seaward strike of the slates, that bring the uppermost beds of the Lynton slates into visible contact with the Hangman Grits, or second series of red sandstone in the steep cliffs and bay of Woodabay. These slates are fossiliferous up to their junction with the red grits, and contain the same species that occur in the Valley of Rocks, with the addition of *Bellerophon striatus*, *Pterinæa spinosa*, and casts of Crinoidal stems, &c. These beds between Lee and Woodabay are certainly higher in position than those which occur at Watersmeet or the Valley of Rocks, and are evidently the same as those underlying the red grits and sandstone at Heddon's Mouth, to be now noticed.

Fig. 7.—*Section at Woodabay.*

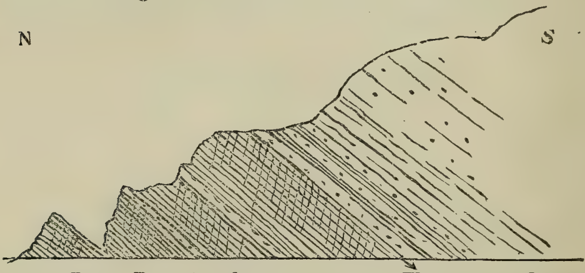


Hangman sandstones. Lower Devonian slates.

Gentle rolling of the strata along the coast to Highwear Point and Heddon's Mouth keep the slates above the sea, beyond which headland the Lower or Lynton group can no longer be well examined.

It is thus clearly seen that these Lower slates are conformable to and succeeded by the grits of Woodabay, Heddon's Mouth, and the Hangman; and their organic remains entirely cease on passing up into the red series, it being only in the highest and fissile beds of the Hangman Grits at Challacombe, Nertherton, &c., near Combe Martin, that casts of a *Myalina* and *Natica* &c. are found; and these beds graduate into the lower part of the Middle Devonian slates of Combe Martin Bay, immediately south of Knap-Down Mine and the places before mentioned. The lower part of the Lynton group is much more calcareous than the upper, and the beds seem persistent and uniform throughout over the Lynton area; but as regards organic remains, and especially the Cœlenterata, we have only a small fauna, as compared with the numerous species occurring in the deeper-sea accumulations of the Ilfracombe group; and the evidence adduced by ripple-marking and false bedding distributed generally through the Lynton group, added to the gritty character of both the slates and limestones, clearly shows their littoral and shallow-sea origin, yet apparently under continued depression; for there is no evidence in the surmounting red grits and sandstone of Woodabay and the Hangman, &c., to show that they were not accumulated in a deep sea; and this continued depression and great development of organic limestones and slates, rich in Cœlenterata and Brachiopoda, were continued through and during the accumulation of the whole of the Ilfracombe group, being followed by the deposition of the fine-grained, smooth, grey, glossy, unfossiliferous slates of Lee, Rockham, Mortehoe, and Winsford (inland), in which as yet no traces whatever of organic remains have been found. They bear all the evidence of deep-sea accumulation.

Fig. 8.—*Section at Heddon's Mouth.*



4. *Conclusions relative to the Lower Devonian Series of West Somerset and the Lynton area &c.*—(1) That the great series of the Foreland red sandstones and grits forming the northern part of the area under description is nowhere (from the Quantock Hills on the east, to the Foreland on the west) seen in its entire thickness, neither the base nor upper portions being clearly visible. The anticlinal in the Valley of the Lynn, nowhere along its line of elevation discloses this, being concealed either by the overlying Lower Devonian slates, which are conformable to its southern dip, after crossing the anticlinal, or by faulting along the course of the anticlinal also.

(2) That the great series of red and grey sandstone and grits constituting the base of all the North Devon and West Somerset deposits is the oldest of the Palæozoic series exposed in that area, and that its mass is greatest from Dunster and Wooton Courtney on the south to the northern and precipitous escarpment of North Hill on the north, overhanging the Bristol Channel, where it is believed we have higher beds than are exposed along the Porlock, Culbone, and Foreland range. An extensive fault and undulation of the strata along North Hill, as exhibited at Hurlstone and Greenlay Points, may, however, modify this apparent thickness, though the strike of the beds seaward and north of the Foreland series would indicate the position of higher beds.

(3) The dip is much greater on the northern side of the anticlinal than on the southern (a mean of fourteen observations along the strike for 13 miles determining it to be 34°), and the beds are much more disturbed. No organic remains are known to occur in these Lower Red Sandstones.

(4) South of the anticlinal of the valley of the East Lynn, and reposing upon the sandstones, there occurs a series of fossiliferous grey and purple slates and grits, with subcrystalline beds of limestone, the whole about 1200 feet thick, in many places rich in organic remains which are characteristic; but, owing to cleavage and the nature of the matrix and lamination, they are badly preserved. These are the Lower Devonian slates—the Lynton group.

(5) The fauna of this lower group of slaty deposits is purely marine, almost peculiar to itself, being entirely and importantly different from that of the Silurian epoch which preceded it, having only one species said to be common, after the obscure and doubtful forms of *Corals* and *Polyzoa* are eliminated; the remaining fauna sufficiently determines it to be a distinct and great life-period existing between the Silurian below, and the Upper Devonian and Carboniferous above.

(6) The community of species, both of the Lynton or Lower Devonian group and of the succeeding Ilfracombe or Middle Devonian (to be hereafter mentioned), added to their equally well-defined physical characters, well enable us to unite, but at the same time to separate them, both in this typical Devonian area and in the equally illustrative and allied districts of the Rhenish provinces and Belgium.

(7) Succeeding these lower slates, and conformable to them, a second great series of red gritty sandstones occurs, nearly devoid of fossils, and parallel to the strike of the lower or Foreland beds; these are the Hangman, Oare Hill, and Exmoor grits, which constitute a base for the succeeding Middle Devonian, or Ilfracombe slates and limestones, but which physically connect the two groups above and below.

(8) A marked and important difference occurs in the structure of the slate masses, as well as the fossil grouping of these two areas—a change by which both may be well correlated and coordinated with those of South Devon, on the one hand, and the Rhenish, Belgian, and French deposits on the other.

B. Middle Devonian Group.

1. *Heddon's Mouth to Barnstaple.*—This traverse across the middle of North Devon was made for the purpose of establishing a comparison with the succession of beds examined between Dunster and Dulverton in West Somerset, and also with the view of detecting any evidence of the supposed fault, or anticlinal, along the northern base of the Pickwell and Span-Head sandstones, midway between the Valleys of the Barle and Exe on the east, and Morte Bay on the west; better sections could also be obtained along this route than over the wilder parts of the Exmoor Forest, which had been partly traversed from Lynton to near Exe Head on the Moor.

Commencing my observations at the sea at Heddon's Mouth and Highwear Point, I obtained conclusive evidence of the position and presence of the upper part of the Lower or Lynton slates, dipping south, which are here grey, green, and red in colour, and crowded with *Orthis arcuata* (*O. longisulcata*), and, here and there, *Chonetes sordida*

(*Hardrensis*?), and *Fenestellæ*; the sections on both headlands correspond with those so well shown at Woodabay, with which they are continuous along the precipitous north shore under Martinhoe. At Heddon's Mouth the slates strike seaward W. 20° N., and are lost under the waters of the Channel; thus at several points along the north coast we have the uppermost portion of the Lower or Lynton slates, and their junction with the succeeding red sandstone, well shown, notably so at Woodabay, Valley of Rocks, and Heddon's Mouth; the cleavage-planes at the latter dip north, at a very high angle; the fossils occur here, as at Lynton, in definite bands of impure limestone, which weather rusty; they are difficult to extract, owing to the indurated nature of the beds.

The beautiful and deep defile through which the river has cut its way, from Kinacot to the sea at Heddon's Mouth, is composed entirely of the red gritty sandstones of the Hangman, overlying the lower slates before mentioned (see fig. 8, p. 600), which at their upper part unite with the slates of the Middle or Ilfracombe group near Radley and Middleton Mill. Iron-ore occurs along the junction of these slates and grits at West Challacombe, and is nearly continuous with their strike. In the deep valley of Paracombe we are fairly in the Lower slates of the Ilfracombe group, which agree in every feature with those containing *Stringocephalus Burtini* and *Streptorhynchus umbraculum*, and which are exposed in the cliffs on the eastern side of Combe Martin Bay, at West Challacombe, under the Little Hangman. There is no evidence whatever of unconformity along this line between the red grits and the base of the grey Combe Martin or Challacombe slates; but the change of condition would seem to have been accompanied by a submarine outpouring of igneous matter, the true condition of which requires careful examination and seeking*. The undulating country between Paracombe and Westland Pound, through Lower and Higher Rowley, is occupied by the Lower or slaty and calcareous fossiliferous division of the Ilfracombe series, the rocks of which all dip to the south; and it may be assumed with but little hesitation that a line drawn from Lee Bay to Challacombe (north of Bratton Down), Eyeson Hill, and Treborough would nearly indicate the marked division that takes place between the lower group of slates, with its associated limestones and well-marked Middle Devonian fauna, and the higher pale-grey glossy unfossiliferous series, accompanied by the quartz veins that form so conspicuous a feature at Lee Bay, Bull Point, Rockham Bay, and Mortehoe, and which unmistakeably strike from the sea on the west to Wiveliscombe on the east, passing north of Bittadon, Arlington, Withypool, Winsford, the Exe Valley, and Exton Hill; this belt of country in the river-courses and valleys everywhere, where I examined it, showed the same physical features.

* On the south side of the Culm trough, from Padstow to Tintagel and Brocastle, there are numerous apparently contemporaneously bedded greenstones, and igneous rocks of various composition; and those of Padstow &c. may belong to about the same horizon, or be chronologically equivalent with the similar deposits associated with the lower part of the Ilfracombe group in North Devon.

On the latitude of Kentisbury and Lower Rowley, and between these two localities in the middle of the lower division of the Ilfracombe group, we again have clear evidence of contemporaneous igneous action, as exhibited in Lower Rowley quarry, where stratified thick-bedded white, grey, pale-brown, and green felstones (?) are worked, and used for road-material: a thickness of from 50 to 70 feet is exposed; but their upper face being covered by fissile slates, and the base not seen, their thickness is unknown. My attention was drawn to this remarkable rock by roadside-heaps, showing its hard porcelain-like character, differing from the Bittadon porphyry or any known rock in North Devon. In Lee Bay a greenstone dyke occurs, striking east, and in a direct line with Kentisbury and Rowley: but an intrusive dyke may take any bearing or direction; and therefore no hypothesis is justifiable to account for metamorphic action, so far away from what might otherwise cause this change. This Lee dyke and the one at Fremington Pill also, south of Barnstaple, I doubt not belong to the grand system of intrusive greenstones that intersect the slates and granite of Lundy Island, there being no less than 60 dykes, varying from 1 foot to 30 feet in width, that traverse that remarkable island from east to west in the space of 2½ miles, affecting both granite and slates alike, all of which have been carefully examined and mapped by myself*.

Bands of limestone in red slates, containing *Cyathophyllum cæspitosum* and casts of bivalve shells, succeed those at Higher Rowley, dipping south, and which, with those of Challacombe and Twichin, appear to be the highest known calcareous beds in this lower division of the Ilfracombe group. Then set in the Lee and Morte-hoe slates, which are traceable into the beautiful dale and ravine of Arlington, and immediately underlie the high land of Garmond Down, Bratton Down, Span Head, &c.,—portions of the upper and persistent zone of red sandstones and grits that stretch from Morte Bay to Wiveliscombe—in other words, the Pickwell Down series, stated by Professor Jukes to be the faulted or repeated series of the Foreland, ten miles to the north.

The junction of the Lee and Morte-hoe slate series, here, as at all other points along this north line, or outcrop of the red grits and sandstones, is complete, and, as at Woolacombe, Bittadon, and the Exe Valley &c., there is no evidence of unconformity, or disturbance, either obscuring or destroying local or general continuity; and the constructed and measured section in Morte Bay, still more to the west, to be yet described, will, I hope, not fail to show this. It is well known that at Bittadon, Smithia Park, and onwards to the east, there are local exhibitions of igneous rocks, doubtless continuous, if carefully traced; and notably stands out the Bittadon felstone-porphyry, at or near the junction of the Morte Slates and the base of the red sandstone of Swinham Down†. Road-sections to Sherwell Cross and those exposed in the river, to Youlston Old

* See also Williams (Rev D.), Quart. Journ. Geol. Soc. vol. ii. p. 68.

† The Viveham iron mines are a little south of this, and were once extensively worked.

Park, continuously expose the variegated Upper Old Red Sandstones dipping S. 30° to 45°, as along the whole strike from Vention, at the south part of Morte Bay, to Dulverton &c.

In this traverse, as in the one made down the Rivers Exe and Barle over the Dulverton area, and in two made between the Ilfracombe and the Muddiford Valley, *viâ* Bittadon, over and across the same beds, I failed to detect any evidence of either fault or anticlinal other than such as would be caused by slight rolling or undulations of the beds from north to south; and while *below*, in the Morte series, the slates were conformable to the Pickwell Down Grits, or Upper Old Red Sandstone, *above* they gradually passed into the pale-yellow and brown slaty and calcareo-siliceous Upper Devonian series of Baggy, Marwood, and Sloly &c.

2. *Little Hangman and West Challacombe to Ilfracombe; Ilfracombe to Baggy Point* viâ *Morte Bay.*—I now return to the junction of the red fine-grained grits of the Little Hangman with the fossiliferous slates of Combe Martin Bay. In West Challacombe Bay the lowest or Stringocephalus-slates of the Ilfracombe group may be examined in detail, where they repose upon the red, grey, and yellow mottled grits of the Little Hangman and Knap Down, further to the east; the junction is also traceable up the road from Combe Martin, leading to Knap Down Mine; and in the bay the passage takes place through a series of alternating or interstratified siliceous red grits and fossiliferous slates, which finally assume their persistent grey slaty character on the coast and in the valley; they dip S.E. 35°. There are numerous intermittent beds and masses of impure and subcrystalline limestones through the entire course of these lower slates; and the purer limestones of Combe Martin, Hagginton, Helesborough, and Ilfracombe, when carefully examined, form an important feature in the structure of the country; they strike west and east through North Devon and on into the Quantock Hills in West Somerset. The aggregate thickness of these lenticularly bedded and apparently disconnected (on the line of strike) masses of impure limestones is very great, equal to the more massed and definite series at Newton Bushel, Torquay, &c.; and to a large extent they contain the same fossils, and a large and well-marked Middle Devonian fauna illustrates this area; but, imperfect as the organic remains necessarily are, through cleavage and excessive induration of the harder rock-masses, I hope to show that they, together with those of the Lower Devonian of the Lynton area, belong to a group unmistakeably and essentially identical with beds of the same age in Rhenish Prussia, Belgium, and the Bas Boulonnais in France. This question will be gone into in my remarks upon the palæontological value of the fossils of the Devonian group of rocks. The slates and grits of Combe Martin Bay require much and careful investigation, owing to disturbance and faulting. There is doubtless a rich fauna in the indurated siliceous sandstones that are interstratified with the slates on the eastern side of the Bay: it is here, and in these beds, that the large *Stringocephalus* (*S. Burtini*) occurs, apparently below which, in the

red grits, are the large and well-known *Myalinæ* and *Naticæ*, occurring as casts only; their position, however, at the Little Hangman and at Holstone in the same grits, fixes their place. At Sprecombe, near Oareford, Wishet, and the Red Deer, near Black Barrow Down, in the North Forest, the same shells, with casts of *Favosites cervicornis*, *Cucullæa*, *Sanguinolaria*, *Solen*?, *Macrocheilus brevis*, *Pleurotomaria*, and *Loxonema*, occur*. At Combe Martin, on crossing the river to the south, a marked change in the aspect of the country takes place; a ridge of elevated country richly wooded, stretching from Widmouth Head on the west to Kentisbury on the east, marks the outcrop of the Limestone series; but unlike the beds of the same age in South Devon, they are here intimately interstratified with the slates in irregular alternating thick- and thin-bedded lenticular calcareous masses, yet very continuous. In the first or lowest series, south-east of the village, the united thickness of the limestone beds is from 60 to 100 feet, and they are extensively burnt for lime. These calcareous beds are chiefly composed of the well-marked Devonian corals, *Cyathophyllum cæspitosum*, *C. Hallii*, *Favosites cervicornis*, *Stromatopora concentrica*, and *Heliolites porosus*, with *Trimerocephalus lævis* (casts) and *Atrypa reticularis*; many of these species are distributed through all the quarries, though sparingly. There appear to be two well-defined series of limestones, confined to about 1000 feet of vertical strata, and occupying the middle part of the lower division of the Ilfracombe group; it is these limestones that here, as in South Devon, so eminently characterize the Middle Devonian Rocks, and, as on the continent, contain that peculiar group of corals, totally unlike, and different from, those of the underlying Silurian rocks as well as, *without exception*, the succeeding Carboniferous; for of the *fifty* species of corals known in the Middle Devonian series of North and South Devon and Cornwall, one doubtful species only is said to occur in the Silurian rocks, viz. *Favosites fibrosa*, and only one is said to pass up into the Carboniferous series, viz. *Amplexus tortuosus*, of which, however, we have *no authentic evidence*. In the North Devon area, thirteen species occur, and with one exception are confined to it—one species only recurring in the beds south of Baggy, viz. *Petraia pleuriradialis*?; and yet, on comparison with the Eifel and Belgian Devonian strata, 20 species, or 40 per cent., are common to the Middle Devonian series of Devonshire and Europe. A similar relation and difference I hope to show in all the groups of organic remains that occur in this formation in Great Britain.

Crossing the calcareous group of slates from the Lee Quarries, east of Combe Martin, to the high ground of Berrydown, we again (near the cross roads) meet with the finer-grained, non-calcareous, unfossiliferous Mortehoe slates, which here occupy an elevated

* No one has more carefully studied the Ilfracombe group of rocks than R. Valpy, Esq.; and to him am I indebted for considerable information relative to fossil localities, permission to examine his rich Collection, and also his notes upon this part of the North Devon coast. He has himself catalogued and noted upwards of 50 species from the Ilfracombe group alone, a work of considerable time and labour.

undulating line of country to Huish Down, where they pass conformably under the red grits and sandstones of the often-mentioned Upper Old Red Sandstone, or Pickwell series, which continues on to Muddiford.

Returning to Combe Martin and the coast, I examined the slates and limestones along their strike to Newbery, Hagginton Mill, Watermouth, Widmouth, &c., and then in ascending order on their dip to Hagginton Beach and Hill, and Helesborough, and on to Ilfracombe, all of which may be taken as typical fossiliferous localities, and where Mr. Valpy has collected almost every species occurring in the district.

At Watermouth, which is in a direct line (on the strike) with the main mass of the shales, slates, and lower limestones of Combe Martin, many good sections occur, both in old quarries and on the coast. The shales, slates, and sandstones which alternate here are remarkable for their diversity of character, yet continuing with the same conditions repeated round Widmouth Head to Hagginton Beach. Quartz veins, with lead, I know nowhere else. At Sandaby, masses of siliceous rocks, containing *Stringocephalus Burtini*, Defr., occur; and Mr. Valpy has obtained *Trimerocephalus lævis*, Münst., from mottled grey and red shaly rocks which overlie the Stringocephalus grits, associated with *Spirifera disjuncta*, Sow., *Atrypa reticularis*, Linn., and its variety *A. aspera*, Schloth., *Rhynchonella pleurodon*? *Fenestella*, &c. The Widmouth series at its lowest part consists of finely laminated thick-bedded sandstones, with *Tentaculites scalaris*, Schloth., and casts of other fossils. Above this Tentaculite-sandstone, succeeds a considerable series of red sandstones, in which no organic remains occur; an irregular mass of dark limestones with corals, especially *Favosites cervicornis*, Blainv., *Stromatopora*, and obscure masses of *Cyathophyllum cæspitosum*, Goldf., overlies the red grits.

Mr. Valpy informs me that on this limestone thin shales occur, which are studded with carbonaceous nodules and coprolites of fish*.

Succeeding the Widmouth rocks, and higher in the series are the Rillage and Hagginton beds. I examined the latter only; but a glance at them convinced me that patient and long study only could enable any one to make out the details of the complicated structure of the rock-masses of Hagginton Beach. The history of the Ilfracombe group is, indeed, written in the coast-series from Combe Martin Bay to Ilfracombe, but particularly so in the fine section of slates, sandstone, shaly limestone, and grits of Hagginton Beach and the Hill quarries, the impure clayey limestones and quartzose sandstones, &c., on the coast and Hagginton Hill Quarry, having yielded upwards of thirty species, twenty of which belong to the Brachiopoda.

* Mr. Valpy has obtained in many places along the coast good evidence of the existence of fish through the remains of bones and coprolites, but no teeth or scales so as to enable us to determine their genera. None but a local observer can do justice to the difficult and obscure structure of this coast; and no one has worked it out so patiently as, or with more detail than, Mr. Valpy.

In Mr. Valpy's collection (from these beds) are the following species:—Brachiopoda: *Spirifera disjuncta*, Sow.; *S. glabra*? *S. curvata*, Schloth.; *S. nuda*, Sow.; *S.*, sp.; *S. speciosa*, Schloth., and var.; *Merista plebeia*, Sow.; *Atrypa reticularis*, Linn.; *A. desquamata*, Sow.; *A. aspera*, Schloth.; *Athyris concentrica*, V. Buch; *Cyrtina heteroclyta*, Defr.; *Orthis interlineata*, Sow.; *O. striatula*, Schloth.; *Rhynchonella pleurodon*. Gasteropoda: *Acroculia vetusta*, Sow.; *Euomphalus serpens*, Phill.; *E. radiatus*, Phill.; and *Natica*, sp., with *Tentaculites*, *Conulariæ*, *Fenestellæ*, and *Favosites cervicornis* (*polymorpha*), Blainv.

In the limestone quarry at Chambercombe, I observed *Cyathophyllum cæspitosum*, Goldf., *Favosites cervicornis*, Blainv., *Spirifera disjuncta*, Sow., casts of *Rhynchonella* like *R. pleurodon*, and *Fenestella antiqua*? The greater part of the slates and dark compact limestone is here fossiliferous, containing especially the ubiquitous coral, *Favosites polymorpha* or *cervicornis*, Polyzoa, and casts of *Crinoidea*. Mr. Valpy has obtained *Streptorhynchus crenistria*, Phill., *Euomphalus radiatus*, Phill., Encrinital remains, and Polyzoa in the beds across and through which the stream passes from Hele to Hagginton Beach, near the waterfall. The prevailing forms found are *Rhynchonella pleurodon*, Phill., fragments of *Spirifera disjuncta*, Sow., *Strophomena rhomboidalis*, Wahl., and two species of *Cypricardia*, Phill., with *Acroculia vetusta*, Sow., imperfect and small *Orthoceratites* and *Theca*?—a series of slates and impure limestones, finely laminated sandstones, blue calcareous sandstones, thick reddish quartzose beds with fish-remains, encrinite-stems, and fragments of *Phacops*, a shaly bed with *Phacops* and *Goniatites*, then shales and slates of some thickness, the weathered surfaces of which contain numerous *Tentaculites* (*T. scalaris*, Schloth., *T.*, sp.), *Euomphalus serpens*, Phill., Polyzoa, *Goniatites*, &c.; then 50 feet of slate to the sea-level, in which *Tentaculites scalaris*, *Euomphali*, *Natica*, and many Brachiopoda occur abundantly.

3. *Helesborough*.—This bold headland, which forms the eastern side of Ilfracombe harbour, I could not satisfactorily examine on shore, owing to the tides; but fossils in the slates and sandstones seemed much more rare here than in the series I have just mentioned, though the limestone bands appeared to contain a large assemblage of individuals, if not of species. Mr. Valpy, who has most carefully worked out the Helesborough beds, informs me that Corals, Crinoidea, Brachiopoda, Gasteropoda, and Cephalopoda are numerous, the limestone, as well as the shales, being full of these remains; he recognizes certain bands of whitish siliceous rocks full of Brachiopoda, and identifies the two well-known forms *Spirifera disjuncta*, Sow., and *Strophomena rhomboidalis*, Wahl., var. *analoga*, Phill., and also on the eastern side of the headland a thin highly calciferous bed which is crowded with weathered-out examples of minute spiral Gasteropoda, *Murchisoniæ*, *Holopellæ*, &c., together with *Tentaculites* and defence-spines of fish; and, more eastward still, beds of the same character contain *Orthoceras cylindraceum*, Sow.

I have thus dwelt somewhat at length upon the general structure of this group and area, from its important bearing upon the question at issue, and also for my purpose when I enter upon the palæontological value of the fossils in the several groups, and also because there has never been any satisfactory notice of the sequence and associated fossils of the Ilfracombe group. Apparently they have been much overlooked; and it is Mr. Valpy's collection that now supplies the mass of authenticated species, by which, with my own observations and the examination of his collection, I am enabled to make the somewhat complete accompanying list. Professor Phillips* names 37 species as occurring in the Ilfracombe group in North Devon; one Brachiopod, viz. *Stringocephalus Burtini*, seemed then to have been the only known form in that area. Through the labours of Mr. Valpy I am now enabled to add between 50 and 60 species to this Middle Devonian or Ilfracombe group alone, so that we have here (in North) as in South Devon, and the three typical areas in Europe, a Middle Devonian fauna of great and important value.

4. *Ilfracombe District.*—Although a traverse was made from Heddon's Mouth to Pilton, *viâ* Paracombe and Kentisbury, across all the series to the south, which I have described at pp. 601–604, I still desire to describe tersely the one made from the sea, at Ilfracombe, to the Muddiford valley, *viâ* Bittadon, to examine the igneous rocks of that place, it being here that the best known exposure of porphyritic felstone occurs, which so nearly resembles the Hestercombe granite—so called—on the Quantock Hills† both in character and stratigraphical position, occupying in both areas the upper part of the Morte slates, or base of the Upper Old Red Sandstone (Pickwell Sandstones), and recognized at places between these two points, and again at Morte Bay. The exposure at Bittadon, although small, is important, the rock being apparently a contemporaneously bedded, coarse-grained, stratified, felstone porphyry, the crystals of felspar being in a green felspathic paste.

The sections exposed in the slates up the steep and winding road leading from Ilfracombe to Two-Post Turnpike-gate are such as are known all through this lower portion of the Ilfracombe or Combe-Martin group—waved, undulating, contorted, and cleaved beds of slate with bands of impure limestone containing but few fossils. After passing the Chambercombe limestone we enter a tract of country almost void of calcareous matter, the meridian of Kentisbury, an exposure west of Ilfracombe being the highest known definitely marked limestone zone. South of this, the slates alter in colour and character, becoming indurated and more thickly bedded, assuming a brown or yellowish tint, and are quarried for building-purposes; roofing-slates are quarried at Woodscot &c.

The mean dip of the slates from the sea at Hagginton beach to Bittadon, over a space of eight miles, is about 40° S.S.W., with cleavage-planes to the south at high angles. It is along the meridian of Bittadon, West Down, Woolacombe, and Arlington &c. that Professor Jukes believes his concealed and hypothetical downthrow

* Pal. Foss. Cornwall and Devon, 1841.

† Leonard Horner.

fault to the north occurs, or a reversed anticlinal to the north, which, as before stated, would (according to his views) place the Lynton beds on the same *general* horizon with those of Baggy Point and Marwood, south of the Pickwell-Down Sandstone, although he admits that all appearances are to the contrary. There is no proof that the igneous rock at Bittadon is eruptive—nothing to prove that it is not a contemporaneously bedded porphyry, and the same as that occurring at Garmond Down and Smithia Park, before mentioned, though differing lithologically. It occurs immediately south of Bittadon, in a romantic dell west of Huish Down, immediately east of the main road from Ilfracombe to Pilton, and is at the top and near the junction of the grey Morte slates with the succeeding Upper Old Red Sandstone; a quarter of a mile north of Bittadon these slates dip 43° south, here 30° south; and immediately south, in the red sandstones at Swinham Down, the dip is south also. The road-sections show local undulations and reversed dips in the sandstones; there are scores of such undulations producing anticlinal and synclinal folds on both a large and a small scale across the whole of the Lower, Middle, and Upper Devonian slates and sandstones, from the north coast at Lynton to the Culm-measures on the south at Coddon Hill &c. Here, as at all points along the strike and junction of the Middle argillaceous group with the Upper Sandstone, there is no evidence whatever of reversion of dip, or fault, or anticlinal, in the sense in which it should be understood as existing along a line or axis of great and extended disturbance; and, moreover, on the question of identity or even similarity of the rock-masses of the two areas under discussion which this belt of sandstones divides, *i. e.* the Baggy, Croyde and Marwood area on the south, and the Ilfracombe and Lynton areas on the north, they are to me physically and palæontologically so different, both in great features and in detail, that it cannot be wondered that the older and able geologists who have examined the North Devon and West Somerset groups of rocks should have assigned to them the position, order, and succession they did, however difficult it might have been to have correlated them with the perhaps contemporaneous, or synchronously deposited, Lower, Middle, or Upper Old Red Sandstone of other areas: to me these red, green, white, and grey Upper Old Red Sandstones that stretch from the sea to the Quantock Hills are the natural physical and palæontological base of the well-defined and to them conformable fossiliferous Upper marine Devonian beds of Baggy, Marwood, and Croyde &c., which are in their turn succeeded by the Carboniferous Slates and Coomhola (?) Grits of Braunton, Barnstaple, &c., themselves covered by the equivalents of the Carboniferous Limestone at Yen, Swimbridge &c., and again by the higher Millstone-grit of Coddon Hill. The succession, position, structure, fossil character, &c., of the group of rocks in this traverse, between Ilfracombe and Pilton, showed and proved to me that the Middle and Upper Devonian series underlie conformably, without a break, the Lower Carboniferous or Carbonaceous beds to the south of Pilton and Barnstaple.

5. *Lee and Morte Bay.*—At Lee the lower calcareous fossiliferous member of the Ilfracombe group is succeeded by the upper or non-fossiliferous, grey, smooth, glossy slates of Morte, whose physical features are totally distinct from those to the north or south, and which nearly equal in thickness the Upper Old Red Sandstones overlying them, viz. from Woolacombe, Osborough, West Down, and Potter's Hill on the north side, to Vention and Pickwell on the south. From Bull Point, west of Lee Bay, through Rockham Bay, the smooth argillaceous slates dip south at a mean angle of 40°, with cleavage at an angle of from 60° to 70° south; a remarkable system of white amorphous quartz veins traverses these Rockham Bay slates, chiefly along their strike, from east to west, or obliquely to it; these veins are due probably to fracture and subsequent infiltration by segregation. The undulations and folding of the slates here are continuous, numerous, and traversed by cleavage; and this continues in various degrees to Morte Point, and south of Mortehoe, where again a system of east and west white quartz veins, 2, 4, and 6 feet thick, traverses the vertical slates up the valley to Twitchim. Reefs also stretch out to sea, dipping at very high angles (varying from 70° to 80° S.W.), and with cleavage nearly coincident (60° to 70°*) with the bedding.

No one who has not examined this section between Lee, Rockham, Mortehoe, and the rivulet that descends to the shore from Twitchim, can tell how difficult it is to work out either the dip or cleavage-system in these slates†. In the elevated ridge of ground about the hamlet of Yard, and continuous with Morte Point to the east, they are rolled and form an anticlinal; this ridge is the axis or watershed to the country north and south of it, all the streams taking their rise in this down and falling on either side to the sea. The *total* absence of this great series of slates to the *south* of Pickwell Down, with their attendant conditions and position above the calcareous group of Ilfracombe, is significant, when treating either of the supposed fault (against which they ought to abut, or their absence should be accounted for) or the anticlinal which, if either existed, should repeat them to the south, where, be it remembered, *no vestige* of them occurs. The Morte series gives proof of deep-sea accumulation and is unfossiliferous, whereas the Upper Devonian beds that rest upon the Upper Old Red Sandstones of Pickwell Down are crowded with organic remains, having been deposited under shallow-sea conditions, and having few species in common with the lower beds and those that live on or pass into the Carboniferous series as gradually as the physical changes oscillate also; and a greater contrast amongst

* This system of quartz veins traverses all North Devon (east and west), from Oakhampton quarries, near Wiveliscombe, to Morte Bay, occurring again at Lundy Island, where they traverse the same slates, and under the same conditions, intersecting like network the grey glossy slates of the "Rattles," "Lamatory," and Rat Island—at the southern end of that remarkable island, where trap dykes and quartz veins vie with each other in their ramifications, the former traversing the granite also, in all directions and at all angles.

† It is most difficult to distinguish cleavage-planes from bedding in these slates.

slaty masses can hardly be conceived, even on lithological grounds alone, than in the rock-masses of these two areas *when carefully* examined. I have now to show, if possible, that there is no unconformity in Morte Bay between the Mortehoe and Woolacombe Slates and the Pickwell-Down Sandstones, and that they here insensibly, through lithological changes, graduate into the hard red grits and sandstones at Potter's Hill, Croscombe, and Pickwell Down, as they do at Wiveliscombe and intermediate points. Up to the village of Woolacombe, north of the stream, the slates are seen in places on the shore under Tracey and Potter's Hill dipping 60° and 70° S. The Woolacombe and Osborough valley was carefully searched; and nowhere down the stream, which here runs over and cuts through the strike of the beds, or to the east, at Dean Mill, where they are cut across by another rivulet, and dip 70° S., did I detect any inversion, notable disturbance, or alteration of dip; more than that, the gradation into the thicker beds of Potter's Hill and Higher Bullen is traced through a series of red gritty slates and fissile sandstones dipping 50° S., and resembling in all particulars the junction at and passage under Main Down, west of Wiveliscombe &c.; the small quarry on Potter's Hill showed the same lower thin-bedded red grits dipping 45° S.; on the strike of these beds, east, across the hill, and in a quarry at Higher Bullen, the same series dip 60° S. Descending to the shore under Potter's Hill, and at Tracey, we now take them in upward succession; the reefs of grey fissile slates, with rusty or decomposed bands, that crop out on the shore immediately west of the Kiln at Woolacombe, are the same that occur in the Tracey and Osborough valley, and are immediately succeeded by the Potter's Hill red group. On and along the shore between Woolacombe and Baggy Point twelve groups or reefs of red, claret, grey, and green micaceous sandstones crop up, and the recent marine sands of Morte Bay (Woolacombe Sands) cover up their inclined edges and continuous dip. Every bed visible along the shore, and composing this series of sandstones, was measured, the interspaces (covered by the sands) were paced, and careful notes made upon the whole magnificent section up to the overhanging abrupt northern face and escarpment of Baggy Point, where, without a trace of movement, break, or unconformity, the passage into the true fossiliferous Upper Devonians is complete*. It is both superfluous and unnecessary to describe the Morte section in detail; it speaks for itself; neither above or at the top of the Upper Old Red Sandstone at Vention and Pulsborough, nor at the base at Tracey or Osborough is there any evidence of dislocation, or any trace of a fault.

6. *Conclusions relative to the Middle Devonian or Ilfracombe Group of West Somerset and North Devon.*—(1) Whether the red grits and sandstones of the Hangman should be classed with the upper part of the Lower Devonian or Lynton group, or should constitute the natural base of the Ilfracombe slates, it may be difficult, if not impossible, to determine, no fossils occurring throughout the whole series until we reach the upper gritty beds of the Little Hangman,

* See Mr. Salter's valuable paper upon the Upper Old Red Sandstone of North Devon and South Wales, Quart. Journ. Geol. Soc. xix. 1863.

where casts of *Myalina*, *Favosites cervicornis*, *Cucullæa*, *Macrocheilus brevis*, *Sanguinolaria* &c., and *Natica* are found; these sandstones and their fossils, however, graduate insensibly into the red and grey slates with *Stringocephalus Burtini* in Combe Martin Bay. I therefore place them at the base of the Middle group as the Middle Red Sandstones, the marine Middle Devonian slates being conformable upon them.

(2) These red gritty sandstones constitute a great belt of country, three miles in width, from Trentishoe and West Challacombe on the west, to Croydon Hill in West Somerset, on the east, the beds at Timberscombe being lowest, and those of Ashwell the highest; few fossils are known to occur in these sandstones along this strike of thirty miles; they divide the lower or Lynton slates from the Middle or Ilfracombe; and the base and top are conformable to the Lower slates of Lynton on the one hand, and the Middle or Ilfracombe above on the other. Their thickness is from 1500 to 2000 feet.

(3) Resting upon this extensive series of red sandstones (Middle Old Red) and along the meridian of West Challacombe, Paracombe, Black Barrow Down, Ashwell, Luxborough, and Nettlecombe, as their northern base, are the argillaceous and calcareous slates of the Middle Devonian or Ilfracombe group, its lower half containing a fine and marked assemblage of fossils, its upper half being entirely unfossiliferous and ending at its junction with the Pickwell Down Sandstones, along a line from Woolacombe, at Morte Bay, to the north of Main Down near Wiveliscombe on the east, and almost parallel to the base-line above named; this series, although much rolled and contorted, chiefly with the dip, passes conformably or unfaulted (along the line described) under the Upper Old Red Sandstone of Pickwell, Favisham, and Garmond Downs, Span Head, and Heydon and Main Downs. This zone or series of slates, grits, and limestones together is at least 8000 feet thick.

(4) The upper half of the Middle or Ilfracombe series of slates is unfossiliferous. They are finely exposed at Lee Bay, Rockham Bay, and Morthoe, and stretch across the whole of North Down, from Morte Bay to the Oakhampton Quarries, north of Wiveliscombe; their physical characters are persistent throughout this strike; they everywhere underlie the upper zone of red sandstones, *the* "Old Red Sandstone" of Prof. Jukes, and are conformable to the base of it. Their thickness cannot be less than 3500 or 4000 feet*.

V. Palæontological Value of the Organic Remains found in the Devonian Groups.

I have now to examine, estimate, and coordinate the values of the Devonian groups, separately and collectively, as one great system, both in Great Britain and Europe, especially in those areas where

* In this communication I do not enter into details relative to the Upper Devonian beds. This has been done for that group south of Pickwell Down by Mr. Salter. It would only be repeating his views in detail to do so. *Vide* Quart. Journ. Geol. Soc. vol. xix. 1863.

they are recognized as largely developed (both physically and palæontologically) and are well understood by the Rhenish, Belgian, and French geologists. I also propose to examine the palæontological relations between the Devonian and Carboniferous systems of North Devon in particular, where their relations to each other are clearly made out, and their succession and superposition complete. Again, I propose to examine them in relation to the Carboniferous generally, more especially to that part of the group called the Carboniferous Slates, Coomhola Grits, or Lower Limestone Shales of Ireland, to which Professor Jukes has assigned all the well-known and peculiar Devonian species, as well as the rocks of Devonshire.

The question as to which of the two conformable groups of rocks, viz. the Old Red Sandstone below, or the Carboniferous above, we are to assign the Devonian series, is one, it is to be admitted, of some difficulty; but if we find an assemblage of organic remains having a distinguished and peculiar fauna, characterized by species which are peculiar to it, and totally distinct from the Silurian below, and largely so from the Carboniferous above, as is the case with the Devonian species, then, other things being equal, there are grounds for assigning to the marine fossiliferous group of rocks under consideration an intermediate position, be their relation to the two what it may.

I take the whole of the Devonian series to be chronologically equivalent to the whole of the Old Red Sandstone, or synchronously deposited with that group, but under different mineral and life conditions, and in a *different geographical area*, not side by side, through its whole or entire series, or synchronous with the Carboniferous, as suggested by Prof. Jukes, the assemblage of organic remains nowhere justifying this proposition. Either we must admit that the Devonian series is a marine equivalent in time of the Old Red Sandstone as a whole, or it must be a distinct life-system, occupying an immense area, spreading over an enormous interval of time between the completion of the Old Red Sandstone as a whole, and the commencement of the succeeding and well-marked Carboniferous series, and represented by contemporaneous deposits over a definite and comparatively small area, in Europe (Russia, Germany, Belgium, and France), that area being governed or marked out, especially in England, by geographical and physical conditions now difficult to trace, owing to subsequent movements and denudation or through the accumulation of newer strata along and over the south and west of England. During this epoch, almost identical conditions seem to have existed over the European area where the sandstones, slates, and associated limestones were deposited, the rocks having peculiar and marked physical resemblance, as well as possessing an almost specifically identical fauna, notably so in the Rhenish provinces, from the Taunus to Düsseldorf, the Belgian area, and the Bas Boulonnais, in the North of France,—the stratigraphical position and the zoological grouping of the Devonian rocks being of marked similarity everywhere.

Whatever precise relation the three divisions of the Devonian may have in time to the three equally well-marked groupings of the

Old Red Sandstone of the adjoining districts of Gloucester, Hereford, and South Wales, as well as Scotland, it is certain that they are most intimately related to the European series in every particular; and if it were possible to reconstruct the old geographical area and coast-lines against which, and the areas over which, the marine equivalents of the Old Red Sandstone were deposited or accumulated, we should, I think, find that the northern boundary to the British marine type would be about the latitude of our Mendip Hills, ranging eastwards to Coblentz and the Hundsrück, and westward to the south-west of Ireland, and a region now covered by the Atlantic. The southern boundary may be the north coast of France, or even Asturias and the Pyrenees on the north of Spain, thus constituting an area of great extent *.

1. *Chronological Equivalents of the Old Red Sandstone of Hereford, Scotland, &c.*—The palæontological break between the Silurian rocks and the Old Red Sandstone was nearly complete; and although they are stratigraphically conformable (*in the typical Silurian area*), yet there are only 13 species known as common to the Old Red of the Silurian area and the Silurian rocks. Those species that occur are represented by the Fishes and Pœcilopod Crustacea, which are found through the passage-beds, at all times a doubtful horizon, especially so when no other zoological group exists for comparison, which is so markedly the case at the close of the Silurian and commencement of the Old-Red-Sandstone period. They are the following:—*Cephalaspis Murchisoni, C. ornatus, Auchenaspis Salteri, Onchus Murchisoni, Pteraspis Banksii, P. Lloydii*, and *P. truncatus*. One genus only of these (*Onchus*) is represented in the Carboniferous series. The Crustacea, which are on the confines also of the two, are:—*Eurypterus abbreviatus*, Salt., *E. acuminatus*, Salt., *E. pygmæus*, Salt., *Pterygotus anglicus*, Ag., *P. problematicus*, Salt., and *Stylonurus megalops*.

It must be remembered that there are nearly 1160 described species in the Silurian rocks, and 149 (113 of which are Fish) in the Old Red Sandstone (Table I.), and only the above 7 Fish and 6 Crustacea are known to occur as common to the two formations, and that strictly on their confines †.

The accompanying Table is constructed to show the census of the Palæozoic rocks as now known, the number of species in each class being numerically expressed. The fifth column shows the number of species (56) common to the marine Devonian and the Carboniferous rocks; it is here incorporated as being also of value in future parts of the paper.

* This area will be more definitely noticed hereafter.

† It is stated by Prof. Jukes (Quart. Journ. Geol. Soc. vol. xxii. 1866, p. 366) that a few species, such as *Strophomena rhomboidalis*, occur in both Silurian and Carboniferous: this must be an error; I know no one species common to these two great formations.

TABLE I.—*Showing the present census of species in the Palæozoic Rocks of Great Britain.*

Classes.	Silurian.	Old Red Sandstone.	Devonian.	Sp. com. to Dev. & Carb.	Carboniferous.	Permian.
Plantæ	10	12	4	2	308	20
Amorphozoa	19	...	9	...	...	5
Rhizopoda	...	...	...	...	...	6
Cœlenterata	93	...	53	1	119	5
Echinodermata	83	...	21	4	129	2
Annelida	37	1	2	...	19	6
Crustacea	267	21	13	...	59	20
Insecta	...	...	...	...	3	...
Polyzoa	79	1	13	6	55	6
Brachiopoda	208	...	99	15	157	20
Lamell. { Monomyaria	30	...	22	3	140	6
Lamell. { Dimyaria	99	1	36	6	194	20
Gasteropoda	96	...	46	7	174	25
Nucleobranchiata	22	...	9	3	29	1
Pteropoda	27	...	1	...	1	...
Cephalopoda	77	...	52	9	145	2
Pisces	7	113	3	...	202	21
Reptilia	...	...	...	...	7	2
	1154	149	383	56	1741	167

The following complete Table (II.) has been constructed to show the *whole of the fauna and flora* of the Old Red Sandstone and Devonian rocks in the British islands; and it shows in a marked and satisfactory manner the palæontological values of the two terms. It is constructed so as to show the natural-history grouping of the classes and genera, with the number of species in each genus, and also general or extended, yet definite, geographical areas over which the Devonian rocks are clearly distributed. Other Tables are constructed out of this, and prepared for purposes of more detail. It is necessary to establish one base for reference, either as a typical general group, or a known and definite and received basis, by means of which the species of one group of rocks may be collated or coordinated with those of another, or for comparing the unknown with the known. Stratigraphical sequence demands that we accept the Old Red Sandstone here as our true base, as it is conformable to, and immediately succeeds in time, the Upper Silurian; but on palæontological grounds the Old Red Sandstone stands alone, and can be compared with no other but itself. These conditions in Britain are general; everywhere is it, as Old Red Sandstone, in its three divisions, a barren series for comparison,—two groups only, the class of fishes among the Vertebrata, and the Merostomata (Pœcilopoda) among the Crustacea, being of any value.

It will be found that there are only 149 known species in the Old Red Sandstone proper; and these are distributed through only four classes of the animal kingdom, but they include some plants. They

Table II.—*Showing the entire Fauna and Flora of the Old Red Sandstone and Devonian Rocks of Great Britain, and their comparison with those of the Rhenish-Prussian, Belgian, and French series.*

SPECIES.	OLD RED SANDSTONE.			DEVONIAN. CORNWALL.			DEVONIAN. SOUTH DEVON.			DEVONIAN. NORTH DEVON.						CARBONIFEROUS.								FOREIGN DEVONIANS. RHINE.			BELGIUM.			FRANCE.		
	Lower.	Middle.	Upper.	Lower (Looe).	Middle (Padstow).	Upper (Petherwin).	Lower (Meadsfoot).	Middle (Torquay).	Upper.	Lower (Lynton).	Mid. (Ilfracombe).	Middle (Morte).	Upper (Baggy).	Upper (Pilton).	Passage (Barnstaple).	Irish (Coomhola).	Lower Limest. shale.	Carbonif. limestone.	Upper Limest. shale.	Millstone grit.	Low. Coal-measures.	Mid. Coal-measures.	Upp. Coal-measures.	Lower	Middle.	Upper.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.
PLANTÆ.																																
Caulopteris Peachii, *Salt.*	...	*																														
Lepidodendron nothum, *Ung.*		*																														
Knorria dichotoma, *Haugh.*	...	...	*	...	...	...	...	...	...	...	...	...	*	*	...	*																
Pachytheca sphærica, *Hooker*	...	...	*																													
Adiantites Hibernicus, *Forbes*			*	...	...	...	...	...	...	...	...	...	*	*	...	*																
Lycopodites Milleri, *Salt.*	...	*																														
Sagenaria Veltheimiana, *Sternb.*	...	...	*	...	...	...	...	...	...	...	...	...	*?	*	...	*																
„ Kiltorkensis, *Haugh.*	...	...	*																													
Bornia (Knorria) transitionis, *Göpp.*	...	...	*	...	...	...	...	...	...	...	...	...	*																			
Sphenopteris sp? (Adiantites)	...	...	*																													
Filicites lineatus	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	*																
Trichomanites adnescens, *Göpp.*	...	...	*																													
AMORPHOZOA.																																
Scyphia turbinata, *Goldf.*	...	...	...	...	...	...	...	*																								
Steganodictyum cornubicum, *M'Coy.*	...	...	...	*	...	...	*	*																								
„ Carteri, *M'Coy.*	...	...	...	*	...	...	*																									
Sphærospongia (Echinosphærites) tessellata, *Phill.*	...	...	...	...	...	...	...	*																								
Stromatopora concentrica, *Goldf.*	...	...	...	...	...	...	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*				
„ placenta, *Lonsd.*	...	...	...	...	...	...	...	*																								

Stromatopora polymorpha, *Goldf.*	...	...	...	...	...	...	...	...	*																								
" ramosa, *Brass.*	...	...	...	...	...	...	...	...	*																								
" verticillata, *M'Coy*	...	...	...	...	...	...	...	...	*																								
CŒLENTERATA.																																	
Acervularia Battersbyi, *Edw.*	...	...	...	...	...	...	...	...	*																								
" coronata, *Edw.*	...	...	...	...	...	...	...	...	*																								
" Goldfussii, *De Vern.*	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*				
" intercellulosa, *Phill.*	...	...	...	...	...	...	...	...	*																								
" pentagona, *Goldf.*	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*			
" Rœmeri, *De Vern.*	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*							
" limitata, *Edw.*	...	...	...	...	...	...	...	...	*																								
Alveolites Battersbyi, *Edw.*	...	...	...	...	...	...	...	...	*																								
" compressa, *Edw.*	...	...	...	...	...	...	...	...	*																								
" suborbicularis, *Lam.*	...	...	...	...	...	...	...	...	*	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*							
" vermicularis, *M'Coy.*	...	...	...	...	...	...	...	...	*																								
Amplexus tortuosus, *Phill.*	...	...	...	...	...	...	*	...	*	...	...	*	...	..	?	...	...	...	...	...	...	...	...	...	...	*							
Arachnophyllum Hennahii, *Lonsd.*	...	...	...	...	...	...	...	...	*																								
Battersbyia inæqualis, *Edw.*	...	...	...	...	...	...	...	...	*																								
Campophyllum flexuosum, *Goldf.*	...	...	...	...	...	...	...	...	*																								
Chonophyllum perfoliatum, *Goldf.*	...	...	...	...	...	...	...	...	*																								
Cyathophyllum æquiseptum, *Edw.*	...	...	...	...	...	...	...	...	*	...	...	*																					
" Boloniense, *Blainv.*	...	...	...	...	...	...	...	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	
" cæspitosum, *Goldf.*	...	...	...	...	...	...	*	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*	...	...	*	
" ceratites, *Goldf.*	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*	...	...	*	
" Damnoniense, *Londs.*	...	...	...	...	...	...	...	...	*																								
" helianthoides, *Goldf.*	...	...	...	...	...	...	...	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*	...	...	*	
" hexagonum, *Goldf.*	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*							
" Marmini, *Edw.*	...	...	...	...	...	...	...	...	*																								
" obtortum, *Edw.*	...	...	...	...	...	...	...	...	*	...	...	*																					
" Rœmeri, *Edw.*	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*				
" Sedgwickii, *Edw.*	...	...	...	...	...	...	...	...	*																								
Cystiphyllum Damnoniense, *Lonsd.*	...	...	...	...	...	...	...	...	*																								
" vesciculosum, *Goldf.*	...	...	...	...	...	...	...	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*				
Emmonsia hemisphærica, *Edw.*	...	...	...	...	...	...	...	...	*																								
Endophyllum abditum, *Edw.*	...	...	...	...	...	...	...	...	*																								
" Bowerbankii, *Edw.*	...	...	...	...	...	...	...	...	*																								
Favosites Goldfussii, *D'Orb.*	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*	...	...	*	
" cervicornis, *Blainv.*	...	...	...	...	...	...	...	*	*	...	*	*	...	...	...	...	...	...	...	...	...	...	...	...	*	*	...	...	*	*	...	*	

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CŒLENTERATA (*continued*).																																
Favosites dubia, *Blainv.*	...	...	...	...	...	...	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	*	
„ fibrosa? *Goldf.*	...	...	...	*	...	...	*	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*				
„ reticulata, *Blainv.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*				
Fistulipora cribrosa (F. Mamon), *Goldf.*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	*	...	*				
Hallia Pengellyi, *Edw.*	...	...	...	...	...	...	...	*	...	...	*																					
Heliolites porosa, *Goldf.*	...	...	...	...	...	...	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*				
Heliophyllum Hallii, *Edw.*	...	...	...	...	...	...	...	*	...	...	*																					
Metriophyllum Battersbyi, *Edw.*	...	...	...	...	...	...	...	*																								
Michelinia antiqua, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	...	*?	*?	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Pachyphyllum Devoniense, *Edw.*	...	...	...	...	...	...	...	*	...	...	*																					
Petraia bina? *Sil.*, *Lonsd.*																																
„ Celtica? *Lonsd.*	...	...	...	*	*	*	*	*	...	...	...	...	...	*																		
„ gigas, *M'Coy.*	...	...	...	...	...	...	...	*																								
„ pleuriradialis, *Phill.*	...	...	...	*	...	...	*	...	...	*	...	...	...	*	...	...	*?															
Pleurodictyum problematicum, *Goldf.*	...	...	...	*	...	...	*	*	...	...	...	...	...	*?	...	*?	...	...	...	...	...	...	...	...	*	*	*	*	...	*		
Smithia Pengellia, *Edw.*	...	...	...	...	...	...	...	*																								
„ Bowerbankii, *Edw.*	...	...	...	...	...	...	...	*																								
„ Hennahii, *Lonsd.*	...	...	...	...	...	...	...	*																								
Spongiophyllum Sedgwickii, *Edw.*	...	...	...	...	...	...	...	*																								
Strephodes gracilis, *M'Coy.*	...	...	...	...	...	...	...	*																								
Syringophyllum cantabricum, *De Vern.*	...	...	...	...	...	...	...	*																								

ECHINODERMATA.																																
Actinocrinus tenuistriatus, *Phill.*	...	...	...	...	...	...	...	*	...	*	...	...	...	*																		
„ triacontadactylus ? ?, *Miller*	...	...	...	...	...	...	...	*	...	...	...	...	...	*	...	*	...	*	...	...	...	...	...	...	...	...	...	*				
Adelocrinus (Platycrinus) hystrix, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*	...	*														
Cupressocrinus crassus, *Phill.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*							
Cyathocrinus distans	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*																	
„ ellipticus	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	*														
„ macrodactylus	...	...	...	...	...	...	...	...	...	...	*	...	*	*																		
„ megastylus	...	...	...	...	...	...	*																									
„ nodulosus	...	...	...	...	...	...	...	*																								
„ pinnatus, *Goldf.*	...	...	...	...	...	...	*	...	...	...	...	...	...	*	...	*	...	*	*	...	...	...	...	...	*	...	...	*				
„ geometricus, *Goldf.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	*				
„ variabilis, *Phill.*	...	...	...	...	...	*	...	...	...	...	*	...	*	*	...	...	...	*	*													
Hexacrinus depressus, *Aust.*	...	...	...	...	...	...	...	*																								
„ interscapularis, *Phill.*	...	...	...	...	...	...	...	*																								
„ macrotatus, *Aust.*	...	...	...	...	...	...	...	*																								
Pentremites ovalis, *Goldf.*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	*?														
Platycrinus tuberculatus, *Miller*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	*														
„ pentangularis, *Miller*	...	...	...	...	...	...	...	*																								
Taxocrinus macrodactylus, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	...	*																		
Protaster, sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	*																		
Palæaster, sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	*																		
ANNELIDA.																																
Serpula advena, *Salt.*	...	...	*																													
Tentaculites annulatus ? *Schloth.*	...	...	...	...	...	...	...	*	...	...	*																					
„ scalaris, *Schloth.*	*	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	*								
CRUSTACEA.																																
Bronteus flabellifer, *Goldf.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*	...	...	*	
Campicaris Forfarensis, *Page*	*																															
Cheirurus articulatus, *Münst.*	...	...	...	...	...	...	...	*																								
„ Sternbergii, *Münst.*	...	...	...	...	...	...	...	*																								
Cypridina serrato-striata, *Sand.*	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	*			
Estheria membranacea, *Pacht.*	*	*																														
Eurypterus abbreviatus, *Salt.*	...	...	*																													
„ acuminatus, *Salt.*	*	...	*																													
„ Brewsteri, *Powrie*	*																															

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CRUSTACEA (*continued*).																																
Eurypterus megalops, *Salt.*	*																															
" Scouleri, *Hibbert*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*													
" pygmæus, *Salt.*	*																															
Harpes macrocephalus, *Goldf.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*							
Homalonotus Herschellii? *Phill.*	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*							
" armatus	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*	...	*					
Parka decipiens, *Page*	*	...	*																													
Leperditia marginata, *Jones*	*																															
Phacops granulatus, *Münst.*	...	...	...	...	...	*	...	*	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	*							
" laciniatus, *Rœm.*	...	...	...	*	*	*	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*							
" latifrons, *Bronn.*	...	...	...	...	*	*	...	*	...	...	...	...	*	*	*	...	...	...	...	...	...	...	...	*	*	*	...	*	*	...	*	*
" punctatus, *Stein.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*							
" (Trimerocephalus) lævis, *Münst.*	...	...	...	...	...	...	...	*	...	...	*	...	...	*																		
" cryptophthalmus, *Emm.*	...	...	...	...	...	...	...	*																								
Pterygotus Anglicus, *Ag.*	*																															
" minor, *H. Woodw.*	*																															
" Brewsteri, *Powrie*	*																															
" problematicus, *Salt.*	*																															
Stylonurus Loganii, *Woodw.*	*																															
" punctatus, *Salt.*	*																															
" ensiformis, *Woodw.*	*																															
" Scoticus, *Woodw.*	*																															

Stylonurus Symondsii, *Salt.*	*																															
„ Powriei, *Page*	*																															
„ magalops, *Salt.*	*	...	*																													
POLYZOA.																																
Berenicea M'Coyii	...	*	...	...	*																											
Ceriopora similis, *Phill.*	...	...	...	...	...	...	...	*	...	...	*	...	...	?	...	...	*	*														
„ gracilis, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	*	*																		
Fenestella antiqua, *Goldf.*	...	...	...	*	...	*	...	*	...	*	*	...	*	*	...	*	*	*														
„ arthritica, *Phill.*	...	...	...	...	...	...	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*			
„ plebeia, *M'Coy*	...	...	...	...	...	*	...	...	...	...	...	...	...	*	...	*	*	*														
„ prisca, *Goldf.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	*	*														
Glauconome bipinnata, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	*	*	...	...	*	*														
„ sp.	...	...	...	...	...	...	...	...	...	...	*																					
Hemitrypa oculata, *Phill.*	...	...	...	...	...	...	*	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*							
Polypora laxa, *Phill.*	...	...	...	...	...	*	...	*	...	...	...	...	*	*	...	*	*	*	...	...	...	...	...	...	*							
Ptylopora flustriformis, *Phill.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*							
Retepora repisteria, *Goldf.*	...	...	...	...	...	...	*	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*	
BRACHIOPODA.																																
Athyris Bartonensis, *Dav.*	...	...	...	...	...	...	...	*																								
„ concentrica, *V. Buch*	...	...	...	...	*	*	*	*	...	...	*	...	*	*	...	...	...	...	...	...	...	...	...	...	...	*	...	*	*	...	*	*
„ decussata, *Sow.*	...	...	...	...	...	*	...	...	...	...	...	...	...	*																		
„ indentata, *Sow.*	...	...	...	...	...	*	...	...	...	...	...	...	...	?	*																	
„ lachryma, *Sow.* ?	...	...	...	...	...	...	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...	*
„ Newtonensis, *Dav.*	...	...	...	...	...	...	...	*																								
„ oblonga (planosulcata ?), *Sow.*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*	*	...	*	*													
„ phalæna, *Phill.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	
Atrypa desquamata, *Sow.*	...	...	...	*	*	*	...	*	...	...	*	...	...	*?																		
„ flabellata, *Goldf.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*				
„ lens, *Phill.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*							
„ lepida, *Goldf.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*	...	...	*				
„ reticularis, *Linn.*	...	...	...	*	...	*	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	*	*	...	...	*	...	...	*	*
„ „ var. aspera, *Schloth.*	...	...	...	*	...	*	...	*	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*	...	...	*	*
Calceola sandalina, *Linn.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*	...	...	*	
Camarophoria rhomboidea, *Phill.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*				
Chonetes Hardrensis (C. sordida), *Phill.*	...	...	...	*	...	...	...	*	...	*	...	...	*	*	*	*	*	*	*	...	...	...	...	*	*	*						
„ minuta, *Goldf.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*				

Table II. (continued).—*Showing the entire Fauna and Flora of the Old Red Sandstone and Devonian Rocks of Great Britain, and their comparison with those of the Rhenish-Prussian, Belgian, and French series.*

SPECIES.	OLD RED SANDSTONE.			DEVONIAN.												CARBONIFEROUS.								FOREIGN DEVONIANS.								
				CORNWALL.			SOUTH DEVON.			NORTH DEVON.														RHINE.			BELGIUM.			FRANCE.		
	Lower.	Middle.	Upper.	Lower (Looe).	Middle (Padstow).	Upper (Petherwin).	Lower (Meadsfoot).	Middle (Torquay).	Upper.	Lower (Lynton).	Middle (Ilfracombe).	Middle (Morte).	Upper (Baggy).	Upper (Pilton).	Passage (Barnstaple).	Irish (Coomhola).	Lower Limest. shale.	Carbonif. limestone.	Upper Limest. shale.	Millstone grit.	Low. Coal-measures.	Mid. Coal-measures.	Upp. Coal-measures.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.
Brachiopoda (*continued*).																																
Cyrtina amblygona, *Phil.*								*																								
„ Demarlii, *V. Buch*								*																							*	
„ heteroclyta, *Defr.*								*			*													*	*	*		*	*			*
„ multiplicata, *Dav.*								*																								
Davidsonia Verneuilii, *V. Buch*								*																				*				
Discina nitida, *Phill.*													*	*		*	*	*	*	*	*											
Leptæna interstrialis, *Phil.*								*																	*			*				
„ laticosta, *Conrad*				*			*																	*				*			*	
„ nobilis, *M'Coy*								*																*								
Merista plebeia, *Sow.*								*			*														*			*				
Lingula squamiformis, *Phill.*													*	*		*	*	*				*										
Orthis arcuata, *Phill.*				*				*		*																						
„ granulosa, *Phill.*							*	*		*																						
„ hians, *V. Buch*																																
„ hipparionyx, *Vanux.*				*			*?																									
„ interlineata, *Sow.*						*					*		*	*	*																	
„ striatula, *Schloth.*						*		*			*			*											*	*		*				*
Pentamerus biplicatus, *Schnur*								*																				*				
„ brevirostris, *Phill.*					*			*																	*			*			*	
Productus longispinus, *Dav.*														*?																		
„ prælongus, *Sow.*													*	*																		

„ scabriculus, *Mart.*														*	*	*		*	*							*			*			*
Rensseleria stringiceps, *Ræm.*								*			*													*	*							
Rhynchonella acuminata, *Mart.*								*										*							*			*			*	
„ angularis, *Phill.*								*																								
„ bifora, *Phill.*								*																								
„ cuboides, *Sby.*							*	*			*														*				*			
„ laticosta, *Phill.*								*					*	*																		
„ Lumatoniensis, *Dav.*								*																								
„ Ogwelliensis, *Dav.*								*																								
„ Pengelliana, *Dav.*				*																												
„ pleurodon, *Phill.*						*		*			*		*	*	*	*		*	*													
„ primipilaris, *V. Buch*								*																	*			*				*
„ protracta, *Sby.*								*																								
„ pugnus, *Mart.*						*		*			*			*		*		*							*			*				*
„ reniformis, *Sby.*						*		*					*	*				*														
„ sphærica? *Sby.*								*																								
„ triloba, *Sby.*								*																								
„ implexa? young of R. primipilaris, *V. Buch*								*																				*				
Retzia ferrita, *V. Buch*								*																	*			*				
Spirifera canalifera, *Valen.*										*	*														*			*			*	
„ comprimata? *Schloth.*								*																					*			
„ curvata, *Schloth.*				*				*			*														*			*				
„ cultrijugata, *Ræm.* (S. primæva, *Stein.*)				*																				*	*		*				*	
„ disjuncta, *Sby.* (S. Verneullii, *Murch.*)						*		*			*		*	*											*	*			*		*	*
„ hysterica, *Schloth.*				*	*					*														*	*		*				*	*
„ lævicosta, *Valen.*				*				*		*															*			*	*			
„ lineata, *Mart.*						*		*						*															*			
„ macronota, *Hall.*																																
„ megaloba, *Phill.*														*																		
„ mesomala, *Phill.*														*																		
„ Newtonensis, *Dav.*								*																								
„ obliterata, *Phill.*														*																		
„ nuda, *Sow.*								*			*																					
„ rudis, *Phill.*													*																			
„ simplex, *Phill.*								*																	*			*				
„ speciosa, *Schloth.*				*	*			*			*													*	*			*		*	*	
„ Urei, *Fleming*						*		*					*	*	*	*		*														

TABLE II. (continued).—*Showing the entire Fauna and Flora of the Old Red Sandstone and Devonian Rocks of Great Britain, and their comparison with those of the Rhenish-Prussian, Belgian, and French series.*

SPECIES.	OLD RED SANDSTONE.			DEVONIAN.												CARBONIFEROUS.								FOREIGN DEVONIANS.								
				CORNWALL.			SOUTH DEVON.			NORTH DEVON.														RHINE.			BELGIUM.			FRANCE.		
	Lower.	Middle.	Upper.	Lower (Looe).	Middle (Padstow).	Upper (Petherwin).	Lower (Meadsfoot).	Middle (Torquay).	Upper.	Lower (Lynton).	Middle (Ilfracombe).	Middle (Morte).	Upper (Baggy).	Upper (Pilton).	Passage (Barnstaple).	Irish (Coomhola).	Lower Limest. shale.	Carbonif. limestone.	Upper Limest. shale.	Millstone grit.	Low. Coal-measures.	Mid. Coal-measures.	Upp. Coal-measures.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.
BRACHIOPODA (*continued*).																																
Cyrtina amblygona, *Phil.*								*																								
,, Demarlii, *V. Buch*								*																							*	
,, heteroclyta, *Defr.*								*			*													*	*	*		*	*			*
,, multiplicata, *Dav.*								*																								
Davidsonia Verneuilii, *V. Buch*								*																				*				
Discina nitida, *Phill.*													*	*		*	*	*	*	*	*											
Leptæna interstrialis, *Phil.*								*																	*			*				
,, laticosta, *Conrad*				*			*																	*				*			*	
,, nobilis, *M'Coy*								*																*								
Merista plebeia, *Sow.*								*			*														*			*				
Lingula squamiformis, *Phill.*													*	*		*	*	*				*										
Orthis arcuata, *Phill.*				*				*		*																						
,, granulosa, *Phill.*							*	*		*																						
,, hians, *V. Buch*																																
,, hipparionyx, *Vanux.*				*			*?																									
,, interlineata, *Sow.*						*					*		*	*	*																	
,, striatula, *Schloth.*						*		*			*			*																		
Pentamerus biplicatus, *Schnur*								*																	*	*		*				*
,, brevirostris, *Phill.*					*			*																				*				
Productus longispinus, *Dav.*														*?											*			*			*	
,, prælongus, *Sow.*													*	*																		
Productus subaculeatus, *Murch.*								*																								
,, scabriculus, *Mart.*														*	*	*		*	*							*			*			*
Rensseleria stringiceps, *Rœm.*								*			*													*	*							
Rhynchonella acuminata, *Mart.*								*										*							*			*			*	
,, angularis, *Phill.*								*																								
,, bifora, *Phill.*								*																								
,, cuboides, *Sby.*							*	*			*														*				*			
,, laticosta, *Phill.*								*					*	*																		
,, Lumatoniensis, *Dav.*								*																								
,, Ogwelliensis, *Dav.*								*																								
,, Pengelliana, *Dav.*				*																												
,, pleurodon, *Phill.*						*		*			*		*	*	*	*		*	*													
,, primipilaris, *V. Buch*								*																	*			*				*
,, protracta, *Sby.*								*																								
,, pugnus, *Mart.*						*		*			*			*		*		*							*			*				*
,, reniformis, *Sby.*						*		*					*	*				*														
,, sphærica ? *Sby.*								*																								
,, triloba. *Sby.*								*																								
,, implexa ? young of R. primipilaris, *V. Buch*								*																				*				
Retzia ferrita, *V. Buch*								*																	*			*				
Spirifera canalifera, *Valen.*										*	*														*			*			*	
,, comprimata ? *Schloth.*								*																					*			
,, curvata, *Schloth.*				*				*			*														*			*				
,, cultrijugata, *Rœm.* (S. primæva, *Stein.*)				*																				*	*		*				*	
,, disjuncta, *Sby.* (S. Verneuilii, *Murch.*)						*		*			*		*	*											*	*			*		*	*
,, hysterica, *Schloth.*				*	*					*														*	*		*				*	*
,, lævicosta, *Valen.*				*				*		*															*			*	*			
,, lineata, *Mart.*						*		*						*															*			
,, macronota, *Hall.*																																
,, megaloba, *Phill.*														*																		
,, mesomala, *Phill.*														*																		
,, Newtonensis, *Dav.*								*																								
,, obliterata, *Phill.*														*																		
,, nuda, *Sow.*								*			*																					
,, rudis, *Phill.*													*																			
,, simplex, *Phill.*								*																	*			*				
,, speciosa, *Schloth.*				*	*			*			*													*	*			*		*	*	
,, Urei, *Fleming*						*		*					*	*	*	*		*														

Table II. (continued).—*Showing the entire Fauna and Flora of the Old Red Sandstone and Devonian Rocks of Great Britain, and their comparison with those of the Rhenish-Prussian, Belgian, and French series.*

SPECIES.	OLD RED SANDSTONE.			DEVONIAN. CORNWALL.			DEVONIAN. SOUTH DEVON.			DEVONIAN. NORTH DEVON.						CARBONIFEROUS.								FOREIGN DEVONIANS. RHINE.			FOREIGN DEVONIANS. BELGIUM.			FOREIGN DEVONIANS. FRANCE.		
	Lower.	Middle.	Upper.	Lower (Looe).	Middle (Padstow).	Upper (Petherwin).	Lower (Meadsfoot).	Middle (Torquay).	Upper.	Lower (Lynton).	Mid. (Ilfracombe).	Middle (Morte).	Upper (Baggy).	Upper (Pilton).	Passage (Barnstaple).	Irish (Coomhola).	Lower Limest. shale.	Carbonif. Limestone.	Upper Limest. shale.	Millstone grit.	Low. Coal-measu res.	Mid. Coal-measures.	Upp. Coal-measures.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.
Brachiopoda (*continued*).																																
Spirifera subcuspidata, *Schnur*								*																	*			*				
„ undifera, *Rœm.*								*																	*			*				
„ „ var. undulata, *Rœm.*								*																	*							
Spiriferina cristata, *Schloth.*				*				*					*	*		*		*														
„ insculpta, *Phill.*								*										*														
Stringocephalus Burtini, *Def.*								*			*														*			*			*	
Streptorhynchus crenistria, *Phill.*						*		*			*		*	*	*	*	*	*											*			
„ gigas, *M'Coy*				*																												
„ persarmentosus, *M'Coy*				*																												
„ plicata, *Sow.*													*	*																		
„ semicircularis, *Phill.*													*																			
„ umbraculum, *Schloth.*				?	*			*		*	*																					
Strophalosia productoides, *Murch.*						*							*	*	*																	*
Strophomena rhomboidalis, *Wahl.*								*			*		*	*	*	*	*	*							*				*			
Terebratula elongata?, *Schloth.*													*	*											*							
„ sacculus, *Mart.*								*					*	*				*										*	*			
„ juvenis, *Sow.*								*																								
„ Newtonensis, *Dav.*								*																							*	
Uncites gryphus, *Schloth.*								*																	*			*				
Lamellibranchiata (Monomyaria).																																
Avicula Damnoniensis, *Sow.*													*	*		*?																

Avicula exarata, *Phill.*						*																										
,, subradiata, *Phill.*						*		*						*																		
Aviculopecten alternatus, *Phill.*						*																										
,, arachnoideus, *Phill.*						*																										
,, granosus, *Sow.*						*																										
,, granulosus, *Phill.*						*																										
,, nexilis, *Sow.*														*	*	*?																
,, pectinoides, *Sow.*															*																	
,, plicatus, *Sow.*								*								*		*														
,, polytrichus, *Phill.*							*							*																		
,, rugosus, *Phill.*								*																								
,, transversus, *Sow.*						*							*	*	*											*		*				
Pterinea anisota, *Phill.*							*																									
,, cancellata, *Phill.*													*	*																		
,, radiata, *Goldf.*								*																								
,, reticulata, *Phill.*								*					*												*			*				
,, rudis, *Phill.*														*																		
,, spinosa, *Phill.*				*		*				*																						
,, texturata, *Phill.*								*																								
,, ventricosa, *Goldf.*						*																		*								
,, subradiata, *Sow.*								*																								
LAMELLIBRANCHIATA (DIMYARIA).																																
Anodonta Jukesii, *Forbes*			*																													
Cardiola retrostriata, *Keys.*						*																							*			
Clidophorus ovatus, *Sow.*							*	*						*?																		
Conocardium aliforme, *Sow.*								*										*								*		*	*			
,, minax, *Phill.*								*																	*							
Corbula Hennahii, *Sow.*								*																								
Cucullæa amygdalina, *Phil.*								*					*	*		*	*															*
,, angusta, *Sow.*													*																			
,, complanata, *Phill.*													*																			
,, depressa, *Phill.*													*																			
,, Hardingii, var., *Sow.*													*	*		*																*
,, trapezium, *Sow.*													*			*																*
,, unilateralis, *Sow.*													*			*																
Ctenodonta elliptica, *Phill.* ?						*																										
,, krachtæ, *Rœm.*										*															*							
,, latissima, *Phill.*													*	*																		

TABLE II. (continued).—*Showing the entire Fauna and Flora of the Old Red Sandstone and Devonian Rocks of Great Britain, and their comparison with those of the Rhenish-Prussian, Belgian, and French series.*

SPECIES.	OLD RED SANDSTONE. Lower.	OLD RED SANDSTONE. Middle.	OLD RED SANDSTONE. Upper.	DEVONIAN. CORNWALL. Lower (Looe).	DEVONIAN. CORNWALL. Middle (Padstow).	DEVONIAN. CORNWALL. Upper (Petherwin).	DEVONIAN. SOUTH DEVON. Lower (Meadsfoot).	DEVONIAN. SOUTH DEVON. Middle (Torquay).	DEVONIAN. SOUTH DEVON. Upper.	DEVONIAN. NORTH DEVON. Lower (Lynton).	DEVONIAN. NORTH DEVON. Mid. (Ilfracombe).	DEVONIAN. NORTH DEVON. Middle (Morte).	DEVONIAN. NORTH DEVON. Upper (Baggy).	DEVONIAN. NORTH DEVON. Upper (Pilton).	DEVONIAN. NORTH DEVON. Passage (Barnstaple).	CARBONIFEROUS. Irish (Coomhola).	CARBONIFEROUS. Lower Limest. shale.	CARBONIFEROUS. Carbonif. Limestone.	CARBONIFEROUS. Upper Limest. shale.	CARBONIFEROUS. Millstone grit.	CARBONIFEROUS. Low. Coal-measures.	CARBONIFEROUS. Mid. Coal-measures.	CARBONIFEROUS. Upp. Coal-measures.	FOREIGN DEVONIANS. RHINE. Lower.	FOREIGN DEVONIANS. RHINE. Middle.	FOREIGN DEVONIANS. RHINE. Upper.	FOREIGN DEVONIANS. BELGIUM. Lower.	FOREIGN DEVONIANS. BELGIUM. Middle.	FOREIGN DEVONIANS. BELGIUM. Upper.	FOREIGN DEVONIANS. FRANCE. Lower.	FOREIGN DEVONIANS. FRANCE. Middle.	FOREIGN DEVONIANS. FRANCE. Upper.
BRACHIOPODA (*continued*).																																
Spirifera subcuspidata, *Schnur*								*																	*			*				
„ undifera, *Rœm.*								*																	*			*				
„ „ var. undulata, *Rœm.*								*																	*							
Spiriferina cristata, *Schloth.*				*				*					*	*		*		*														
„ insculpta, *Phill.*								*										*														
Stringocephalus Burtini, *Def.*								*			*														*			*			*	
Streptorhynchus crenistria, *Phill.*						*		*			*		*	*	*	*	*	*											*			
„ gigas, *M'Coy*				*																												
„ persarmentosus, *M'Coy*				*																												
„ plicata, *Sow.*													*	*																		
„ semicircularis, *Phill.*													*																			
„ umbraculum, *Schloth.*				?	*			*		*	*																					
Strophalosia productoides, *Murch.*						*							*	*	*																	*
Strophomena rhomboidalis, *Wahl.*								*			*		*	*	*	*	*	*							*				*			
Terebratula elongata?, *Schloth.*													*	*											*							
„ sacculus, *Mart.*								*					*	*				*										*	*			
„ juvenis, *Sow.*								*																								
„ Newtonensis, *Dav.*								*																							*	
Uncites gryphus, *Schloth.*								*																	*			*				
LAMELLIBRANCHIATA (MONOMYARIA).																																
Avicula Damnoniensis, *Sow.*													*	*		*?																
Avicula exarata, *Phill.*						*																										
„ subradiata, *Phill.*						*		*						*																		
Aviculopecten alternatus, *Phill.*						*																										
„ arachnoideus, *Phill.*						*																										
„ granosus, *Sow.*						*																										
„ granulosus, *Phill.*						*																										
„ nexilis, *Sow.*														*	*	*?																
„ pectinoides, *Sow.*															*																	
„ plicatus, *Sow.*								*								*		*														
„ polytrichus, *Phill.*							*							*																		
„ rugosus, *Phill.*								*																								
„ transversus, *Sow.*						*							*	*	*											*		*				
Pterinea anisota, *Phill.*							*																									
„ cancellata, *Phill.*													*	*																		
„ radiata, *Goldf.*								*																								
„ reticulata, *Phill.*								*					*												*			*				
„ rudis, *Phill.*														*																		
„ spinosa, *Phill.*				*		*				*																						
„ texturata, *Phill.*								*																								
„ ventricosa, *Goldf.*						*																		*								
„ subradiata, *Sow.*								*																								
LAMELLIBRANCHIATA (DIMYARIA).																																
Anodonta Jukesii, *Forbes*			*																													
Cardiola retrostriata, *Keys.*						*																							*			
Clidophorus ovatus, *Sow.*							*	*						*?																		
Conocardium aliforme, *Sow.*								*										*								*		*	*			
„ minax, *Phill.*								*																	*							
Corbula Hennahii, *Sow.*								*																								
Cucullæa amygdalina, *Phil.*								*					*	*		*	*															*
„ angusta, *Sow.*													*																			
„ complanata, *Phill.*													*																			
„ depressa, *Phill.*													*																			
„ Hardingii, var., *Sow.*													*	*		*																*
„ trapezium, *Sow.*													*			*																*
„ unilateralis, *Sow.*													*			*																
Ctenodonta elliptica, *Phill.*?						*																										
„ krachtæ, *Rœm.*										*															*							
„ latissima, *Phill.*													*	*																		

TABLE II. (continued).—*Showing the entire Fauna and Flora of the Old Red Sandstone and Devonian Rocks of Great Britain, and their comparison with those of the Rhenish-Prussian, Belgian, and French series.*

SPECIES.	OLD RED SANDSTONE.			DEVONIAN.												CARBONIFEROUS.								FOREIGN DEVONIANS.								
				CORNWALL.			SOUTH DEVON.			NORTH DEVON.														RHINE.			BELGIUM.			FRANCE.		
	Lower.	Middle.	Upper.	Lower (Looe).	Middle (Padstow).	Upper (Petherwin).	Lower (Meadsfoot).	Middle (Torquay).	Upper.	Lower (Lynton).	Mid. (Ilfracombe).	Middle (Morte).	Upper (Baggy).	Upper (Pilton).	Passage(Barnstaple).	Irish (Coomhola).	Lower Limest. shale.	Carbonif. Limestone.	Upper Limest. shale.	Millstone grit.	Low. Coal-measures.	Mid. Coal-measures.	Upp. Coal-measures.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.
LAMELLIBRANCHIATA (DIMYARIA) (*continued*).																																
Ctenodonta lineata, *Phill.*	...	...	...	...	...	...	...	*	...	...	...	...	*	*																		
„ plicata, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	*	*																		
„ pullastriformis, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	...	*																			
„ antiqua	...	...	...	...	...	*	...	...	...	...	...	...	*	*																		
Curtonotus unio, *Salt.*	...	...	...	...	...	...	...	...	...	...	...	...	...	*																		
„ elegans, *Salt.*	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*	*															
Cypricardia Phillipsii ?, *D'Orb.*	...	...	...	...	...	...	...	...	...	...	...	...	*	*																		
Leptodomus constrictus, *M'Coy.*	...	...	...	...	...	...	...	...	...	...	...	...	*																			
Megalodon carinatus, *Goldf.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*				
„ cucullatus, *Sow.*	...	...	...	...	...	...	...	*?	...	*	*?	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*				
Modiola amygdalina, *Phill.*	...	...	...	...	...	*																										
„ scalaris, *Phill.*	...	...	...	...	...	...	...	*																								
Mytilus Damnoniensis, *Phill.*	...	...	...	...	...	...	...	*																								
Orthonota semisulcata	...	...	...	...	...	*																										
Sanguinolaria elliptica, *Phill.*	...	...	...	...	...	*	...	...	...	...	...	...	...	*																		
„ (Edmondia) sulcata, *Münst.*	...	...	...	...	...	*	...	*	...	...	...	...	...	*																		
Sanguinolites complanatus, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	*	*																		
„ liratus, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	...	*																		
Schizodus deltoideus, *Phill.*	...	...	...	...	...	*	...	...	...	...	*																					
Myalina, sp.	...	...	...	...	...	...	...	...	...	...	*																					

GASTEROPODA.																																
Acroculia sigmoidalis, *Phill.*								*																								
„ vetusta, *Sow.*								*			*			*		*		*							*			*				
„ triloba, *Phill.*								*																								
Euomphalus annulatus, *Phill.*								*																								
„ circularis, *Phill.*								*																								
„ radiatus, *Phill.*								*			*																	*				
„ serpens, *Phill.*						*		*			*			*																		
„ lævis, *Goldf.* (E. serpens, *Phill.*).								*																	*			*				
„ planorbis, *Vern.*								*										*							*			*				
Helminthochiton								*																								
Loxonema Hennahiana, *Phill.*								*																								
„ lincta, *Phill.*								*																								
„ nexilis, *Phill.*						*		*																	*							
„ præterita, *Phill.*								*																								
„ reticulata. *Phill.*								*																	*							
„ rugifera, *Phill.*														*				*														
„ sinuosa, *Phill.*						*																										
„ tumida, *Phill.*						*												*														
Macrocheilus brevis, *Sow.*								*			*																					
„ elongatus, *Phill.*								*																								
„ harpula, *Sow.*								*																				*				
„ imbricatus, *Sow.*								*																								
„ neglectus, *Phill.*														*																		
„ subcostatus, *Schloth.*								*																								
„ ventricosus, *Goldf.*								*																	*							
Murchisonia angulata, *Phill.*						*								*				*								*						
„ bigranulosa, *D'Arch.*								*																	*	*		*				
„ geminata, *Phill.*								*																		*						
„ spinosa, *Phill.*								*										*							*			*				
„ tricincta, *Phill.*								*																								
Natica meridionalis, *Phill.*												*	*																			
„ nexicosta, *Phill.*						*																							*			
Nerita deformis, *Sow.*								*																								
Pleurotomaria aspera, *Sow.*						*		*		*				*																		
„ cancellata, *Phill.*						*								*																		
„ cirriformis, *Sow.*								*																				*				
„ expansa, *Phill.*													*	*				*?														
„ gracilis, *Phill.*													*	*																		

TABLE II. (continued).—*Showing the entire Fauna and Flora of the Old Red Sandstone and Devonian Rocks of Great Britain, and their comparison with those of the Rhenish-Prussian, Belgian, and French series.*

SPECIES.	OLD RED SANDSTONE.			DEVONIAN.															CARBONIFEROUS.								FOREIGN DEVONIANS.								
				CORNWALL.			SOUTH DEVON.			NORTH DEVON.														RHINE.			BELGIUM.			FRANCE.		
	Lower.	Middle.	Upper.	Lower (Looe).	Middle (Padstow).	Upper (Petherwin).	Lower (Meadsfoot).	Middle (Torquay).	Upper.	Lower (Lynton).	Mid. (Ilfracombe).	Middle (Morte).	Upper (Baggy).	Upper (Pilton).	Passage(Barnstaple).	Irish (Coomhola).	Lower Limest. shale.	Carbonif. Limestone.	Upper Limest. shale.	Millstone grit.	Low. Coal-measures.	Mid. Coal-measures.	Upp. Coal-measures.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.
GASTEROPODA—*continued.*																																
Pleurotomaria impendens, *Sow.*								*																								
„ monilifera, *Phill.*								*										*?											*			
„ multispira								*																								
Scoliostoma textata, *Phill.*								*																								
Trochus Boueii, *Stein.*								*																				*				
Turbo cirriformis, *Sow.*								*																	*							
„ subangulatus, *Sow.*								*																								
Vermetus antitorquatus, *Phill.*						*		*																		*						
„ annulosus								*																								
NUCLEOBRANCHIATA.																																
Bellerophon bisculcatus, *Rœm.*				*		*					*			*																		
„ striatus, *Bronn.*								*		*																		*				
„ subglobatus, *M'Coy.*													*	*		*																
„ Urii, *Fleming*													*	*		*		*											*			
„ hiulcus, *Sow.*						*												*											*			
Porcellia Woodwardii, *Sow.*							*	*?																				*	*			
„ striata							*	*																								
„ Symmondsii													*	*	*																	
PTEROPODA.																																
Conularia											*																					

CEPHALOPODA.																																
Clymenia bisulcata, *Münst.*	...	...	...	...	...	*																										
" fasciata, *Phill.*	...	...	...	...	...	*																										
" lævigata, *Münst.*	...	...	...	...	...	*	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*				
" Münsteri, *M'Coy*	...	...	...	...	...	*																										
" Pattisonii, *M'Coy*	...	...	...	...	...	*																										
" pleurisepta, *Phill.*	...	...	...	...	...	*																										
" quadrifera, *M'Coy*	...	...	...	...	...	*																										
" sagittalis, *Phill.*	...	...	...	...	...	*																										
" striata, *Münst.*	...	...	...	...	...	*																										
" valida, *Phill.*	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*				
" undulata = linearis, *Münst.*	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Cyrtoceras armatum, *Phill.*	...	...	...	...	...	...	...	*																								
" bdellalites, *Phill.*	...	...	...	...	...	...	*	*																								
" fimbriatum, *Phill.*	...	...	...	...	...	...	...	*																								
" marginale, *Phill.*	...	...	...	...	...	...	...	*																								
" nautiloideum, *Phill.*	...	...	...	...	...	...	...	*																								
" nodosum, *Phill.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	*				
" obliquatum, *Phill.*	...	...	...	...	...	...	...	*																								
" ornatum, *Goldf.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*				
" quindecimale, *Phill.*	...	...	...	...	...	...	...	*																								
" reticulatum, *Phill.*	...	...	...	...	...	...	...	*																								
" rusticum, *Phill.*	...	...	...	...	...	*	...	*?																								
" subornatum, *M'Coy*	...	...	...	...	...	...	...	*																								
" tridecimale, *Phill.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*				
Goniatites biforus, *Phill.*	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*				
" excavatus, *Phill.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	*														
" globosus, *Münst.*	...	...	...	...	...	...	...	*																								
" linearis, *Münst.*	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*				
" serpentinus, *Phill.*	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	*														
" spirorbis ?, *Phill.*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*?	...	...	*	...	*												
" subsulcatus, *Bronn*	...	...	...	...	...	*																										
" transitorius, *Phill.*	...	...	...	...	...	...	...	*																								
" vinctus, *Sow.* (G. insignis, *Phill.*)	...	...	...	...	...	*	...	...	...	...	...	...	...	*	*																	
" compressus ?	...	...	...	...	...	...	...	*																								
Nautilus germanus, *Phill.*	...	...	...	...	...	...	...	*																								
" ? megasipho, *Phill.*	...	...	...	...	...	*																										
Orthoceras cinctum, *Sow.*	...	...	...	...	...	*	...	*	...	...	...	...	*?	...	...	*	...	*	*													
" cylindraceum, *Sow.*	...	...	...	...	...	...	...	...	...	...	*?	...	*	...	*	...	...	...	*													

Table II. (continued).—*Showing the entire Fauna and Flora of the Old Red Sandstone and Devonian Rocks of Great Britain, and their comparison with those of the Rhenish-Prussian, Belgian, and French series.*

SPECIES.	Old Red Sandstone. Lower.	Old Red Sandstone. Middle.	Old Red Sandstone. Upper.	Devonian. Cornwall. Lower (Looe).	Devonian. Cornwall. Middle (Padstow).	Devonian. Cornwall. Upper (Petherwin).	Devonian. South Devon. Lower (Meadsfoot).	Devonian. South Devon. Middle (Torquay).	Devonian. South Devon. Upper.	Devonian. North Devon. Lower (Lynton).	Devonian. North Devon. Mid. (Ilfracombe).	Devonian. North Devon. Middle (Morte).	Devonian. North Devon. Upper (Baggy).	Devonian. North Devon. Upper (Pilton).	Devonian. North Devon. Passage (Barnstaple).	Carboniferous. Irish (Coomhola).	Carboniferous. Lower Limest. shale.	Carboniferous. Carbonif. Limestone.	Carboniferous. Upper Limest. shale.	Carboniferous. Millstone grit.	Carboniferous. Low. Coal-measures.	Carboniferous. Mid. Coal-measures.	Carboniferous. Upp. Coal-measures.	Foreign Devonians. Rhine. Lower.	Foreign Devonians. Rhine. Middle.	Foreign Devonians. Rhine. Upper.	Foreign Devonians. Belgium. Lower.	Foreign Devonians. Belgium. Middle.	Foreign Devonians. Belgium. Upper.	Foreign Devonians. France. Lower.	Foreign Devonians. France. Middle.	Foreign Devonians. France. Upper.
Cephalopoda (*continued*).																																
Orthoceras cylindricum, *Sow.*											*				*																	
" ellipsoideum, *Phill.*								*																								
" ibex, *Sow.*						*?																			*							
" imbricatum ?, *Wahl.*													*	*																		
" lineolatum, *Phill.*														*				*														
" Ludense ?						*		*					*	*																		
" Phillipsii, *D'Orb.*						*																										
" striatulum, *Sow.*						*																										
" tentaculare, *Phill.*								*			*		*	*																		
" tubicinella, *Sow.*								*																	*							
" undulatum (O. laterale, *Sow.*)						*		*						*		*	*	*														
" gracile				*																				*	*							
" striatum, *Sow.*						*								*				*														
Poterioceras fusiforme, *Sow.*						*												*														
Pisces.																																
Acanthodes pusillus, *Ag.*		*																														
" Peachii, *Egert.*		*																														
" coriaceus, *Egert.*		*																														
" Mitchellii, *Egert.*	*																															
Actinolepis tuberculatus, *Ag.*		*	*																													
Asterolepis Asmusii, *Ag.*		*																														

Asterolepis Malcolmsii, *Ag.*	...	*	*																												
„ minor, *Ag.*	...	...	*																												
Auchenaspis Salteri, *Egert.*	*																														
„ ornatus, *Egert.*	*																														
Bothriolepis favosus, *Ag.*	...	*	*																												
„ ornatus, *Eichw.*	...	*	*																												
Brachyacanthus scutiger, *Egert.*	...	*																													
Byssacanthus arcuatus, *Ag.*	*																														
Cephalaspis asterolepis, *Huxl.*	*																														
„ Lewisii, *Ag.*	*																														
„ Lyellii, *Ag.*	*																														
„ Murchisoni, *Ag.*	*																														
„ Solwayi, *Egert.*	*																														
„ ornatus, *Egert.*	*																														
Cheiracanthus grandispinus, *M'Coy*	...	*																													
„ latus, *Egert.*	...	*																													
„ microlepidotus, *M'Coy*	...	*																													
„ minor, *Ag.*	...	*																													
„ Murchisoni, *Ag.*	...	*																													
„ pulverulentus, *M'Coy*	...	*																													
Cheirolepis Cummingiæ, *Ag.*	...	*																													
„ Traillii, *Ag.*	...	*																													
„ uragus, *Ag.*	...	*																													
„ velox, *M'Coy*	...	*																													
Climatius reticulatus, *Ag.*	*																														
„ scutiger, *Egert.*	*																														
„ uncinatus, *Egert.*	*																														
Coccosteus cuspidatus, *Ag.*	...	*																													
„ decipiens, *Ag.*	...	*																													
„ maximus, *Ag.*	...	*																													
„ Milleri, *Egert.*	...	*																													
„ oblongus, *Ag.*	...	*																													
„ minor, *Mill.*	...	*																													
Conchodus ostreiformis, *M'Coy*	...	*																													
Cosmacanthus Malcolmsonii, *Ag.*	...	*																													
Ctenacanthus ornatus, *Ag.*	*																														
Ctenoptychius priscus, *Ag.*																															
Dendrodus incurvus, *Duff*	...	*																													
„ latus, *Owen*	...	*																													

Table II. (continued).—*Showing the entire Fauna and Flora of the Old Red Sandstone and Devonian Rocks of Great Britain, and their comparison with those of the Rhenish-Prussian, Belgian, and French series.*

SPECIES.	OLD RED SANDSTONE. Lower.	OLD RED SANDSTONE. Middle.	OLD RED SANDSTONE. Upper.	DEVONIAN. CORNWALL. Lower (Looe).	DEVONIAN. CORNWALL. Middle (Padstow).	DEVONIAN. CORNWALL. Upper (Petherwin).	DEVONIAN. SOUTH DEVON. Lower (Meadsfoot).	DEVONIAN. SOUTH DEVON. Middle (Torquay).	DEVONIAN. SOUTH DEVON. Upper.	DEVONIAN. NORTH DEVON. Lower (Lynton).	DEVONIAN. NORTH DEVON. Mid. (Ilfracombe).	DEVONIAN. NORTH DEVON. Middle (Morte).	DEVONIAN. NORTH DEVON. Upper (Baggy).	DEVONIAN. NORTH DEVON. Upper (Pilton).	DEVONIAN. NORTH DEVON. Passage (Barnstaple).	CARBONIFEROUS. Irish (Coomhola).	CARBONIFEROUS. Lower Limest. shale.	CARBONIFEROUS. Carbonif. Limestone.	CARBONIFEROUS. Upper Limest. shale.	CARBONIFEROUS. Millstone grit.	CARBONIFEROUS. Low. Coal-measures.	CARBONIFEROUS. Mid. Coal-measures.	CARBONIFEROUS. Upp. Coal-measures.	FOREIGN DEVONIANS. RHINE. Lower.	FOREIGN DEVONIANS. RHINE. Middle.	FOREIGN DEVONIANS. RHINE. Upper.	FOREIGN DEVONIANS. BELGIUM. Lower.	FOREIGN DEVONIANS. BELGIUM. Middle.	FOREIGN DEVONIANS. BELGIUM. Upper.	FOREIGN DEVONIANS. FRANCE. Lower.	FOREIGN DEVONIANS. FRANCE. Middle.	FOREIGN DEVONIANS. FRANCE. Upper.
Pisces (*continued*).																																
Dendrodus sigmoideus, *Owen*	...	*																														
" strigatus, *Owen*	...	*																														
Diplacanthus crassispinus, *Ag.*	...	*																														
" gibbus, *M'Coy*	...	*																														
" longispinus, *Ag.*	...	*																														
" perarmatus, *M'Coy*	...	*																														
" striatulus, *Ag.*	...	*																														
" striatus, *Ag.*	...	*																														
Diplopterus affinis, *Ag.*	...	*																														
" Agassizi, *Traill*	...	*																														
" borealis, *Ag.*	...	*																														
" macrocephalus, *Ag.*	...	*																														
Dipterus macrolepidotus, *Sedg.*	*	*																														
Euthacanthus MacNicoli, *Powrie*	*																															
Glyptolepis elegans, *Ag.*	...	*																														
" leptopterus, *Ag.*	...	*																														
" microlepidotus, *Ag.*	...	*																														
Glyptopomus minor, *Hux.*	...	...	*																													
Glyptolæmus Kinnairdi, *Hux.*	...	...	*																													
Gyroptychius angustus, *M'Coy*	...	*																														
" diplopteroides, *M'Coy*	...	*																														
Holoptychius Andersoni, *Ag.*	...	...	*																													

Holoptychius giganteus, *Ag.*	...	*																														
„ Murchisoni, *Ag.*	...	*																														
„ nobilissimus, *Ag.*	...	*	*																													
„ Sedgwickii, *M'Coy*	...	*																														
Homothorax Flemingii, *Ag.*	...	...	*																													
Ichnacanthus gracilis, *Egert.*	*																															
Lamnodus biporcatus, *Owen*	...	*																														
„ Panderi, *Ag.*	...	*																														
„ sulcatus, *Ag.*	...	*																														
Onchus arcuatus, *Ag.*	*																															
„ semistriatus, *Ag.*	*																															
„ ? Murchisoni ?, *Ag.*	*																															
Osteolepis arenatus, *Ag.*	...	*																														
„ brevis, *M'Coy*	...	*																														
„ macrolepidotus, *Ag.*	...	*																														
„ major, *Ag.*	...	*																														
Pamphractus Andersoni, *Ag.*	...	...	*																													
Parexus incurvus, *Ag.*	*																															
Phaneropleuron Andersoni, *Hux.*	...	...	*																													
Phyllolepis concentricus, *Ag.*	*	*	...	...	...	...	*																									
Placothorax paradoxus, *Ag.*	...	*																														
Platygnathus Jamesoni, *Ag.*	...	...	*																													
„ paucidens, *Ag.*	...	*																														
Pterichthys cancriformis, *Ag.*	...	*																														
„ cornutus, *Ag.*	...	*																														
„ hydrophyllus, *Ag.*	...	...	*																													
„ latus, *Ag.*	...	*																														
„ major, *Ag.*	...	*																														
„ Milleri, *Ag.*	...	*																														
„ macrocephalus, *Egert.*	...	...	*																													
„ oblongus, *Ag.*	...	*																														
„ productus, *Ag.*	...	*																														
„ quadratus, *Egert.*	...	*																														
„ testudinarius, *Ag.*	...	*																														
Pteraspis Banksii, *Hux.*	*																															
„ Dunensis, *Hux.*	*																															
„ Lloydii, *Ag.*	*																															
„ rostratus, *Ag.*	*																															
„ Mitchellii, *Powrie*	*																															

TABLE II. (continued).—*Showing the entire Fauna and Flora of the Old Red Sandstone and Devonian Rocks of Great Britain, and their comparison with those of the Rhenish-Prussian, Belgian, and French series.*

SPECIES.	OLD RED SANDSTONE.			DEVONIAN.												CARBONIFEROUS.								FOREIGN DEVONIANS.								
				CORNWALL.			SOUTH DEVON.			NORTH DEVON.														RHINE.			BELGIUM.			FRANCE.		
	Lower.	Middle.	Upper.	Lower (Looe).	Middle (Padstow).	Upper (Petherwin).	Lower (Meadsfoot).	Middle (Torquay).	Upper.	Lower (Lynton).	Mid. (Ilfracombe).	Middle (Morte).	Upper (Baggy).	Upper (Pilton).	Passage(Barnstaple).	Irish (Coomhola).	Lower Limest. shale.	Carbonif. Limestone.	Upper Limest. shale.	Millstone grit.	Low. Coal-measures.	Mid. Coal-measures.	Upp. Coal-measures.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.
PISCES (*continued*).																																
Pteraspis truncatus, *Hux.*	*																															
Ptychacanthus dubius, *Ag.*	*																															
Tripterus Pollexfeni, *M'Coy*	...	*																														
Tristichopteris alatus, *Egert.*	...	*																														
Holoptychius (Meadsfoot, Baggy Point)	...	...	...	...	...	...	*	...	...	...	...	...	*																			
Ichthyodorulite (Looe)	...	...	...	*																												
Fish-remains (Ilfracombe)	...	...	...	...	...	...	...	...	...	...	*																					

stand thus:—Plantæ 12 species, Annelida 1 sp., Crustacea 20 sp., Polyzoa 1, Pisces 113; whereas the Marine Devonian contains 12 classes, 125 genera, and 383 species, distributed through its Lower, Middle, and Upper members in the West Somerset, North and South Devonian, and Cornish areas, or in the typical Devonian region. With these Devonian species are compared those occurring in the Carboniferous Slate of Ireland, many of which pass from the *Upper* Devonian group beneath into the Carboniferous series, which in the North-Devon area reposes upon the Upper Devonian rocks at Barnstaple, and in the country to the south. The whole Devonian fauna is also compared with the Carboniferous generally; and, to make my comparisons still more important and complete, I have endeavoured to compare the English types of the Devonian species and those of the Irish Carboniferous slate with those in the groups of rocks recognized as Lower, Middle, and Upper Devonian in the Rhenish provinces, Belgium and France (the Bas Boulonnais); by this means I have arrived at some data as to the distribution of the Devonian species in space and time, and their true relation to the Old Red Sandstone on the one hand, and the succeeding Carboniferous group above on the other; it serves to show us also that the marine Devonian system, as a whole, stands alone, through its organic remains—5 species only being common to the Old Red Sandstone and Devonian, out of the 149 species known in the former, and 385 in the latter. Three of these are Plants, and the remaining two Fish; the 113 species of fish, therefore, are almost the only witnesses of animal life in the vast thickness of the Old Red Sandstone. As we have, therefore, no standard by which to compare the Devonian, or the Carboniferous, except through the "Devonian," there is no alternative but to accept the British species as types and data for comparison with the continental Devonian series and the Carboniferous; and admitting, upon stratigraphical evidence, that the Devonian is beneath the Carboniferous everywhere in England and Europe where they have been examined, it of necessity follows that the species distributed through the Devonian rocks preceded the Carboniferous in time, and also that the few species that occur in both are, without exception, of Devonian types, occurring either in the British area, or in one or more of the three European areas named; and this stratigraphical position and life-succession are clearly shown in North and South Devon and West Somerset. (See Table II., p. 616, and Table IV., p. 640).

I purpose comparing the British species occupying the two Devonian areas amongst themselves, and then entering upon their comparison with relation to their foreign equivalents in the Rhenish provinces, Belgium, and France, and finally comparing them with the succeeding Carboniferous series in this country and in Ireland.

2. *Lower Devonian species of West Somerset and North Devon.*—These lower gritty slates and associated bands of limestone contain a fauna almost peculiar to themselves; and it is remarkble how many of the known species are common to North Devon and the Rhenish and Belgian areas, notwithstanding that they are so widely separated;

and although there is poverty in the number of known forms, yet it is evident that similar conditions then occurred equally favourable to the laws of life, the zoological relations over this extended area during the deposition of these lower beds, like those of the higher members, being marked and important. 18 species are known to occur in this lower series of West Somerset and North Devon; and their distribution is given in the following Table, in which are compared those species occurring in beds of the same age in the Rhenish provinces, Belgium, and France. It is somewhat singular that in our own group we have not as yet a single known species of the class Cephalopoda, no Crustacean, and, as far as we yet know, no Fish-remains.

Table III.—*Species occurring in the Lower Devonian Slates, Grits, and Limestones of North Devon, and those found in the same group on the Rhine, in Belgium, and in France.*

Species.	British.						Foreign.		
	Lynton.	Valley of Rocks.	Watersmeet.	Woodabay.	Lee.	Heddon's Mouth.	Rhine.	Belgium.	France.
1. Alveolites suborbicularis, *Lam.*	*	...	...	...	...	*	*		
2. Favosites cervicornis, *Blainv.*	*	*	*	...	...	...	*		
3. Petraia pluriradialis, *Phill.*	*	*							
4. Actinocrinus tenuistriatus, *Phill.*	*								
5. Fenestella antiqua, *Goldf.*	*	*	*	*	*	*	*	...	*
6. Chonetes sordida, *Sow.*, vel Hardrensis, *Phill.*	*	...	...	...	...	*	*	*	
7. Orthis arcuata, *Phill.*	*	*	*	*	*	*			
8. —— granulosa, *Phill.*	*	...	...	*					
9. Spirifera canalifera, *Valen.*	*	*	...	...	...	...	*	*	*
10. —— hysterica, *Schloth.*	*	*	...	...	...	...	*	*	*
11. —— lævicosta, *Valen.*	*	*	*	...	...	...	*	*	
12. Streptorhynchus crenistria? *Phill.*	*	*							
13. Pterinea spinosa, *Phill.*	...	...	...	*					
14. Ctenodonta Krachtæ, *M'Coy*	*								
15. Pleurotomaria aspera, *Sow.*	*	*							
16. Bellerophon striatus, *Bronn*	...	...	...	*					
17. Tentaculites, sp.	...	...	...	*	*	*			
18. Megalodon cucullatum, *Sow.*	...	...	...	...	*				

We thus see that of the 18 British species 7 are common to the Lower Devonian of North Devon, and that of one or other of the three European areas given in the Table, viz. *Alveolites suborbicularis, Favosites cervicornis, Fenestella antiqua, Chonetes sordida* vel *Hardrensis, Spirifera canalifera, S. hysterica*, and *S. lævicosta*. The paucity of known species in our area may arise from want of search, and also the absence of workable limestone on the Lynton group. Some of these species, Nos. 1, 6, 8, 9, 10, 14, and 16, do not pass up to the Middle or Upper Devonian, or the Carboniferous, and are therefore peculiar to the lower series of North Devon. But *Alveolites suborbicularis*, *Orthis granulosa*, *O. arcuata*, and *Spirifera lævicosta* occur in the Middle Devonian beds of South Devon, and *S. hysterica* and *Pterinea spinosa* in rocks of the same age in Cornwall.

The full relations of species occurring in the Lynton group of West Somerset and North Devon cannot be clearly arrived at—so little, as yet, being known of the fossils of the lower gritty slates of the Quantock Hills, and of the lower beds that sweep round the Croydon Hill promontory, north of Luxborough and Treborough Wood &c., and also from the difficulty we still have in assigning the true position of the Cannington-Park limestone, though I have no doubt that it belongs to the lowest part of the *Middle* Devonian Rocks. The physical characters of this limestone more strongly resemble those of the Torquay and Plymouth limestones than any in the northern area; and the corals which occur in them are of the same species as those of the middle series in the Quantook Hills; but the crystalline structure of the rock seems to have obliterated nearly all traces of life.

If we compare the species that are known to be peculiar to the Lower or Lynton group of North Devon, with those of the lower in *South* Devon, as at Looe &c., and of that of Cornwall, only 1 species is found to occur as common, viz. *Leptæna laticosta*; whereas if we examine and compare those species which are found in the three areas occupied by the same rocks, a similar result takes place; for only two, and those corals, are known to occur in common to the three areas, viz. *Petraia Celtica* and *P. pluriadialis*, whatever *this* may be. This is doubtless due to our incomplete knowledge of the fauna of the three areas, and a proof how little we yet know of the distribution of life through these obscure rocks; they are facts, nevertheless, as based upon what is known. Be it remembered we have here only examined and compared the Lower Devonian species amongst themselves, not the relation of the Lower to the Middle or Upper, where very different results will be found, tending to connect them as one and a complete series in a very conclusive manner. Careful search, then, gives us but 18 known species in the Lower Devonian group of Rocks in North Devon; and 13 of these are found and will be noticed as occurring in the Middle Devonian of either North or South Devon.

Table III. is constructed to show the relation of the Lower Devonian species of Britain to those of Europe, irrespectively of the species passing into higher members of the Devonian series in any area. It is singular that in the British Lower Devonian series there is only 1 Gasteropod known in any area (viz. *Pleurotomaria aspera*), only 4 Lamellibranchs (*Pterinea spinosa*, *P. anisota*, *Ctenodonta Krachtæ*, and *Clidophorus ovatus*), one Cephalopod (*Orthoceras gracile*), and a solitary Nucleobranch (*Bellerophon bisulcatus*); and these are from the lower series in Cornwall, the species found being either deep-sea or pelagic forms, thus agreeing with the nature of the deposits which contain them.

It has been stated that 13 species are common to the *Lower Old Red Sandstone* and the preceding Silurian rocks; but our comparisons are confined to the group of Fishes contained in the passage-beds between the two formations, of which there are seven species; and, from the want of this group of vertebrata in our Lower Devonian slates, it is negative evidence only for the British area. I doubt not that both the Lower, or Lynton, and the Middle, or Ilfracombe, beds will yet yield many species of fish, remains of which, but with hardly determinable characters, are frequently found in the slates on the north coast; for we now have conclusive evidence of their presence from bones and coprolitic débris *.

The following Table contains those invertebrate species still retained by many as common to the Silurian and Devonian rocks; I place the mark of interrogation against those I would reject as being very doubtful:—

Species.	Silurian.	Low. Dev.	Mid. Dev.	Up. Dev.
Favosites fibrosa? *Goldf.*	*	*	*	
Tentaculites annulatus? *Schloth.*	*	...	*	
Atrypa reticularis, *Linn.*	*	*	*	
——— ———, var. aspera, *Schloth.*	*	*	*	
Ctenodonta (Clidophorus) ovata? *Sow.*	*	*	*	
Orthoceras imbricatum? *Wahl.*	*	...	...	*

The 7 species of Fish-remains cannot be compared, as we are not dealing with the Old Red proper of the Silurian area.

With the exception, therefore, of the ubiquitous *Atrypa reticularis*, which is undoubtedly common to the Silurian and Devonian Rocks in England and Europe, I believe we have no reliable species connecting the two great life-periods, viz. the Silurian and Devonian.

Whilst comparing the relation of the Silurian to the Devonian fossils, it would be as well to name (before we discuss critically) those species which are said to occur as common to the Lower Devonian rocks of the Lynton area and the so-called Carboniferous Slate above or to the south, and to link the two areas together in North Devon, and which have been referred to as one of the reasons for relating them, though this has only been done through the apparent similarity of the rock-masses of the two areas, and from the general resemblance that the slates of North Devon bear to the Coomhola and Carboniferous Slates of the South of Ireland. Professor Jukes, in his paper †, states that at Lynton, in the Valley of Rocks, he "was again among rocks belonging to the Carboniferous Slate," and that the fragments of Brachiopoda and all other fossils seemed to be the same as those of Ireland. To all outward appearance there is and may be *similarity*, as there is in most slaty regions; and the Croyde and Baggy Slates to the south in a few par-

* Mr. Valpy's collection supplies this evidence.
† Quart. Journ. Geol. Soc. vol. xxii. 1866, p. 350.

ticulars physically resemble those of Lynton; but their *identity* stratigraphically (or by position in time) is impossible; and the second assertion, as to complete identity of species or organic contents, is an error; the only species out of the 18 known in the Lower or Lynton series (in the Lynton area) and common to it and the Carboniferous Slate to the south, or in any area, are two—*Fenestella antiqua** and *Chonetes sordida* or *Hardrensis,* a species still doubted by Mr. Davidson—and this admitting that the Barnstaple fossils are Carboniferous. No other forms pass up from the Lower Devonian to the Carboniferous, and no others are common in the North Devon area; and we must in this case, when absolute identity of rock-masses is stated to exist, compare the species that occur in each. Succeeding Tables will show their relation, when all the known Carboniferous species of North Devon will be compared with the three groups of the Devonian in the same area. It was necessary to show the palæontological relations of the species in these Lower Devonian rocks to the Silurian below on the one hand, and to the Carboniferous above on the other, as one amongst other proofs or evidence of their intermediate position and distinct character, and of their having, as I have stated, only one species common to the two systems. The gradual addition to the known number of species in the Middle and Upper Devonian rocks will show a marked relation to the succeeding Carboniferous; for of the 495 known species in the Old Red and whole Devonian, 57 are also found in the Carboniferous; these 57 species will also be compared in their proper place when I treat of the relation of the two groups to each other.

I have thus endeavoured to draw some comparison between the community of species in the Lower Devonian and Silurian rocks, also of those in the Lower Devonian of the North Devon area with the fossils of the Lower or Spirifer-sandstones &c. of the Rhine; and also, preparatory to further analysis, I have stated the relation which the Lynton Group bears to those rocks above the Pickwell-Down and Baggy series, which have been asserted to be of the same age. I now purpose analyzing the species that occur in the Middle Devonian or Ilfracombe Group.

3. *Middle Devonian or Ilfracombe Group.*—In the slates and limestones, and occasionally the gritty beds, chiefly (in North Devon) at and near Combe Martin, Watermouth, Widmouth, Hagginton, and Ilfracombe, a large assemblage of Middle-Devonian species occurs; 73 known forms are distributed through the slaty and calcareous rocks of this group; and 35 of these occur in one or other of the three European areas selected for comparison. Thus nearly 46½ per cent. are common to the Middle Devonian strata of Britain and Europe. Doubtless a still closer relation will be found to exist when other groups of fossils have been as extensively studied and accurately worked out as the Brachiopoda and Cœlenterata; for of the

* One of the most doubtful species in the Devonian Rocks; in nine cases out of ten it occurs only in the form of moulds and casts; and the Polyzoa are, of all other groups, when required for the identification of beds, the most deceptive.

former class 25 are common, and of the latter 17 belong to the areas under discussion; whereas there are only 8 species that pass up to the Carboniferous in any area, viz. 1 Gasteropod (*Acroculia vetusta*), 1 Polyzoon (*Fenestella antiqua*), 5 Brachiopoda, and 1 Cephalopod (*Orthoceras cylindraceum*).

The following Table is compiled to show the occurrence and distribution of all the known species in the Middle Devonian rocks of North Devon and West Somerset in the best-known localities, though many more will yet be added:—

TABLE IV.—*Distribution of species in the Middle Devonian or Ilfracombe Group in North Devon and West Somerset.*

Species.	North Devon.						West Somerset.							
							Qantock Hills.			Croydon Area.				
	Holdstone.	Ilfracombe.	Hagginton.	Widmouth.	Watermouth.	Combe Martin.	Adscombe.	Asholt.	Buncombe.	Withycombe.	Nettlecombe.	Wheddon Cross.	Treborough.	Cannington.
Stromatopora concentrica, *Goldf.*	...	...	...	...	...	*								
Amplexus tortuosus, *Phill.*	...	...	...	...	...	...	...	*	...	*				
Alveolites suborbicularis, *Lam.*	...	*	...	...	...	...	*	*	...	*				
Acervularia Goldfussii, *De Vern.*	...	...	...	...	...	...	...	...	...	*				
Cyathophyllum æquiseptum, *M.-Edw.*	...	*	*	...	...	*								
—— cæspitosum, *Goldf.*	...	*	*	...	...	*	*	*						
—— Damnoniense, *Lonsd.*	...	*	...	...	...	...	...	...	...	*	...	...	...	*
—— Boloniense, *Blainv.*	...	...	...	...	...	*	...	...	...	*				
—— helianthoides, *Goldf.*	...	...	*	...	...	*	...	...	...	*				
—— obtortum, *M.-Edw.*	...	...	*											
Cystiphyllum vesiculosum, *Goldf.*	...	*	...	...	...	...	...	...	...	*				
Endophyllum abditum, *M.-Edw.*	...	...	...	...	...	...	...	*						
Favosites cervicornis, *Blainv.*	*	*	*	*	...	*	*	*	...	*	*			
—— fibrosa? *Goldf.*	...	*	*	...	...	*								
—— dubia, *Blainv.*	...	*	*	...	...	*								
—— reticulata, *Blainv.*	...	...	...	...	...	...	*	...	...	*				
Hallia Pengellii, *M.-Edw.*	...	...	...	...	...	*								
Heliophyllum Halli, *M.-Edw.*	...	*	...	...	...	...	*	*	...	*				
Heliolites porosa, *Goldf.*	...	...	*	...	...	*								
Cyathocrinus macrodactylus, *Phill.*	...	*												
—— variabilis, *Phill.*	...	*												
Hexacrinus, sp.	...	...	*											
Tentaculites annulatus, *Schloth.*	...	*	*											
—— scalaris, *Schloth.*	...	...	*	*										
Trimerocephalus lævis, *Münst.*	...	...	...	*	...	*								
Ceriopora similis, *Phill.*	...	*												
Fenestella antiqua, *Goldf.*	...	*	*											
—— arthritica, *Phill.*	...	*	*											
Retepora repisteria, *Goldf.*	...	*												
Athyris concentrica, *V. Buch*		...	*											
Atrypa desquamata, *Sow.*	...	...	*											
—— reticularis, *Linn.*	...	...	*											

Table IV. (*continued*).

Species.	North Devon.						West Somerset.							
							Qantock Hills.			Croydon Area.				
	Holdstone.	Ilfracombe.	Hagginton.	Widmouth.	Watermouth.	Combe Martin.	Adscombe.	Asholt.	Buncombe.	Withycombe.	Nettlecombe.	Wheddon Cross.	Treborough.	Cannington.
Atrypa aspera, *Schloth.*	...	...	*											
Cyrtina heteroclyta, *Defr.*	...	*	*											
Merista plebeia, *Sow.*	...	*	*											
Orthis striatula, *Schloth.*	...	*	*											
Rensseleria stringiceps, *Roem.*	...	*	*											
Rhynchonella pleurodon, *Phill.*	...	*												
—— pugnus, *Martin*	...	*												
Spirifera curvata, *Schloth.*	...	*												
—— disjuncta, *Sow.*	...	*	*											
—— nuda, *Sow.*	..	*												
—— speciosa, *Schloth.*	...	*												
—— glabra ? *Martin*	..	*	*											
Spiriferina cristata, *Schloth.*	...	*												
Stringocephalus Burtini, *Defr.*	...	*	*	*	...	*								
Streptorhynchus crenistria, *Phill,*	...	...	*											
—— umbraculum, *Schloth.*	...	*												
Strophomena rhomboidalis, *Wahl.*	...	*	*											
Cypricardia, sp.	...	*												
——, sp.	...	*												
Cucullæa, sp.	*													
Myalina, sp.	*													
Schizodon deltoideus, *Phill.*	...	*												
Sanguinolaria, sp.	*	*												
Solen ?	*													
Acroculia vetusta, *Sow.*	...	*	*	...	...	...	*							
Euomphalus serpens, *Phill.*	...	...	*											
—— radiatus, *Phill.*	...	...	*											
Holopella ?	...	...	*											
Macrocheilus brevis, *Sow.*	*	...	*											
Pleurotomaria	*													
Loxonema	...	...	*											
Murchisonia	...	...	*											
Natica	*	...	*											
Conularia	...	...	*											
Orthoceras cylindraceum, *Sow.*	...	*												
—— tentaculare, *Phill.*	...	...	*											
——, sp.	...	...	*											
Cyrtoceras, sp.	...	...	*											
——, sp.	...	...	*											

In this Table an analysis is given of the occurrence and geographical distribution of the entire known fauna of the Middle

Devonian Rocks of North Devon, to which are added the species that occur in the Quantock Hills and other localities in West Somerset, chiefly from the Limestones east and south of Croydon Hill. It may be largely added to by diligent search along the east side of the Quantocks at Adscombe, Stowey, &c. &c. This table will form the basis of my comparisons both with species that may range lower or higher in this area, and also with the European Devonian fossils as collated with our British types.

This Middle division or group of the Devonian rocks, both in North and South Devon, has received most attention, arising partly from circumstances peculiar to its geographical position on the one hand, and to the economical value of its limestones on the other; and this applies to Europe as well as Britain. It is the source of the lime used in the interior of North Devon; in quarrying, therefore, the amount of limestone removed is considerable; and it is to this circumstance alone that we owe our knowledge of the Cœlenterate fauna of the Middle Devonian of North and South Devon. In the south, at Torquay, Plymouth, &c., the excess of workable limestone over that of the north is so great that long ago extensive collections were made, the species carefully examined, and then justly referred by Lonsdale to an extensive formation existing between the Silurian and Carboniferous systems*—in other words, occupying the stratigraphical place of the Old Red Sandstones, whatever may be the exact relation of this marine Devonian group to that great and almost non-fossiliferous formation.

Having enumerated the entire fauna as known in North Devon, it will be important to compare the species that are known to occur in beds of the same age in South Devon to aid us in generalizing upon the value of the term Middle Devonian, as now used, applied to, and correlated with, the European groups.

4. *Species common to the Middle Devonian Rocks of North and South Devon.*—It will perhaps surprise many to find that there are 235 marine species known in the Middle (or Torquay, Newton, and Plymouth) group in South Devon, which are distributed through 11 classes of the animal kingdom. I briefly enumerate the 11, also the genera and species in each (Table V.)

* Proceedings Geol. Soc. 1840, vol. iii.; Trans. Geol. Soc. vol. v. p. 721, &c. &c.

Table V.—*Species occurring in the Middle Devonian Rocks of South Devon, compared with those of North Devon and Europe, and with the Carboniferous generally.*

Classes.	Species.	South Devon.	North Devon.	Foreign.	Carboniferous.
Amorphozoa	Scyphia turbinata, *Goldf.*	*			
	Steganodictyum cornubicum, *M'Coy*	*			
	Sphærospongia tessellata, *Phill.*	*			
	Stromatopora concentrica, *Goldf.*	*	*	*	
	—— placenta, *Lonsd.*	*			
	—— polymorpha, *Goldf.*	*	...	*	
	—— ramosa, *Brass.*	*			
	—— verticillata, *M'Coy*	*			
Cœlenterata	Acervularia Battersbyi, *M.-Edw.*	*			
	—— coronata, *M.-Edw.*	*			
	—— Goldfussii, *De Vern.*	*	*	*	
	—— intercellulosa, *Phill.*	*			
	—— pentagona, *Goldf.*	*	...	*	
	—— Rœmeri, *De Vern.*	*			
	—— limitata, *M.-Edw.*	*			
	Alveolites Battersbyi, *M.-Edw.*	*			
	—— compressa, *M.-Edw.*	*			
	—— suborbicularis, *Lam.*	*	*	*	
	—— vermicularis, *M'Coy*	*			
	Amplexus tortuosus, *Phill.*	*	*	*	
	Arachnophyllum Hennahii, *Lonsd.*	*	...	*	
	Battersbyia inæqualis, *M.-Edw.*	*	...	*	
	Campophyllum flexuosum, *Goldf.*	*	...	*	
	Chonopyllum perfoliatum, *Goldf.*	*			
	Cyathophyllum æquiseptum, *M.-Edw.*	*	*	*	
	—— Boloniense, *Blainv.*	*	*	*	
	—— cæspitosum, *Goldf.*	*	*		
	—— ceratites, *Goldf.*	*			
	—— Damnoniense, *Lonsd.*	*	*		
	—— helianthoides, *Goldf.*	*	*		
	—— hexagonum, *Goldf.*	*			
	—— Marmini, *M.-Edw.*	*			
	—— obtortum, *M.-Edw.*	*	*		
	—— Rœmeri, *M.-Edw.*	*	...	*	
	—— Sedgwickii, *M.-Edw.*	*			
	—— turbinatum, *Goldf.*	*	...	*	
	Cystiphyllum vesiculosum, *Goldf.*	*	*	*	
	Emmonsia hemisphærica, *M.-Edw.*	*			
	Endophyllum abditum, *M.-Edw.*	*	*		
	—— Bowerbanki, *M.-Edw.*	*			
	Favosites cervicornis, *Blainv.*	*	*	*	
	—— dubia, *Blainv.*	*	*	*	
	—— Goldfussii, *D'Orb.*	*	...	*	
	—— reticulata, *Blainv.*	*	...	*	
	—— fibrosa, *Goldf.*	*	*		
	Hallia Pengellyi, *M.-Edw.*	*	*		
	Heliolites porosa, *Goldf.*	*	*	*	
	Heliophyllum Halli, *M.-Edw.*	*	*		
	Metriophyllum Battersbyi, *M.-Edw.*	*			

TABLE V. (*continued*).

Classes.	Species.	South Devon.	North Devon.	Foreign.	Carboniferous.
CŒLENTERATA............	Pachyphyllum Devoniense, *M.-Edw.*.......	*	*		
	Petraia Celtica?, *Lonsd.*	*	*	*	*
	—— gigas, *M'Coy*............................	*			
	Pleurodictyum problematicum, *Goldf.* ...	*	...	*	
	Smithia Pengellyi, *M.-Edw.*	*			
	—— Bowerbankii, *M.-Edw*...................	*			
	—— Hennahii, *Lonsd*........................	*			
	Spongiophyllum Sedgwickii, *M.-Edw.* ...	*			
	Strephodes gracilis, *M'Coy*	*			
	Syringophyllum cantabricum, *De Vern*....	*			
ECHINODERMATA.........	Platycrinus pentangularis, *Mill.*............	*	...	*	
	—— tuberculatus, *Mill.*	*	...	*	
	Actinocrinus tenuistriatus, *Phill*............	*			
	—— triacontadactylus, *Mill.*	*	...	*	
	Cupressocrinus crassus?	*	...	*	
	Cyathocrinus nodulosus, *Phill.*	*			
	—— geometricus, *Goldf*.......................	*			
	Hexacrinus depressus, *Aust.*	*			
	—— interscapularis, *Phill.*	*			
	—— macrotatus, *Aust*..........................	*			
	——, sp.	*			
ANNELIDA	Tentaculites annulatus, *Schloth.*	*	*		
	——, sp..	*			
CRUSTACEA	Bronteus flabellifer, *Goldf.*	*			
	Cheirurus articulatus, *Münst.*	*			
	Harpes macrocephalus, *Goldf.*	*	...	*	
	Phacops granulatus, *Münst*....................	*	...	*	
	—— latifrons, *Bronn*	*	...	*	
	—— (Chryphæus) punctatus, *Stein.*	*	*	*	
	—— Latreillii	*	...	*	
	—— (Trimerocephalus) lævis, *Münst.* ...	*	*		
	—— cryptophthalmus, *Emmer.*	*			
POLYZOA	Ceriopora similis, *Phill.*	*	*	...	*
	Fenestella antiqua, *Goldf.*	*	*	*	*
	—— arthritica, *Phill.*	*	*	*	
	—— prisca, *Goldf.*	*			
	Hemitrypa oculata, *Phill.*	*	...	*	
	Polypora laxa, *Phill.*	*	...	*	*
	Ptylopora flustriformis, *Phill*................	*	...	*	
	Retepora repisteria, *Goldf.*	*	*	*	
BRACHIOPODA	Athyris Bartonensis, *Dav.*	*			
	—— concentrica, *V. Buch*	*	*	*	
	—— lachryma, *Sow.*	*	*	*	
	—— Newtonensis, *Dav.*	*			
	—— phalæna, *Phill*............................	*	...	*	
	Atrypa desquamata, *Sow.*	*	*		
	—— flabellata, *Goldf.*	*	...	*	
	—— lens, *Phill.*	*	...	*	
	—— lepida, *Goldf.*	*	...	*	
	—— reticularis, *Linn.*.........................	*	*	*	
	—— aspera, *Schloth.*	*	*	*	
	Calceola sandalina, *Linn.*	*	...	*	

TABLE V. (*continued*).

Classes.	Species.	South Devon.	North Devon.	Foreign.	Carboniferous.
BRACHIOPODA	Camarophoria rhomboidea, *Phill.*	*	...	*	
	Chonetes Hardrensis, *Phill.*	?*	...	*	*
	—— minuta, *Goldf.*	*	...	*	
	Cyrtina amblygona, *Phill.*	*			
	—— Demarlii, *V. Buch*	*	...	*	
	—— heteroclyta, *Def.*	*	*	*	
	—— multiplicata, *Dav.*	*	...	*	
	Davidsonia Verneuilii, *V. Buch*	*	...	*	
	Leptæna interstrialis, *Phill.*	*	...	*	
	—— nobilis, *M'Coy*	*	...	*	
	Merista plebeia, *Sow.*	*	*	*	
	Orthis arcuata, *Phill.*	*			
	—— granulosa, *Phill.*	*			
	—— striatula, *Schloth.*	*	*	*	
	Pentamerus brevirostris, *Phill.*	*	...	*	
	—— biplicatus, *Schnur*	*	...	*	
	Productus subaculeatus, *Murch.*	*	...	*	
	Rhynchonella acuminata, *Mart.*	*	...	*	*
	—— angularis, *Phill.*	*			
	—— bifora, *Phill.*	*			
	—— cuboides, *Sow.*	*	...	*	
	—— laticosta, *Phill.*	*			
	—— Lumatoniensis, *Dav.*	*			
	—— Ogwelliensis, *Dav.*	*			
	—— pleurodon, *Phill.*	*	*	...	*
	—— primipilaris, *V. Buch*	*	...	*	
	—— protracta, *Sow.*	*			
	—— pugnus, *Martin*	*	*	*	*
	—— reniformis, *Sow.*	*	...	...	*
	—— triloba, *Sow.*	*			
	—— implexa, *Sow.*	*	...	*	
	Retzia ferrita, *V. Buch*	*	...	*	
	Spirifera comprimata	*	...	*	
	—— curvata, *Schloth.*	*	*	*	
	—— disjuncta, *Sow.*	*	*	*	
	—— lævicosta, *Val.*	*	...	*	
	—— lineata, *Mart.*	*	...	*	*
	—— Newtonensis, *Dav.*	*			
	—— nuda, *Sow.*	*	*		
	—— simplex, *Phill.*	*	...	*	
	—— speciosa, *Schloth.*	*	*	*	
	—— subcuspidata, *Schnur*	*	...	*	
	—— undifera, *Rœm.*	*	...	*	
	—— ——, var. undulata, *Rœm.*	*	...	*	
	—— Urii, *Flemg.*	*	...	*	*
	Spiriferina cristata, *Schloth.*	*	...	*	*
	—— insculpta, *Phill.*	*			
	Stringocephalus Burtini, *Def.*	*	*	*	
	Streptorhynchus crenistria, *Phill.*	*	*	*	*
	—— umbraculum, *Schloth.*	*	*	*	
	Strophalosia fragaria, *Sow.*	*	*		
	Strophomena rhomboidalis, *Wahl.*	*	*	*	*

TABLE V. (*continued*).

Classes.	Species.	South Devon.	North Devon.	Foreign.	Carboniferous.
BRACHIOPODA	Terebratula sacculus, *Mart.*	*	...	*	
	—— juvenis, *Sow.*	*			
	—— Newtonensis, *Dav.*	*			
	Uncites gryphus, *Schloth.*	*	...	*	
LAMELLIBRANCHIATA	Avicula subradiata, *Sow.*	*			
	Aviculopecten plicatus, *Sow.*	*	...	...	*
	—— rugosus, *Phill.*	*			
	Pterinea radiata, *Goldf.*	*			
	—— reticulata, *Phill.*	*			
	—— texturata, *Phill.*	*			
	Clidophorus ovatus, *Sow.*	*			
	Conocardium aliforme, *Sow.*	*	...	*	*
	—— minax, *Phill.*	*	...	*	*
	Corbula Hennahii, *Sow.*	*			
	Cucullæa amygdalina, *Phill.*	*			
	Ctenodonta lineata, *Phill.*	*			
	Megalodon carinatum, *Phill.*	*			
	—— cucullatum, *Sow.*	*	?*		
	Modiola scalaris, *Phill.*	*			
	Mytilus Damnoniensis, *Phill.*	*			
	Sanguinolaria sulcata, *Münst.*	*			
GASTEROPODA	Acroculia sigmoidalis, *Phill.*	*			
	—— vetusta, *Sow.*	*	*	*	*
	—— triloba?	*			
	Euomphalus annulatus, *Phill.*	*			
	—— circularis, *Phill.*	*			
	—— radiatus, *Phill.*	*	...	*	
	—— serpens, *Phill.*	*	*		
	—— lævis	*	...	*	
	—— planorbis, *Vern.*	*	...	*	*
	Helminthochiton?	*			
	Loxonema Hennahiana, *Phill.*	*			
	—— lincta, *Phill.*	*			
	—— nexilis, *Phill.*	*			
	—— præterita, *Phill.*	*			
	—— reticulata, *Phill.*	*	...	*	
	Macrocheilus brevis, *Sow.*	*			
	—— elongatus, *Phill.*	*			
	—— harpula, *Sow.*	*	...	*	
	—— imbricatus, *Sow.*	*	...	...	*
	—— subcostatus, *Schloth.*	*			
	—— ventricosus, *Goldf.*	*	...	*	
	Murchisonia bigranulosa, *D'Arch.*	*	...	*	
	—— geminata, *Phill.*	*	...	*	
	—— spinosa, *Phill.*	*	...	*	*
	—— tricincta, *Phill.*	*			
	Nerita deformis, *Sow.*	*			
	Pleurotomaria aspera, *Sow.*	*			
	—— cirriformis, *Sow.*	*	...	*	
	—— impendens, *Sow.*	*			
	—— monilifera, *Phill.*	*	...	*	
	—— multispira	*			

TABLE V. (*continued*).

Classes.	Species.	South Devon.	North Devon.	Foreign.	Carboniferous.
GASTEROPODA	Scoliostoma texta, *Phill.*	*	...	*	
	Trochus Boueii, *Stein.*	*	...	*	
	Turbo cirriformis, *Sow.*	*			
	—— subangulatus, *Sow.*	*			
	Vermetus antitorquatus, *Phill.*	*	...	*	
	—— annulosus	*			
NUCLEOBRANCHIATA	Bellerophon striatus, *Bronn*	*			
	Porcellia Woodwardii, *Sow.*	*	...	*	
CEPHALOPODA	Clymenia lævigata, *Münst.*	*			
	—— undulata, *Münst.*	*			
	Cyrtoceras armatum, *Phill.*	*			
	—— bdellatus, *Phill.*	*			
	—— fimbriatum, *Phill.*	*			
	—— marginale, *Phill.*	*			
	—— nautiloideum, *Phill.*	*			
	—— nodosum, *Phill.*	*	...	*	
	—— obliquatum, *Phill.*	*			
	—— ornatum, *Goldf.*	*	...	*	
	—— quindecimale, *Phill.*	*			
	—— reticulatum, *Phill.*	*			
	—— subornatum, *M'Coy*	*			
	—— tridecimale, *Phill.*	*	...	*	
	Goniatites excavatus, *Phill.*	*	...	...	*
	—— globosus, *Münst.*	*			
	—— serpentinus, *Phill.*	*			
	—— transitorius, *Phill.*	*			
	Nautilus germanus, *Phill.*	*			
	Orthoceras cinctum, *Sow.*	*	...	...	*
	—— ellipsoideum, *Phill.*	*			
	—— tubicinella, *Sow.*	*	...	*	
	—— unctum	*			
	—— undulatum, *Sow.*	*			

In the above Table will be found all the known species:—*Amorphozoa*: 4 genera and 8 species, all, with one exception (*Stromatopora concentrica*), confined to the southern area. *Cœlenterata*: 23 genera and 50 species; 10 genera and 17 species of which are known in the Ilfracombe group in North Devon and West Somerset; the physical conditions of the rocks of the two areas, and the small amount of old sea-bottom opened in the north compared with that in the south, will readily account for the wide difference as to number of species, though individually they appear to be as abundant in North Devon, many of the limestones being crowded with corals, especially at Adscombe, on the *east flanks* of the Quantock Hills (West Somerset), and the Combe-Martin area. *Echinodermata*: 4 genera and 8 species; and, as far as I know, no species of this group occurs in the Middle Devonian of North Devon; and, such as they are, they appear confined to the typical southern area. I must, however, state that no group in the whole Devonian series is so difficult of identification, or perhaps more erroneously determined; the Crinoidea and Asteroidea, in nine cases out of ten, occur only as casts and moulds; yet some of the Upper Devonian beds of Baggy, Marwood, Croyde, Braunton, &c. are literally composed of the rusty decomposed remains of the Echinodermata, especially the *Crinoidea*. The 20 known species in the whole Devonian rocks are irregularly distributed through them; though 8 certainly occur in the Middle South Devonian beds. *Annelida*: only one determined species occurs, *Tentaculites annulatus**, known in both North and South Devon. *Crustacea*: 5 genera and 13 species occur in the Middle series in South Devon, one of which only, *Trimerocephalus lœvis*, is known in the Ilfracombe series of North Devon, and was found by Mr. Valpy in the gritty shales of Watermouth near Ilfracombe; this is important as being another and important link in evidence of the same species of Crustacea occurring in the two areas. Mr. Jukes states that he found *Phacops latifrons* in the Lower Devonian slates of Lynton (Valley of Rocks); and on his or Mr. Baily's authority I insert it in my list; these two species of the family Phacopidæ give us some hope that *Homalonotus* and *Harpes* will ere long reward the labours of some patient geologist. *Polyzoa*: 6 genera, and 8 species out of the 12 known, occur in South Devon; we cannot, however, at all depend upon the specific characters of these generally badly preserved and minute organisms; and as such they possess little or no stratigraphical value. *Fenestella antiqua* is, *according to every one, in everything*, from the slates of Looe to the Coomhola grits &c. Prof. Phillips admits 4 varieties of this species, all having different geographical positions; each should be carefully examined and understood, if weight is to be attached to so ubiquitous a deep-sea form. Lonsdale even refers it to the Silurian rocks; the whole group of the palæozoic Polyzoa requires great and critical examination.

Brachiopoda.—This class, like the Actinozoa among the Cœlenterata, highly typify and characterize the Middle Devonian rocks of South and North Devon; 23 genera and 68 species have been accurately determined as coming from these beds in South Devon; 10 genera and 22 of these species are common to the slates and limestones of the middle group in North Devon; and by comparison with those of the Rhine, Belgium, and France, in beds of the same age, no less than 47 species are common to the two marine areas; 7 only of these, viz.—

Rhynchonella acuminata, *Martin*.
—— pleurodon, *Phill.*
—— pugnus, *Martin.*
—— reniformis, *Sow.*
Spiriferina cristata, *Schloth.*
Streptorhynchus crenistria, *Phill.*
Strophomena rhomboidalis, *Wahl.*

pass up to the Lower Carboniferous, all of which, with the exception of *Rhynchonella acuminata*, form an important feature in the Upper Devonian slates and limestones of Baggy, Marwood, Sloly,

* There are perhaps two if not three species, though their remains are obscure.

and Pilton. The typical genera, not known in higher beds, such as *Calceola*, *Merista*, *Pentamerus*, *Rensseleria*, *Retzia*, *Davidsonia*, *Stringocephalus*, and *Uncites* (all peculiarly Devonian), appear to have died out *prior* to the deposition of the Carboniferous series, during those changes of conditions which are evidenced by the physical structure of the Devonian sedimentary rocks, where through North Devon we recognize at the base great accumulations of red sandstones, succeeded by the fine and coarse gritty slates and impure limestones of the Lynton or Lower Devonian group, and another great and succeeding deposit of red sandstones and grits almost void of organic remains (the Hangman Grits), and a second series (the Ilfracombe group) of fine-grained fissile slaty deposits with associated organic limestones, rich in corals and Brachiopoda, differing in the two British areas in the amount of limestone, but in nothing as regards life-contents. This Middle-Devonian period was one of continued depression, which must have gone on continuously, as is proved by the position of the thick, glossy, fine-grained, unfossiliferous slates of Lee, Mortehoe, and Rockham, that overlie the Ilfracombe fossiliferous series &c., which sequence, with identical conditions, can be detected in the South Devon area. These unfossiliferous Morte Slates were probably again brought within the influence of shallow water; and on them rest the now higher Upper Old Red Sandstone beds of Pickwell Down, and then succeeds the upper marine Devonian series of Baggy, Marwood, and Pilton &c., with their crowds of typical Upper-Devonian species*.

Singularly scarce are the remains of *Lamellibranchs* in this group of deposits; and the 12 genera and 17 species known are Laminarian and deep-water forms — *Avicula*, *Pterinea*, *Ctenodonta*, *Corbula*, the dwarfed *Conocardia*, *Cucullæa*, &c.; and indisputably the marked assemblage of peculiar species of corals and Brachiopoda accompanying them indicate the same bathymetrical conditions. Two species only of the Lamellibranchiata, viz. *Aviculopecten plicatus* and *Cardium aliforme* lived on to Carboniferous times: and 2 British species only are as yet known to occur in the three European areas, as compared with the known South-Devon forms; and they are *Conocardium aliforme* and *C. minax*.

Gasteropoda.—Similar facts are obtained by an examination of the Gasteropoda of this Middle zone: 11 genera occur, many of them being represented by only one or two species, such as *Nerita*, *Scoliostoma*, *Trochus*, *Turbo*, and *Vermetus*; 36 species are distributed amongst the 11 genera, only four of which, or proportionally less than half as many as the Lamellibranchs, lived on to the Carboniferous Limestone; they are, *Acroculia vetusta*, *Euomphalus lævis*, *Macrocheilus imbricatus*, and *Murchisonia spinosa*; whereas we know of 15 European species being common to our Devonian series of North and South Devon. They are enumerated in Table V.

* Consult the able paper by J. W. Salter, Esq., on the Upper Old Red Sandstone and Devonian rocks, Quart. Journ. Geol. Soc. vol. xix. for a complete description of these beds and their fossil contents, as well as of those of the Pembroke area.

Nucleobranchiata.—*Bellerophon* and *Porcellia*, with perhaps *Conularia*, are the only three genera known in the Middle Devonian rocks of South Devon; 3 species occur, and all are confined to that area, viz. *Bellerophon striatus*, *Porcellia Woodwardii*?, and *P. striata*.

Cephalopoda.—The species in this class are singularly distributed through the Devonian series, and seem to have here been localized in groups or colonies, the two genera *Clymenia* and *Cyrtoceras* especially so. The former (*Clymenia*), both in Europe and Britain, seems confined to the Upper Devonian, and notably so with us, at Petherwin and Landlake, the genus not occurring higher in the series; and, with one exception, the species are all localized, or confined to one area. Eleven species are found in the Upper Devonian beds, below the Marwood group, and south of the great Culm-trough. The species of the genus *Cyrtoceras* seem to have been equally locally colonized, 12 species being confined to the Middle Devonian of Newton Bushel in South Devon, *C. rusticum* being the only form recorded as coming from the upper series at Petherwin. However difficult it may be to account for this speciality and colonization of a definite area by a group of Mollusca pelagic in their habits, the evidence, as it is, must be received in both cases, viz. of the *Clymeniæ* in the Upper Devonian, and the *Cyrtocerata* in the Middle. The species typifying the Goniatites, Orthoceratites, and *Nautili* are, on the other hand, as widely scattered through the Devonian of North Cornwall, South Devon, and North Devon; 6 species of *Orthoceras* occur in the Middle Devonian of South Devon, and two species of each genus recur in the Carboniferous beds, viz. *Goniatites excavatus*, *G. serpentinus*, *Orthoceras cinctum*, and *O. undulatum*. This analysis of the 235 Middle or Eifelian species of South Devon will show a marked feature of close affinity with forms occurring in beds of the same age in Rhenish Prussia, the Eifel, and France, as a large percentage of the species common to each can be adjusted to, and collated with, our Devonian types.

Table VI.—*Showing the species common to the Middle Devonian rocks of North Devon, South Devon, and West Somerset.*

Species.	North Devon.	South Devon.	West Somerset.
Stromatopora concentrica, *Goldf.*	*	*	*
Tentaculites annulatus, *Schloth.*	*	*	
Amplexus tortuosus, *Phill.*	*	*	*
Cyathophyllum æquiseptum, *M.-Edw.*	*	*	
—— Boloniense, *Blainv.*	*	*	*
—— cæspitosum, *Goldf.*	*	*	*
—— Damnoniense, *Lonsd.*	*	*	*
—— helianthoides, *Goldf.*	*	*	*
—— obtortum, *M.-Edw.*	*	*	
Cystiphyllum vesiculosum, *Goldf.*	*	*	*
Favosites cervicornis, *Blainv.*	*	*	*
—— dubia, *Blainv.*	*	*	

Species.	North Devon.	South Devon.	West Somerset.
Favosites fibrosa, *Goldf.*	*	*	
Hallia Pengellyii, *M.-Edw.*	*	*	
Heliophyllum Hallii, *M.-Edw.*	*	*	*
Heliolites porosus, *Goldf.*	*	*	
Pachyphyllum Devoniense?, *M.-Edw.*	*	*	
Endophyllum abditum, *M.-Edw.*	*	*	*
Alveolites suborbicularis, *Lam.*	*	*	*
—— (Favosites) reticulatus, *Blainv.*	*	*	*
Phacops (Trimerocephalus) lævis, *Münst.*	*	*	
Ceriopora similis, *Phill.*	*	*	
Fenestella antiqua, *Goldf,*	*	*	*
—— arthritica, *Phill.*	*	*	
Retepora repisteria, *Goldf.*	*	*	
Athyris concentrica, *V. Buch*	*	*	
—— lachryma, *Sow.*	*	*	
Atrypa desquamata, *Sow.*	*	*	
—— reticularis, *Linn.*	*	*	
—— aspera, *Schloth.*	*	*	
Cyrtina heteroclyta, *Def.*	*	*	
Merista plebeia, *Sow.*	*	*	
Orthis arcuata, *Phill.*	*	*	
—— granulosa, *Phill.*	*	*	
—— striatula, *Schloth.*	*	*	
Rensseleria stringiceps, *Rœm.*	*	*	
Rhynchonella cuboides, *Sow.*	*	*	
—— pleurodon, *Phill.*	*	*	
—— pugnus, *Martin.*	*	*	
—— reniformis, *Sow.*	*	*	
Spirifera curvata, *Schloth.*	*	*	
—— disjunata, *Sow.*	*	*	
—— lævicosta, *Valen.*	*	*	
—— nuda, *Sow.*	*	*	
—— speciosa, *Scloth.*	*	*	
Steptorhynchus crenistria, *Phill.*	*	*	
Strophomena rhomboidalis, *Wahl.*	*	*	
Acroculia vetusta, *Sow.*	*	*	
Euomphalus serpens, *Phill.*	*	*	

5. *Species common to the Middle Devonians of North Devon, South Devon, and West Somerset.*—We will now examine those species that are common to the Middle or Eifelian beds of South and North Devon (Table VI.) so as to show their identity, and, by the community of species, to endeavour to establish still more the relations of the group and the value of its middle position in North Devon. It will be found that in South Devon the position of this series can only be clearly determined by palæontological research, and by no other. In other words, the stratigraphical sequence in that area is so obscure through disturbance, that palæontology alone can decide or guide us; whereas, in the north, the physical sequence is clear and unmistakeable, and, aided by the assemblage, condition, and identity of the fossil fauna of its slates and sandstones with that of South Devon and Western Europe, we can, I believe, firmly establish the true zoological position of the rocks under examination. Know-

ing, then, that 235 species occur in South Devon (Table V.), we will adopt them as our standard for comparison with the northern species in the middle zone. We find, in all, that 50 species of the known 235 are common to the two areas (*vide* Table VI.), which are related by a marked and peculiar facies, one distinctly characteristic of, and identical with, the Middle Devonian, or Eifelian and Stringocephalenkalk, of the Rhenish provinces &c., which is especially borne out by the Brachiopoda and Cœlenterata: 21 species of the *former*, out of 67 in South Devon, are common to the Middle Devonian of it and the North; and 17 of these occur in European areas.

This close approximation in the number of identical species is most significant of their synchronous deposit; and similarity of conditions is evidenced by the structure of the rock-masses in all the areas. Comparison among the corals shows different results, so far as numbers are concerned. Of the 50 species known in South Devon 18 are also common to it and the North; and of these 18, seven are found in the Western European Devonians, *no species living on to the Carboniferous period.* The grand development of limestone in South Devon will fully account for the greater number of known species of corals over that of the northern area, added to its being also more extensively worked for economical purposes; and the rocks of the southern area have been more industriously searched and examined by many able geologists*; and now, under the patient research of a few good observers†, the northern slates and limestones are abundantly yielding species identical with those of the south. One bivalve only occurs common to the two, *Megalodon cucullatum*; two univalves, *Acroculia vetusta* and *Euomphalus serpens*; the sponge *Stromatopora concentrica*, and four Polyzoa, with *Phacops* (*Trimerocephalus*) *lævis*, and *Tentaculites annulatus*, complete the 50 common or connecting species; 8 of these 50, chiefly Brachiopoda, recur in the Carboniferous series. Want of more complete evidence prevents our comparing the Middle Devonian of Cornwall with either area; but of the known species only 4 occur as common, viz. *Athyris concentrica*, *Atrypa desquamata*, *Spirifera speciosa*, and *Favosites cervicornis*. In Table IV. p. 640, is given the whole *Middle Devonian* fauna of North Devon and West Somerset, in which 71 species are shown to be distributed through that area; to these 71 I now adjust and compare those known to occur in the Rhenish, Belgian, and French areas, so as to correlate them, through their fossils, with our North-Devon types, and to show their intimate relation, connexion, and identity; for most of them are cognate species.

In Table V. it is shown that 34 species are common to North Devon and Europe, and that chiefly as before, through the two classes, Actinozoa and Brachiopoda, 10 species of corals and 16 species of Brachiopoda occurring in our own and one or other of the European Devonian areas, whereas only one Lamellibranch, *Megalodon cucul-*

* Mr. Godwin-Austen (Geol. Trans.), Phillips, Pengelly, Sedgwick & Murchison, Lee, Vicary, &c. &c.

† Mr. Valpy, Mr. Hall, Rev. W. Mules, the Rev. H. H Winwood, &c.

latus, one Gasteropod, *Acroculia vetusta*, and two Polyzoa, *Fenestella antiqua* and *Retepora repisteria*, help to unite them: the species of the typical genera, *Cyrtina*, *Merista*, *Rensseleria*, *Stringocephalus*, &c., all characteristic of the slates of North Devon, are of themselves weighty and good evidence of pre-Carboniferous times.

It is, however, singular, and will show how little we yet know of the original conditions and distribution of life over even this one area, that at present we are acquainted with only 3 species that are common to the lower, middle, and upper groups in North Devon and West Somerset; these are the questionable *Fenestella antiqua*, the ubiquitous *Chonetes Hardrensis*, and *Streptorhynchus crenistria*. These long-lived species all pass the confines of the Upper Devonian, and are abundant in the lower beds of the Carboniferous group.

This imperfect record can only arise from the very incomplete search which the rocks of this area have undergone, and the little we therefore know of their palæontological contents. No agreement with the Carboniferous strata can be deduced from the presence of these three forms, as no real value can be attached to them; it simply shows that the individuals of the species were abundant, widely diffused, and long-lived. It also shows, in the absence of other evidence, that the assemblage of forms which constitute the population of a given area is peculiar and almost definite. In the present case, 16 species are known to occur in the Lower Devonian 53 in the Middle, and 104 in the Upper Devonian; and yet, out of these, only the 3 species before named are common to the three divisions, or pass through all three; and these lived on to the Carboniferous slates. This, be it remembered, is in North Devon; these three species necessarily ally the lower or Lynton group with the Barnstaple beds (Carboniferous *) to which they pass; but these are all: it would therefore appear that, palæontologially, there is no evidence to identify, or hardly to connect, the beds *above* the Upper Old Red Sandstone of Pickwell Down with the underlying Lynton slates and grits, similarity in lithological conditions being no proof of identity or of synchronous deposition.

6. *Agreement of Foreign Devonian Species with our British Middle and Upper Series in North and South Devon.*—We know that 144 species are common to the Devonian rocks of England and the Continent, as expressed in the general Table II., p. 616. Taking them at percentage value, we have an agreement of 38 per cent. as being common to the British and European areas; or, of 3 species which occur in our typical beds, 1 is found in the Rhenish, Belgian, and French taken collectively,—a far closer agreement than that which is recognized as existing between our Devonian and the Carboniferous, which, according to the analysis given in the Table, as is 1 to 7, or only $14\frac{1}{4}$ per cent. occurring as common to the two formations. This relation and identity of species in two chief areas, so widely separated as are the three Continental from the two British, is to my mind a most valid reason for their contemporaneity and simul-

* That is, admitting that the Barnstaple beds may be of Carboniferous age.

taneous deposition, which took place in one general sea, over one definite, once connected, but now disunited area.

Having compared the Devonian species generally amongst themselves, in their respective areas in North and South Devon, and with those of the Rhenish, Belgian, and French areas, and partly with the Carboniferous, it now remains for me to analyze the particular groups of organic remains amongst themselves, in our North Devon district, and also to compare the species in that area with those of Ireland and the Continent: in no other way can we arrive at the relation which I believe exists amongst the fossil remains, and at the value of the term "Devonian" or "the Devonian System."

I propose, therefore, to examine and compare the British Devonian Cœlenterata, Brachiopoda, and Cephalopoda amongst themselves, these groups being of chief value,—also their relation to the continental species of the same age, and to the Carboniferous of Devon, Ireland, and Britain generally.

Table VII.—*Comparison of the British Devonian Cœlenterata with those of the Rhine, Belgium, and France.*

	British.			Foreign.								
	Lower Devonian.	Middle Devonian.	Upper Devonian.	Rhine.			Belgium.			France.		
				L.	M.	U.	L.	M.	U.	L.	M.	U.
Acervularia pentagona, *Goldf.*	...	*	...	...	...	...	...	*	*			
—— Goldfussii, *De Vern.*	...	*	...	...	*	...	...	*				
—— Roemeri, *De Vern.*	...	*	...	...	*							
Alveolites suborbicularis, *Lam.*	*	*	...	...	*							
Amplexus tortuosus, *Phill.*	...	*	*	...	*							
Cyathophyllum cæspitosum, *Goldf.*	...	*	...	...	*	...	...	*	...	...	*	
—— Boloniense, *Blainv.*	...	*	...	...	...	...	...	...	...	...	...	*
—— ceratites, *Goldf.*	...	*	...	...	*	...	...	*	...	...	*	
—— helianthoides, *Goldf.*	...	*	...	...	*	...	...	*	...	...	*	
—— hexagonum, *Goldf.*	...	*	...	...	*							
—— Roemeri, *M.-Edw.*	...	*	...	...	*	...	...	*				
—— turbinatum? *Goldf.*	...	*	...	...	*	...	...	*	...	...	*	
Cystiphyllum vesiculosum, *Goldf.*	...	*	...	...	*	..	...	*				
Favosites Goldfussii, *D'Orb.*	...	*	...	...	*	...	...	*	...	...	*	
—— cervicornis, *Blainv.*	*	*	...	...	*	...	...	*	*	...	*	
—— dubia, *Blainv.*	...	*	...	...	*	...	...	...	...	...	*	
—— fibrosa? *Goldf.*	*	*	...	...	*	...	...	*				
—— reticulata, *Blainv.*	...	*	...	...	...	...	...	*				
Fistulipora cribrosa, *Goldf.*	...	...	*	...	...	*						
Heliolites porosa, *Goldf.*	...	*	...	...	*							
Petraia Celtica, *Lonsd.*	*	*	*									
Pleurodictyum problematicum, *Gldf.*	*	*	...	*	*	...	*	*	...	...	*	

Cœlenterata (Corals).—There are 24 genera and 51 species of Corals known in the Devonian rocks of North and South Devon (*vide* Tables II. and V.); and there appear to be 2 forms, *Fistulipora* (*Manon*) *cribrosa*, Goldf., and *Michelinia antiqua*, M'Coy, on the confines of the two systems (Devonian and Carboniferous), which can hardly be regarded in our calculations, much doubt existing as to their position; regarding them, however, as strictly passage-species and common to either group, we have 49 species belonging to this horizon. None are *peculiar* to the Lower Devonian of either North or South Devon; whereas 35 species are *not* known out of the Middle, and four are *common* to Lower and Middle, viz. *Alveolites suborbicularis*, Lam., *Favosites cervicornis*, Blainv., *Petraia celtica*, Phill., and *Pleurodictyum problematicum*, Goldf.* When we compare this important group of fossils with their equivalents in the Rhenish provinces, Belgium, and France, we find that 22 out of the 51, or 43 per cent., are identical species with those found in the three areas on the Continent, 17 are Rhenish, 14 are Belgian, 11 are common to both areas, and 11 occur in the Boulonnais.

The accompanying Table (VII.) shows the distribution of those species only that are known to be common to Britain and Europe in either the Lower, Middle, or Upper division: 35 are absolutely confined to the Middle Devonian series of South Devon; and 22 of these occur in Europe; see Table II., p. 616, and Table V., p. 643; so that the relation of an area to the species that occupy it, the entity of the Middle Devonian Corals amongst themselves, with other equally definite physical conditions, palæontological affinities, and results, in all the areas, give a marked and peculiar character to the Middle Devonian group: 3 species only of the 22 (Table VII.) occur in the Upper Devonian beds of North Devon, as we should expect from the nature of the sea-bottom; and two of these belong to the Turbinoliæ, or simple forms, whose habits are different from those of the compound species; they are *Amplexus tortuosus*, Phil., and *Petraia Celtica*, Phill., the remaining species being the dubious *Fistulipora* (*Manon*) *cribrosa*, Goldf.; *and no single species of the known* 51 *passes up to the Carboniferous system.* It cannot, then, be asserted that we have no true Devonian Corals, or that there "are or were local coral-banks in the Carboniferous sea," when no single form is known common to the two horizons, either *here or in any known area*: such reasoning would not and could not apply either to the great assemblage of Corals and Crinoidea in the Upper Silurian, or to the Corals of the Carboniferous Limestone, where the surrounding relations are the same; they, like the species in the limestones and slates of the Middle Devonian series, were a group peculiar to themselves, and to the seas in which they lived, and as definitely determine it. This class, like the Brachiopoda, which will claim our next attention, occupies and typifies one physically united area, dying out or changing when the conditions favourable to their existence no longer continued; and the continuous or fringing barrier-like reef of slaty coral and limestones which extends *from what is now* Ilfracombe and Combe Martin to the Quantock Hills, in West Somerset, and farther east still, under the Secondary rocks, ceased to exist as the area they then occupied deepened, or became depressed, thus giving origin to the grey fine-grained sedimentary non-fossiliferous slates of Lee, Rockham, Mortehoe, Lundy, Winsford, and the southern flanks of the Exmore,

* Always occurring in the slates.

indeed to all that underlie the zone of Upper Old Red Sandstone to the south*. All research, as far as I know, has failed to detect a single organism in these upper slates of the middle group; and, save on the strike of the older or lower slates and limestones, which I doubt not continue on to Belgium and the Rhine, we neither know nor again find a single cognate species.

7. *Analysis of the British and Foreign Devonian Brachiopoda.*—It is difficult, amidst the conflicting opinions of distinguished naturalists in this country, Europe, and America, to definitely arrive at their conclusions as to the strict nomenclature of a large number of either genera or species in this important class of Mollusca; but no group has played so important a part in the history of the past as the Brachiopoda, and particularly in Palæozoic times. Generically and specifically they are of high value in determining the age of the rocks in which they occur, and notably so when we endeavour to trace the history and succession of the series forming the Devonian system, especially as regards the overlying Carboniferous system which at its base is intimately connected with the Devonian. We have no fear of confounding the Silurian with the Old Red Sandstone or Devonian; for, except through the fishes†, one doubtful coral, viz. *Favosites fibrosa*, one Annelide (*Tentaculites annulatus*?), one Brachiopod (*Atrypa reticularis*, and its var. *aspera*), one Lamellibranch (*Ctenodonta*?), with perhaps *Orthoceras Ludense* and *O. ibex* among the Cephalopoda (8 forms in all), there was a complete break between the two, and it is thus quite clear that the 1150 known species of the Silurian fauna in the British area entirely disappeared or changed before any of the Marine Devonian species had existence. The accompanying Table (Table VIII.) will enable us to understand the distribution and relations of the class Brachiopoda through the three groups of the Devonian series, both in our own areas and those of the Rhine, Belgium, and France; and as our standard of comparison must be taken from the species occupying the British area, I adjust the groups amongst themselves, and compare the European species with them and ultimately with the Carboniferous. There are 99 known Devonian species (see Table II. p. 616). These species are distributed through 26 genera, many of which are peculiar to the Devonian age. 21 genera and 52 species of the 99 are common to British and Foreign Devonian rocks, and are found in one or other of the three divisions, or in the Lower, Middle, and Upper Devonian; 2 species only are common to, or occur in, all three divisions in our two areas, viz. *Athyris concentrica* and *Chonetes Hardrensis* (*C. sordida*). 47 of the 52 species enumerated in the Table are found in our Middle Devonian; and out of the total of 52 enumerated, 6 pass up to our Lower Carboniferous system, viz. *Chonetes Hardrensis*? (*C. sordida*), *Rhynchonella acuminata*, *R. pugnus*, *Productus scabriculus*, *Streptorhynchus crenistria*, and *Strophomena rhomboidalis*. This is in accordance with what we should expect in the conformable and succeeding system, where no stratigraphical break is known to exist; none, however, of

* The Pickwell-Down Sandstones.

† The fishes on the confines of the Silurian and Old Red being chiefly confined to the Passage series, 4 genera and 7 species occurring.

the peculiar and typical Devonian genera are known in the Carboniferous rocks, either in our own two areas or in the European; the prominent and characteristic species recognized everywhere, viz. *Calceola sandalina*, Linn., *Davidsonia Verneuili*, V. Buch, *Merista plebeia*, Sow., *Rensseleria stringiceps*, Rœm., *Retzia ferita*, V. Buch, *Stringocephalus Burtini*, Defr., *Cyrtina Demarlii*, V. Buch, and *Uncites gryphus*, Schloth., characterize the British as well as the Foreign Middle Devonians; but species of other well-known genera mark equally well the unity of the middle group over Europe and in England. Amongst the many strictly Lower-Devonian forms prominently stand out *Leptæna laticosta*, Conrad, *Orthis hipparionyx*, Vanux., and *Spirifera cultrijugata*, Rœm., which with us are confined to the Lynton group in North Devon and the equivalent Looe beds in South, and appear confined to the same stage in Europe. Thus, then, of the 99 known British Devonian species, 52, or 50 per cent., are known to occur in Europe, and are therefore common to both the great areas; and both are related to a higher or succeeding system (the Carboniferous) by only the 6 species above enumerated; we must not, however, fail to again notice the above 8 remarkable genera with their known single representatives, which so distinguish the Middle Devonian group.

It is now equally necessary to analyze and examine the British species of Devonian Brachiopoda with those of the Carboniferous, so far as they are known to be common to each other, and in each of the three Devonian groups separately, because it is asserted by Mr. Jukes that the rock-masses which are believed and acknowledged to be of Lower, Middle, and Upper Devonian age in North Devon, at Lynton, Ilfracombe, and Baggy &c. are, by community of fossils and by stratigraphical and physical relations, " part of the same group of rocks as those called Carboniferous Slates in Ireland;" and, more than this, it is asserted that the particular and so-called Upper Devonian series of Baggy and Marwood are " on the same general horizon with those of the Lower Devonian slates and grits of Lynton," &c. &c. These views are based on the similarity of the slaty and other rock-masses, in both these North Devonian areas, and by comparison of them with that area of the South of Ireland containing Carboniferous Slates and certain fossils.

I have endeavoured to prove that neither fault nor anticlinal exists in North Devon of a nature or magnitude to invert the order of, or to repeat, the beds of the two areas from south to north, and I will now endeavour to show through the Brachiopoda, as I have done through the Cœlenterata, that there are valid grounds for not receiving either the physical or the palæontological interpretation put upon them by Prof. Jukes; and these will be appealed to by a more complete analysis of all the known Devonian and Carboniferous fossils occurring in the Northern or disputed area.

Table VIII.—*Comparison between the British and Foreign Devonian Brachiopoda, showing also their range to the Carboniferous.*

Species.	British.			Foreign.									Carboniferous.
				Rhine.			Belgium			France.			
	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.	Lower.	Middle.	Upper.	
Athyris concentrica, *V. Buch*	*	*	*	...	...	*	...	*	*	...	*	*	
—— lachryma? *Sow.*	...	*	...	...	*	...	...	...	...	...	...	*	
—— phalæna, *Phill.*	...	*	...	...	...	...	...	...	...	...	*		
Atrypa flabellata, *Goldf.*	...	*	...	...	*	...	...	*					
—— lens, *Phill.*	...	*	...	...	*								
—— lepida, *Goldf.*	...	*	...	*	*	...	...	*					
—— reticularis, *Linn.*	...	*	*	*	*	...	...	*	...	...	*	*	
—— aspera, *Schloth.*	...	*	*	...	*	...	...	*	...	...	*	*	
Calceola sandalina, *Linn.*	...	*	...	...	*	...	...	*	...	...	*		
Camarophoria rhomboidea, *Phill.*	...	*	...	...	*	...	...	*					
Chonetes minuta, *Goldf.*	...	*	...	...	*	...	...	*					
—— sordida, *Sow.* (C. Hardrensis, *Phill.*)	*	...	*	*	*	*	...	*	*	...	...	...	*
Cyrtina Demarlii, *V. Buch*	...	*	...	...	...	...	...	...	...	...	*		
—— heteroclyta, *Def.*	...	*	...	*	*	*	...	*	*	...	...	*	
Davidsonia Verneuilii, *V. Buch*	...	*	...	...	...	...	...	*					
Leptæna interstrialis, *Phill.*	...	*	...	...	*	...	...	*					
—— laticosta, *Conrad*	*	...	...	*	...	...	*	*	...	...	*		
—— nobilis, *M'Coy*	...	*	...	*									
Merista plebeia, *Sow.*	...	*	...	...		...	...	*					
Orthis hipparionyx, *Vanux*	*												
—— striatula, *Schloth.*	...	*	*	...	*	*	...	*	...	...	...	*	
Pentamerus brevirostris, *Phill.*	...	*	...	...	*	...	...	*	...	...	*		
Productus subaculeatus, *Murch.*	...	*	*	...	...	*	...	...	*	...	*	*	
—— scabriculus, *Mart.*	...	...	*	...	...	*	...	...	*	...	...	*	*
Rensseleria stringiceps, *Rœmer*	...	*	...	*	*								
Rhynchonella acuminata, *Mart.*	...	*	...	...	*	...	...	*	...	...	*	...	*
—— cuboides, *Sow.*	...	*	...	...	*	...	...	...	*				
—— primipilaris, *V. Buch*	...	*	...	...	*	...	...	*					
—— pugnus, *Martin*	...	*	*	...	*	...	...	*	...	...	*	...	*
Retzia ferrita, *V. Buch*	...	*	...	...	*								
Spirifera canalifera, *Valen.*	*	*	...	...	*	...	...	*	...	...	*		
—— comprimata	...	*	...	...	...	...	...	...	*				
—— curvata, *Schloth.*	*	*	...	...	*	...	...	*					
—— cultrijugata, *Rœmer*	*	...	...	*	*	...	*	...	...	...	*		
—— disjuncta, *Sow.*	...	*	*	...	*	*	...	...	*	...	*	*	
—— hysterica, *Schloth.*	*	*	...	*	*	...	*	...	...	...	*	*	
—— lævicosta, *Valen.*	*	*	...	...	*	...	...	*	*				
—— lineata, *Mart.*	...	*	*	...	...	...	...	...	*				
—— simplex, *Phill.*	...	*	...	...	*	...	...	*					
—— speciosa, *Schloth.*	*	*	...	*	*	...	...	*	...	*	*		
—— subcuspidata, *Schnur*	...	*	...	...	*	...	...	*					
—— undifera, *Rœm.*	...	*	...	...	*	...	...	*					
—— undulata, *Rœm.*	...	*	...	...	*								
Stringocephalus Burtini, *Defr.*	...	*	...	...	*	...	...	*	...	...	*		
Streptorhynchus crenistria, *Phill.*	?	*	*	...	...	...	...	...		...	...	...	*
—— umbraculum, *Schloth.*	...	*	...	...	...	...	...	*					
Strophalosia fragaria, *Sow.*	...	*	*										
—— productoides, *Murch.*	...	...	*	...	...	...	...	...	*	...	...	*	
Strophomena rhomboidalis, *Wahl.*	...	*	*	...	*	...	...	...	...	...	...	...	*
Terebratula sacculus	...	*	*	...	...	...	...	*	*				
—— Newtonensis, *David*	...	*	...	...	...	...	...	...	...	...	*		
Uncites gryphus, *Schloth.*	...	*	...	...		...	...	*					

8. *Devonian and Carboniferous Brachiopoda.*—It has been before stated that 99 species of this class are in the Devonian rocks of Britain. Table II. shows every species in North Devon, arranged in the order of time or succession. Those species occurring in South Devon and Cornwall are compared with them; in other words, every species in North Devon is collated with the same in Cornwall and South Devon. Of the 99 known forms, we have, then, in the Northern area 52 common; and of 26 genera known in British Devonian rocks 22 occur in North Devon, 5 only, viz. *Camarophoria, Davidsonia, Leptœna, Pentamerus*, and *Retzia*, being required to complete the generic equivalence of the two areas. This Table also shows that 27 of the 48 North-Devon species also occur in the foreign Continental rocks, and that 13 are common to the Carboniferous above; but these are related chiefly, as will be seen, through the passage-series (*vide* Table VIII. p. 658, and Table IX. p. 669).

We will now see how far the species occurring in the Lower Devonian (Lowest or Lynton) beds agree with those of the Upper and of the Carboniferous south of Pickwell Down at Baggy, Marwood, Sloly, and Pilton—the two groups of rocks which Mr. Jukes states are on the same geological and palæontological horizons, and that both are the "Carboniferous Slates" of Ireland. In this comparison I neglect all but the Brachiopoda. The mass of species in other classes and orders will be compared hereafter in their proper place. The species occurring in the Lynton Slates are the following:—

Lynton.	*South of Pickwell.*
Athyris concentrica, *V. Buch.*	Chonetes Hardrensis, *Phill.*
Chonetes sordida, *Sow.* (*vel* C. Hardrensis ?, *Phill.*).	
Spirifera canalifera, *Valen.*	
—— hysterica, *Schloth.*	
—— lævicosta, *Valen.*	
Orthis granulosa, *Phill.*	
—— arcuata, *Phill.*	
Streptorhynchus umbraculum, *Schloth.*	

The only species, therefore, believed to be common is the *Chonetes Hardrensis*; and there is much doubt still as to the Lynton, *C.* (*Lep.*) *sordida*, Sow., being the *Upper* Devonian and Carboniferous *Chonetes Hardrensis* of Phillips. It is, however, *retained.* Should they on closer research prove to be distinct, we then have *no species* in this or any class common to the Lower Devonian slates of the Lynton area and the Upper Devonian, or to the Carboniferous Slates, or to the Lower Limestone shales, anywhere. Casts of *Crinoidea* cannot be received as of specific value; and the dubious *Fenestella antiqua*, said to be in every bed, has yet to be understood. However much, then, at a *casual glance*, the slates and grits of Lynton may be said to physically resemble the beds of Baggy, Marwood, Croyde, Braunton, and Pilton &c., on close inspection and zoological analysis, they bear scarcely any resemblance. The physical conditions, structure, arrangement, and cleavage of the Lynton Slate group generally, altogether differ from the associated slates, brown sandy grits, and limestones in the Baggy and Croyde area—to say nothing of what I believe to be the case, that hardly a single species will ever be found common to the two areas. The very band of Upper Old Red Sandstone which stretches (in place) across North Devon from Pickwell Down (Morte Bay) to Wiveliscombe and the Quantock Hills constitutes a natural base-line to the Upper Devonian rocks and species. The physical changes that accompanied and produced that great accumulation of red sandstone also seem to have modified the forms of life that succeeded it, now enabling us to draw both a physical and palæontological boundary-line between the well-marked Ilfracombe or Middle Devonian group below, and the Upper, or Baggy and Marwood, group above; and, more important still, the species comprising the Petherwin fauna to the south of the Culm-trough, which are older in time than those of the Baggy and Marwood beds, have to be interpolated and accounted for, although at present not yet recognized below the Baggy series on the north side of the Culm series. To still carry on our analysis as to the value of the Brachiopoda, and the relationship between the admitted Lower and Middle Devonian rocks of this area and the supposed Carboniferous Slates south of Vention and Morte Bay, we must state the evidence collected and given in Tables IX. and X. It is there seen that, of the 48 species of this class distributed through the Lower, Middle, and Upper Devonian slates and limestones, only 13 species of the whole are common to the two formations, namely the 9 following:—

Athyris oblonga, *Sow.*	Rhynchonella reniformis, *Sow.*
Discina nitida, *Phill.*	Spirifera Urei, *Fleming.*
Lingula squamiformis, *Phill.*	Spiriferina insculpta, *Phill.*
Productus scabriculus, *Martin.*	Terebratula sacculus, *Mart.*
Rhynchonella acuminata, *Martin.*	

all of which are Upper-Devonian and Carboniferous forms, and not known in older beds north of the Pickwell or Morte-Bay Old Red Sandstones; and the remaining 4,

Rhynchonella pleurodon.	Streptorhynchus crenistria.
—— pugnus.	Strophomena rhomboidalis.

are common to the Middle and Upper Devonian and Carboniferous rocks of North Devon; but if the remaining form, *Chonetes sordida*, Sow., of the Lower or Lynton Group, and the *Chonetes Hardrensis*, Phill., be *one* species, then *we have only one shell that passes through the whole of the rocks of North Devon*, or only one species connecting the Upper Devonian slates of Baggy and Marwood, &c. &c., with those of the Lower at Lynton and the Middle at Ilfracombe. The 9 Upper-Devonian forms before named have ever been regarded as passage-species, and subject to the caprice and views of those who would (all other evidence wanting) place them either at the base of the Carboniferous, or at the top of the Upper Devonian, although careful examination into their specific value would determine them (at least 3 of the 9) as having far greater affinity with Devonian types, and but a slight range into the Carboniferous series. The paucity of species, in all the other zoological groups that exist in common in the Devonian and Carboniferous, is known and recognized by all palæontologists, this doubtless arising from the littoral and sublittoral habits of the Invertebrata, and their migration or change under different bathymetrical and other physical conditions as regards land and water. North and South Cornwall possess 22 species in common with the Middle and Upper Devonian of North Devon. They are placed in their respective positions in Table II. pp. 616–634, so as to complete the evidence; and it is only in the Upper Devonian beds of Petherwin, Tintagel, &c. that the species approach and have passage affinities; they are generally true Upper-Devonian forms, and have been well determined. It will also be seen that of the 27 species found in the Ilfracombe group only 4 are common to it and the beds south of Morte Bay as well as to the "Carboniferous slates." These are stated above, and need no further comment.

I will embody in one Table (IX., p. 669 *et seqq.*) all the known species in the Lower, Middle, and Upper Devonian series of North Devon, and include also the Upper Devonian species of Petherwin in a separate column, and indicate those that pass up and occur in the passage-beds between the Devonian and Carboniferous of the same area, admitting that the Barnstaple beds, and all south of them to the latitude of Venn and Swinbridge &c., belong to the Carboniferous group, as determined by Sir R. Murchison and Prof. Sedgwick in the year 1836*. With these Devonian species I have collated those recognized as belonging to the Carboniferous Slate of Ireland and the Coomhola Grits which are associated with them, in other words recurrent forms†. This Table will go far to show us, if it does not prove, that these so-called Coomhola species of Ireland are chiefly, if not entirely, derived from the typical Upper-Devonian fauna—from that group which so conspicuously and conformably rests (in North Devon at least) upon the unfossiliferous Upper Old Red Sandstone of Morte Bay.

The assertion of Prof. Jukes, in his "Notes for a Comparison" &c.‡, that all the species occurring in the rocks above the Vention Old Red Sandstone are those of the Carboniferous Slate, with those of the Coomhola Grits in the lower parts, is based upon the fact that the Irish species are compared with those of North Devon, and referred to them as the types. The 97 species named in his "Fossils of the Carboniferous Slate," page 22 §, and referred to 8 localities (p. 17) in North Devon, and one locality (Petherwin) in North Cornwall are, without exception, well-known and recognized Devonian species, no one form occurring in the so-called Coomhola Grits or Carboniferous Slate of the typical Irish area. In this list there are 84 species catalogued as *belonging to* rocks of this age; yet not one occurs either in these lower members of the Carboniferous group, or in the Carboniferous Limestone of any area: it is simply

* These beds were called "Greywacke" by most writers up to the time of De la Beche, who also retained the title in his 'Report on the Geology of Cornwall,' &c.

† In the column headed "Carboniferous generally."

‡ "Notes for a Comparison between the Rocks of the South-west of Ireland and those of North Devon and of Rhenish Prussia," &c., Journn. Roy. Geol. Soc. Ireland, 1865.

§ *Ibid.*

an assertion, arising from or through similarity, not identity, in rock-masses, without any physical or palæontological proof whatever. When it is *proved, determined* and *admitted* that all the slates, grits, and limestones to the south of, and that rest upon, the Upper Old Red Sandstone of Pickwell Down, are of Carboniferous age, and not Upper Devonian, *then these* 84 *species may* occupy the place assigned to them, or be classed with the Irish Carboniferous Slates and their associated Grits. I have, however, good evidence to the contrary, and will not confound either the two areas (North Devon and South Ireland) or the species occupying them*.

Whatever views may be entertained relative to the contemporaneity of the Carboniferous Slate, either with the Carboniferous Limestone or the Upper Devonian, it is quite evident that in the North Devon area the succession of the strata and of the groups of associated fossils is continuous and natural—being, in fact, one great physical and zoological group. It is only south of the Baggy, Marwood, and Croyde zones, in the order of succession, that we see anything approaching the physical and zoological conditions of the Carboniferous series. The assertion that these beds *are* Carboniferous Slate with Coomhola Grits, is not borne out by the lists of fossils intended to convey that impression in Professor Jukes's paper†; the Baggy and Croyde series conformably overlie the upper red sandstone of Vention, which constitutes the natural base to the Upper Devonian of North Devon, these being still succeeded at Barnstaple &c. by the Lower Carboniferous beds, which are of great thickness before they reach the Culm-measures to the south.

I have clearly shown in these Tables the relations that the Upper Devonian fossils of Baggy, Marwood, Sloly &c., have to the Carboniferous in this and other areas; and Mr. Jukes's list, *when divested of* the 84 species from the Upper Devonian of Petherwin and the above-named places, tells the same facts.

VI. Stratigraphical Value of the Species comprising the Devonian Fauna.

No one disputes either the intermediate position of the rock-masses comprising the so-called Devonian system, or that, accompanying them, there is also a fauna composed of genera and species at present not known either below, in the Silurian system, or above, to a very large extent, in the Carboniferous.

I propose to briefly discuss the evidence and value of this fauna, which will aid us in affixing a value to the whole system, and also enable us to distinguish it from the Carboniferous, which, although allied to, and containing many species (54) in common with the Devonian, is yet a totally distinct group; it is chiefly through its upper division, and at the close or passage into the Carboniferous, that the relation exists, which we should expect.

* Consult Table X. p. 674.

† Notes for a comparison between the rocks of the south-west of Ireland and those of North Devon and of Rhenish Prussia (Journ. Roy. Geol. Soc. Ireland, 1865).

It is well known that in the Continental areas where the Devonian system is well developed, and also in Britain, certain and peculiar genera occur which are represented by a limited number of species; yet the fauna of the Devonian period, so far as at present known, when compared with those of the two periods (the Silurian and Carboniferous), is comparatively poor *.

We may assume that eleven classes are represented in the fauna of the Devonian system, viz. the Amorphozoa, Cœlenterata, Echinodermata, Crustacea, Polyzoa, Brachiopoda, Lamellibranchiata, Nucleobranchiata, Gasteropoda, Cephalopoda, and Pisces,—the last but sparingly (as far as we know), but still of considerable importance as bearing upon the question of the synchronism of occurrence of certain forms of life in deposits believed to be of equal value, or equivalent in time, though accumulated under different conditions and in different areas. We know that 9 of the 11 classes do not occur in the true Old Red Sandstone, none of the marine Devonian Mollusca, Cœlenterata, and Echinodermata having any representative in the Scotch, Welsh, or English areas occupied by that group of rocks; but evidence of late tends to connect these two disconnected yet contemporaneous deposits through the group of Fishes, so that chronologically the difficulty of correlating them is partly overcome; for the Middle and Upper Old Red Sandstone of Russia contains a marine Molluscan fauna associated with the Fish; Scotland contains the same Fish, but no intermixture of associated and marine Invertebrata. This fact clearly identifies the Middle and Upper Old Red Sandstone of the northern or Scotch area with the slates and calcareous series of the Eifel, and with the Devonshire Devonians†; and now we have in South and North Devon conclusive evidence of the same fact, from the occurrence of *Phyllolepis concentricus* and Ichthyodorulites of *Onchi* in the Lower Devonian Slates of Looe Island in South Devon, and *Holoptychius* in the Lower and Upper Devonians.

No value is attached to the occurrence of many species of Fish that occur in common at the top of the Upper Silurian series and in the lower beds of the Old Red Sandstone; they are locally connecting species, in the passage-beds, and do not occur higher; and the want of absolute chronological and palæontological identity between the Lower Old Red Sandstone and Lower Devonian prevents our true correlation of the two series. *Auchenaspis Salteri*, *Cephalaspis Murchisoni*, *C. ornatus*, *Onchus Murchisoni*, *O. tenuistriatus*, *Plectrodus mirabilis*, *P. pleiopristis*, *Pteraspis Banksii*, and *P. truncatus* are all Upper-Silurian species, four of which, *A. Salteri*, *C. Murchisoni*, *C. ornatus*, and *Pteraspis Banksii*, are common to the Upper Silurian and Old Red Sandstone‡. The remaining 108 species of Fish are distributed through the Lower, Middle and Upper Scotch Old

* *Vide* numerical or census-table of the number of genera and species in the Silurian, Old Red Sandstone, Devonian, and Carboniferous strata, p. 615.

† Siluria, 3rd edit. pp. 382 &c.

‡ For much valuable information and tabular results see Pengelly, Brit. Assoc. Report, 1860, Oxford Meeting. Also Pengelly " On the Devonian Age of

Red Sandstone, three only being known in the Marine Devonian, viz. *Phyllolepis concentricus*, *Onchus*, and *Holoptychius* (*vide* Table II. p. 630–634, for distribution of all the species through the Old Red series).

1. *Amorphozoa.*—Four genera and nine species of this class occur in, and are here noticed as being peculiar to, the Lower and Middle Devonian rocks of Cornwall and South Devon; one species only, *Stromatopora concentrica*, Goldf., is known in North Devon and West Somerset. They likewise occur in the Rhenish beds of the same age. The singular and typical *Sphærospongia* (*Sphæronites*) *tessellata*, Phill., is strictly British, and at present is known only in, and confined to, the limestones of the Middle series at Launceston and Woolborough in South Devon. The abundance of *Steganodictyum* in the Lower Devonian slates of Polperro, Fowey and Looe, indeed all along the South Devon and South Cornish coast, from Mudstone bay to Brixham and Fowey, as well as on the north coast of Cornwall at Bedruthen, testifies to the widely spread distribution of this hitherto peculiar British species; and, confined, as it is, to the Lower division of the Devonian slates, careful search will, I believe, reveal one or both of the species in the Lynton area. No Amorphozoa are known either in the Upper Devonian rocks of any area, or in the Carboniferous group, unless we accept the doubtful genus *Tragos*, which is peculiar to the Carboniferous Limestone, and which may belong to this class. These nine Lower (and one Middle) Devonian Amorphozoa, amongst other fossils, must therefore be considered evidence of much value when associated with higher forms which are also strictly Devonian types.

2. *Cœlenterata.*—The greatest significance must be attached to this class, when treating of the stratigraphical value of the Devonian fossils. They stand alone, and, side by side with certain genera of the Brachiopoda, serve especially to distinguish and characterize the Middle Devonian series. No less than 24 genera are known to occur in this Middle division alone, of which the following 15 are confined to it, viz. *Acervularia*, *Arachnophyllum*, *Battersbyia*, *Campophyllum*, *Chonophyllum*, *Emmonsia*, *Endophyllum*, *Hallia*, *Heliophyllum*, *Metriophyllum*, *Pachyphyllum*, *Pleurodictyum*, *Smithia*, *Spongiophyllum*, and *Strephodes*. These known 24 genera embrace 53 species, 52 of which are strictly Devonian, 45 being confined to and characterizing the Middle group alone (see Tables II. and V. *for distribution*). Analysis and comparison of the British species with those of the three European areas reveal and give the same results.

Table VIII. has been constructed to show the remarkable distribution of, and zoological agreement between, the British and Foreign species in space, and their distribution in time also.

We find that 10 genera and 22 species are identical and common to the four areas, and also to the received stratigraphical groupings

the World," the substance of six lectures delivered at the Royal Institution, 1861, Geologist, vol. iv. p. 332, 1861; and Pengelly "On the Geological and Chronological Distribution of the Devonian Fossils of Devon and Cornwall," Geologist, vol. v. p. 10, 1862.

in these four areas *. Four species of one genus are known also in the Russian Devonians, viz. the widely distributed and characteristic *Favosites Goldfussii*, *F. reticulata*, *F. fibrosa*, and *F. cervicornis* (*polymorpha*).

It is needless attempting any comparison of the British Devonian corals with the Carboniferous; for they stand alone, one species only, *Michelinia antiqua*, M'Coy, with much doubt being referred as common to the Upper Devonian series of North Devon and the Carboniferous beds of Hook &c. in the South of Ireland.

Comparisons made amongst the Devonian Cœlenterata (Tables II., V., & VII.) reveal to us the importance that must be attached to the intermediate grouping and stratigraphical place of the South and North Middle Devonian limestones and slates, the limestones of both areas yielding, as in all others, the *chief* mass of the species; but *Petraia celtica*, *P. gigas*, *P. pleuriradialis*, and *Pleuorodictyum problematicum* are abundant in the slates, and *Favosites cervicornis* is common to both, in North and South Devon.

The relation of the two allied and connected regions is shown from the fact that they contain 10 genera and 18 species of corals in common, an agreement singularly close to that borne by the three European areas to our own, where the same number of genera occur, and 22 species (see Tab. V.). This coincidence may not have any great value in itself, but it tends to show the persistency and distribution of species through a given time, and over a definite area. No species is known to be common to the Lower, Middle, and Upper series, and only one to the Lower and Middle, viz. *Favorites cervicornis*. No attempt need be made to individualize special genera or species, as the Devonian corals as a group are peculiar to the beds in which they occur, and distinctly mark the intermediate character of the Devonian series, as well as, being a zoological group, distinctly characterizing the Middle Devonian series, to which they are confined.

3. *Crustacea*.—This class, as a whole, is but feebly represented in the marine Devonian group, two orders only being known, viz. the Ostracoda and Trilobita. Our present means of comparison between the Old Red Sandstone proper and its believed equivalents, the Lower, Middle, and Upper Devonian of Cornwall and Devon, both on physical and palæontological grounds, do not enable us to affirm positively that they are identical; but it is not a little singular that two such opposite classes in the animal kingdom as the Crustacea and Fish should be so largely represented at the close of the Silurian and commencement of the Old Red Sandstone period, the former through the suborder Eurypterida (order Merostomata); the latter through the Ganoid and Placoid Fishes, both of which, and the species in which, equally represent the close of one period and the commencement of the other, the one (Merostomata) not again appearing in the Devonian rocks of any area, whilst the Fishes are only sparingly represented in the Middle Devonian of Livonia, in Russia, of the Eifel, in Rhenish Prussia, of Looe, in

* Devonshire, Rhenish provinces, Belgium, and France.

Cornwall, and of Baggy, in Devonshire. As before stated, we have no means of establishing any real comparison between the 43 genera and 113 species of Fish that are known to be in the true Lower, Middle, and Upper Old Red Sandstone of Scotland, England, and Wales &c.

The typical Upper Devonian beds of Petherwin yield *Cypridina serratostriata*, the only form of bivalve Crustacean (Ostracoda) known in the Marine Devonian beds. It is the Rhenish species, and occupies the same position in our English Upper Devonian of North Cornwall as in Nassau, Thuringia, and Franconia; its abundance and persistency, accompanied also by the genus *Clymenia*, affords a parallelism which cannot be overlooked, other conditions also coinciding.

The Trilobita, as contrasted with the Silurian species, afford no comparison; they, like the Corals, are a group of genera and species peculiar to the Devonian rocks which contain them. No genus or species occurs common to the Carboniferous and Devonian rocks. It should be noticed also that although the 6 genera, viz. *Bronteus*, *Cheirurus*, *Harpes*, *Homalonotus*, *Phacops*, and *Trimerocephalus* are Silurian, yet their 11 species are all peculiar to Devonian strata; and although *Phacops granulatus*, *P. laciniatus*, and *P. latifrons* occur in the uppermost Devonian beds, they have, nevertheless, never been found in the Carboniferous series, unless it be admitted that the Barnstaple beds are positively of that age, and *P. latifrons* occurs in them. This affinity with the Silurian series through the Trilobites adds one other element to strengthen the view that difference of province, migration to new areas, nature of sea-bottom &c., or the remnant of an older and almost extinct fauna might have existed during the series of changes which took place, even over so small a geographical area as that occupied by the Silurian and succeeding Devonian seas, at, or contemporaneous with, the close of the Silurian period and the commencement of the Devonian. These genera and species of Trilobites died out at the close of the Devonian period, and were replaced by one family only (the Proetidæ), possessing three new generic types, which characterize the Carboniferous rocks, viz. *Phillipsia*, *Griffithides*, and *Brachymetopus*, which contain 15 known species; so that neither families, genera, nor species of this group passed from the Devonian to the Carboniferous sea*. The remaining seven genera in the orders Merostomata or Pœcillopoda, and their nineteen species, found in the Old Red Sandstone have no significance in our present inquiry and examination, arising from want of comparison and our not yet being able to satisfactorily correlate the group of the marine Devonians with the received divisions of the Old Red Sandstone.

4. *Cephalopoda.*—Comparisons amongst the chief Devonian genera and species themselves, or between them and those of the formations above or below them, would not be complete

* The distribution of this order, both stratigraphically and chronologically, is the same through and over the three European areas, the same results being observed in the Rhenish, Eifélien, and Boulonnais rocks.

without some notice of the class Cephalopoda, which, as a group, occupies a very prominent place in the fauna of the Devonian period, and one of marked significance. Five well-defined genera, all belonging to the order Tetrabranchiata, occur in the British Devonian rocks. Two of these, *Clymenia* and *Cyrtoceras*, have no such distinctive zoological parallel in any other British formation: they would appear to have constituted two colonies of very restricted range, both in time and space; and this remark applies to either genus at the time of its culmination, the one (*Cyrtoceras*) in the Middle Devonian of the South Devon area, at Newton &c., the other (*Clymenia*) in the Upper Devonian of North Cornwall, at Petherwin, Landlake, &c. Whether the upper portion of the Newton deposit, through synchrony or homotaxis, or both, be regarded as equivalent to that of Petherwin or not*, two more distinct zoological groups do not exist in any known area of the British islands. The species of the genus *Cyrtoceras* are, with one exception (*C. rusticum*), confined to the Middle Devonian series of Newton Bushel, where twelve species are known to occur, three of them (*C. nodosum*, *C. ornatum*, and *C. tridecimale*) being also found in the Rhenish and Eifel beds of the same age. No form is known in the Upper Devonian in any area; and only two, totally distinct, species occur in the Carboniferous Limestone of Ireland, Derbyshire, and Belgium, viz. *C. Gesneri*, Martin, and *C. Verneuillianum*, Koninck. The distribution of the genus *Clymenia*, which contains ten species, is yet more remarkable and definite as bearing upon that of the Devonian fauna in our own area, and clearly also identifies it with the true Upper Devonian (Clymenia-limestone and Goniatite limestone and shale) of the Rhenish provinces. Ten species colonize this one area, and appear to have been confined to it in Britain; but through *C. lævigata* and *C. striata* being found in the Eifel, and *C. undulata* in the French Devonian beds, we are enabled, aided by other characteristic fossils, to associate the Upper Devonian series of Petherwin with deposits of the same age on the continent.

These two colonies of Cephalopoda, singularly distinguished by two genera of the same order and numerous species in each, and occupying two geographical areas, may yet have been contemporaneous, and their remains synchronously deposited. Their zoological associations, however, are notably different, and would point to different conditions, dependent perhaps more upon *province or station* than time. The genus *Cyrtoceras*, with its thirteen species, is associated with a numerous assemblage of corals and Brachiopoda in the Middle Devonian of Newton Bushel; whereas the eleven species of *Clymenia* and three species of *Goniatites*, with one *Nautilus*, occupy a marked position in the true Upper Devonian slates and limestones of Petherwin and Landlake, not one of these species occurring in any higher beds; and of the whole 243 known species comprising the Middle Devonian fauna of South Devon, twenty-eight are common to it and the Petherwin beds; these added to the twenty-seven

* Mr. Salter believes, and with good reason, that the uppermost part of the Newton beds are of the same age as the Petherwin series of North Cornwall.

peculiar species of *Clymenia* and *Goniatates* (55 in all) constitute an assemblage of organic remains not known in the Carboniferous series anywhere.

5. *Brachiopoda.*—We cannot pass over this important class of Mollusca, which plays so important a part in the fauna of the marine Devonian rocks; and although in this group there is more community with the fossils of the Carboniferous series than any other, still it will be shown that it is chiefly through the Upper Devonian and passage-beds that the affinity exists. I restrict the term "Upper Devonian" to those beds that repose upon the highest member of the Upper Old Red Sandstone at Vention, George Ham, Marwood, High Bray, Dulverton, and Wiveliscombe—in other words, to that latitude occupied by the uppermost beds of the non-fossiliferous red sandstone that stretch from Morte Bay to Wiveliscombe. The labours of Mr. Davidson *, in his elaborate monographs upon the Devonian and Carboniferous Brachiopoda, have now determined and fixed the specific nomenclature of this class with such precision that we are enabled, through his valuble researches, to correctly estimate their numerical and specific values, as well as to collate them with the continental Devonian species. We find that twenty-five genera and ninety-nine species are known in the British Devonian rocks, and that thirteen of these are common to them and the Carboniferous in Britain or Ireland. Seven of these thirteen do not occur below the Upper Devonian—viz. *Athyris oblonga, Discina nitida, Lingula squamiformis, Productus scabriculus, Rhynchonella acuminata, Spirifera Urei,* and *Terebratula sacculus*; whereas the *remaining* 6 species, *Rhynchonella pleurodon, R. pugnus, R. reniformis, Spiriferina insculpta, Streptorhynchus crenistria, Strophomena rhomboidalis,* and *Terebratula sacculus* are common to both the Middle Devonian and Carboniferous, one species only, the doubtful *Chonetes Hardrensis,* being common to the Lower, Upper, and Carboniferous. The remaining eighty-six species are therefore strictly Devonian forms. (*Vide* Table II. p. 616.) Considerable weight must be attached to those genera which here as well as in continental Europe are not known above the Middle group, and equally characterize it both in our own two areas (viz. North and South Devon) and in those of the continent. The following eight genera and nine species are here given to show their value and relation:—

Calceola sandalina †.	Rensseleria stringiceps.
Davidsonia Verneuilii.	Retzia ferrita.
Merista plebeia.	Stringocephalus Burtini.
Pentamerus biplicatus.	Uncites gryphus.
„ brevirostris.	

Of the *ninety-nine* British species, *fifty-two* are represented in either the Rhenish, Belgian, or French areas, only six of which are known in, or are common to, the Carboniferous rocks. In Table VIII. p. 658, is shown the relation of our Devonian species to those of the three areas

* Monog. Brit. Dev. Brachiopoda, Pal. Soc. 1864–66.

† This form has not yet been satisfactorily determined in North Devon.

above mentioned, in which it is seen that 52 (*or more than* 50 *per cent.*) are common to the British and European Devonian rocks. Again, if we admit that the Barnstaple beds are of Carboniferous age, and take the whole of the North-Devon Brachiopoda, or compare those of the same area together (*i.e.* the north and south side of the supposed fault) and with those of *any* Carboniferous locality, the result is, that of the 48 species known in the North Devon Devonian series, thirteen are also Carboniferous, all of which are in the Upper division south of, or above, the red Pickwell sandstones, 5 occurring in the Middle division ranging north of Pickwell, and one (*Chonetes Hardrensis* or *C. sordida*) in the Lower or Lynton group; in fact, the relations and affinities of nearly the whole of the Devonian fossil fauna are through those species that comprise the Upper Devonian group south of and upon the Upper Old Red Sandstone of the line above mentioned. (See Tables VIII., IX., and X.)

Table IX.—*Species occurring in the Lower, Middle, and Upper Devonian Series of North Devon and Petherwin (in North Cornwall), showing those species that pass into the Carboniferous in any area.*

Species.	North Devon.			Petherwin.	Carboniferous generally.
	Lower Devonian.	Middle Devonian.	Upper Devonian.	Upper Devonian.	
Knorria dichotoma, *Houghton*			*		*
Adiantites Hibernicus, *Forbes*			*		*
Bornia (Knorria) transitionis, *Göpp.*			*		
Stromatopora concentrica, *Goldf.*		*			
Alveolites suborbicularis, *Lam.*	*				
Amplexus tortuosus, *Phill.*		*		*	
Cyathophyllum æquiseptum, *M.-Edw.*		*			
—— Boloniense, *Blainv.*		*			
—— cæspitosum, *Goldf.*		*		*	
—— helianthoides, *Goldf.*		*			
—— obtortum, *M.-Edw.*		*			
Cystiphyllum vesiculosum, *Goldf.*		*			
Favosites cervicornis, *Blainv.*	*	*			
—— dubia, *Blainv.*		*			
—— fibrosa ?, *Goldf.*		*			
Fistulipora cribrosa, *Goldf.*			*		
Hallia Pengellii, *M'Edw.*		*			
Heliolites porosus, *Goldf.*		*			
Heliophyllum Hallii, *M.-Edw.*		*			
Michelinia antiqua, *M'Coy*			*		*
Petraia celtica, *Lonsd.*	*		*		
—— pleuriradialis ?, *Phill.*	*		*		
Actinocrinus tennustriatus, *Phill.*	*		*		
—— triacontadactylus, *Mill.*			*		*
Adelocrinus hystrix, *Phill.*			*		*
Cyathocrinus distans, *Phill.*			*		
—— ellipticus, *Phill.*				*	

Table IX. (*continued*).

Species.	North Devon. Lower Devonian.	North Devon. Middle Devonian.	North Devon. Upper Devonian.	Petherwin. Upper Devonian.	Carboniferous generally.
Cyathocrinus macrodactylus, *Phill.*		*	*		
—— pinnatus, *Goldf.*			*		*
—— variabilis, *Phill.*		*	*	*	*
Pentremites ovalis, *Goldf.*			*		*
Taxocrinus macrodactylus, *Phil.*			*		
Protaster, sp.			*		
Palæaster, sp.		*			
Tentaculites annulatus, *Schloth.*		*			
—— scalaris, *Schloth.*			*	*	
Phacops granulatus, *Münst.*			*	*	
—— laciniatus, *Rœm.*				*	
—— latifrons, *Bronn*			*	*	
—— Latreillii, *Stein.*			*		
Trimerocephalus lævis, *Münst.*		*	*		
Cypridina serrato-striata, *Sandb.*				*	
Ceriopora similis, *Phill.*		*			
—— gracilis, *Phill.*			*		
Fenestella antiqua, *Goldf.*	*	*	*	*	*
—— arthritica, *Phill.*		*			
—— plebeia, *M'Coy*			*	*	*
Glauconome bipartita, *Phill.*			*		*
Polypora laxa, *Phill.*			*	*	*
Retepora repisteria, *Goldf.*		*			
Athyris concentrica, *Von Buch*	*	*	*	*	
—— decussata, *Sow.*			*	*	
—— indentata, *Sow.*			*	*	
—— oblonga, *Sow.*			*		*
Atrypa desquamata, *Sow.*		*	*	*	
—— reticularis, *Linn.*		*		*	
—— ——, var. aspera, *Schloth.*		*		*	
Chonetes sordida, *Sow.*, vel Hardrensis, *Phill.*	*		*		*
Cyrtina heteroclyta, *Def.*		*			
Discina nitida, *Phill.*			*		*
Merista plebeia, *Sow.*		*			
Lingula squamiformis, *Phill.*			*		*
Orthis arcuata, *Phill.*	*				
—— granulosa, *Phill.*	*				
—— interlineata, *Sow.*		*	*	*	
—— striatula, *Schloth.*		*	*	*	
Productus longispinus, *Dav.*			*		
—— prælongus, *Sow.*			*		
—— scabriculus, *Murch.*			*		*
Rensseleria stringiceps, *Rœmer*		*			
Rhynchonella cuboides, *Sow.*		*			
—— laticosta, *Phill.*			*		
—— pleurodon, *Phill.*		*	*	*	*
—— pugnus, *Martin*		*	*	*	*
—— reniformis, *Sow.*			*	*	*

TABLE IX. (*continued*).

Species.	North Devon.			Petherwin.	Carboniferous generally.
	Lower Devonian.	Middle Devonian.	Upper Devonian.	Upper Devonian.	
Spirifera canalifera, *Valen.*	*	*			
—— curvata, *Schloth.*		*			
—— disjuncta, *Sow.*		*	*	*	
—— glabra?, *Martin*		*			*
—— hysterica, *Schloth.*	*				
—— lævicosta, *Valen.*	*				
—— lineata, *Martin*			*	*	
—— megaloba, *Phill.*			*		
—— mesomala, *Phill.*			*		
—— obliterata, *Phill.*			*		
—— nuda, *Sow.*		*			
—— rudis, *Phill.*			*		
—— speciosa, *Schloth.*		*			
—— Urei, *Flem.*		*	*	*	*
Spiriferina cristata, *Schloth.*			*		*
Stringocephalus Burtini, *Defr.*		*			
Sreptorhynchus crenistria, *Phill.*		*	*	*	*
—— plicatus, *Sow.*			*		
—— semircicularis, *Phill.*			*		
—— umbraculum, *Schloth.*	*?	*			
Strophalosia productoides, *Murch.*			*	*	
Strophomena rhomboidalis, *Wahlenb.*		*	*		*
Terebratula sacculus, *Mart.*			*		*
Avicula Damnoniensis, *Sow.*			*		
—— exarata, *Phill.*				*	
—— subradiata, *Sow.*			*		
Aviculopecten alternatus, *Phill.*				*	
—— arachnoideus, *Phill.*				*	
—— nexilis, *Sow.*			*		*
—— granosus, *Sow.*				*	
—— granulosus, *Phill.*				*	
—— pectinoides, *Sow.*			*		
—— polytrichus, *Phill.*			*		
—— transversus, *Phill.*			*	*	*
Pterinæa cancellata, *Phill.*			*		
—— rudis, *Phill.*			*		
—— spinosa, *Phill.*	*			*	
—— ventricosa, *Goldf.*				*	
Cardiola retrostriata, *V. Buch*				*	
Cucullæa amygdalina, *Phill.*			*		*
—— angusta, *Sow.*			*		
—— complanata, *Phill.*			*		
—— depressa, *Phill.*			*		
—— Hardingii, *Sow.*			*		*
—— trapezium, *Sow.*			*		
—— unilateralis, *Sow.*			*		*
——, sp.		*			
Ctenodota elliptica, *Phill.*				*	

TABLE IX. (*continued*).

Species.	North Devon.			Petherwin.	
	Lower Devonian.	Middle Devonian.	Upper Devonian.	Upper Devonian.	Carboniferous generally.
Ctenodonta Krachtæ, *M'Coy*	*				
—— antiqua, *Sow.*	...	...	*	*	
—— latissima, *Phill.*	...	...	*		
—— lineata, *Phill.*	...	...	*		
—— plicata, *Phill.*	...	...	*		
—— pullastriformis, *M'Coy*	...	...	*		
Curtonotus rectus, *Salt.*	...	...	*		
—— elegans, *Salt.*	...	...	*		
Cypricardia Phillipsii, *D'Orb.*	...	...	*		
Leptodomus constrictus, *M'Coy*	...	...	*		
Megalodon cucullatus, *Sow.*	*	*			
Modiola amygdalina, *Phill.*	...	...	...	*	
Sanguinolaria elliptica, *Phill.*	...	...	*	*	
—— sulcata, *Münst.*	...	...	*	*	
Sanguinolites complanatus, *Phill.*	...	...	*		
—— liratus, *Phill.*	...	...	*		
Schizodus deltoideus, *Phill.*	...	*	...	*	
Orthonota, sp.	...	...	...	*	
Myalina, sp.	...	*			
Solen ?, sp.	...	*			
Acroculia vetusta, *Sow.*	...	*	*	...	*
Euomphalus serpens, *Phill.*	...	*	*	*	
—— radiatus, *Phill.*	...	*			
Loxonema rugifera, *Phill.*	...	...	*	...	*
—— nexilis, *Phill.*	...	...	...	*	
—— tumida, *Phill.*	...	...	...	*	
—— sinuosa, *Phill.*	...	...	...	*	
Macrocheilus neglectus, *Phill.*	...	...	*		
—— brevis, *Sow.*	...	*			
Holopella ?	...	*			
Murchisonia angulata, *Phill.*	...	...	*	*	*
Natica meridionalis, *Phill.*	...	...	*		
—— nexicosta, *Phill.*	...	...	*		
Pleurotomaria aspera, *Sow.*	*	...	*	*	
—— cancellata, *Phill.*	...	...	*	*	
—— expansa, *Phill.*	...	...	*	...	*
—— gracilis, *Phill.*	...	...	*		
Bellerophon bisulcatus, *Röm.*	...	*	*		
—— striatus, *Bronn*	*				
—— subglobatus, *M'Coy*	...	...	*	...	*
—— Urei, *Flemg.*	...	...	*	...	*
Porcellia Symondsii	...	...	*		
Conularia	...	*			
Cyrtoceras rusticum, *Phill.*	...	...	...	*	
——, sp.	...	*			
Goniatites biforus, *Phill.*	...	...	...	*	
—— linearis, *Münst.*	...	...	...	*	
—— spirorbis, *Phill.*	...	...	*?	...	*

Table IX. (*continued*).

Species.	North Devon. Lower Devonian.	North Devon. Middle Devonian.	North Devon. Upper Devonian.	Petherwin. Upper Devonian.	Carboniferous generally.
Goniatites subsulcatus				*	
—— vinctus, *Sow.*			*	*	
Orthoceras cinctum, *Sow.*				*	
—— cylindraceum, *Sow.*			*		*
—— cylindricum, *Sow.*		*	*		
—— ibex, *Sow.*				*	
—— imbricatum, *Wahl.*			*		
—— lineolatum, *Phill.*			*		*
—— *Ludense* ?, Sow.			*		
—— Phillipsii, *D'Orb.*				*	
—— tentaculare, *Phill.*		*	*		
—— striatulum, *Sow.*				*	
—— striatum, *Sow.*			*	*	*
—— undulatum, *Sow.*				*	
Nautilus megasipho, *Phill.*				*	
Clymenia, sp.				*	
—— fasciata, *Phill.*				*	
—— lævigata, *Münst.*				*	
—— Münsteri, *M'Coy*				*	
—— Pattisoni, *M'Coy*				*	
—— pleurisepta, *Phill.*				*	
—— quadrifora, *M'Coy*				*	
—— sagittalis, *Phill.*				*	
—— striata, *Münst.*				*	
—— valida, *Phill.*				*	
—— undulata, *Münst.*				*	
Poterioceras fusiforme, *Sow.*				*	

6. *Other Groups.*—It is unnecessary to carry our analysis of the individual groups further, the paucity of the Lamellibranchiata and Gasteropoda affording no means for our rigidly collating them either with the continental species or even amongst themselves in the two Devonian areas; and those species, in these classes, said to be common to the Devonian and Carboniferous require yet much critical examination. I may, however, notice the genera *Cucullæa*, *Curtonotus*, and *Megalodon*, the latter as not being known out of the Middle Devonian of South and North Devon, and the two former as being important Upper-Devonian forms in the Marwood, Baggy, and Sloly beds.

The whole group, however, of Devonian Lamellibranchiata contains twenty genera and fifty-eight species, of which five genera and seven species only occur in the Carboniferous series, viz. *Avicula Damnoniensis*, *Aviculopecten plicatus*, *Conocardium aliforme*, *Cucullæa amygdalina*, *C. Hardingii*, *C. trapezium*, and *Curtonotus elegans*.

The same difference exists between the two formations through the Gasteropoda, which have been carefully compared. Twelve genera and forty-six species occur in the Devonian; and of these also five genera and seven species pass to the Carboniferous, viz. *Acroculia vetusta, Euomphalus planorbis, Loxonema rugifera, L. tumida, Murchisonia angulata, M. spinosa,* and *Pleurotomaria expansa.* Three or four of these I much doubt, but I give them as they are recorded by Prof. Phillips, although a comparison with his figures and descriptions causes me to interrogate them.

Much could be said relative to the Echinodermata. I, however, feel confident that great confusion exists respecting the whole of the Devonian species, and especially so with relation to those said to be common to the Carboniferous and the Lower and Middle Devonian; their badly preserved condition, usually only in a fragmentary state, scarcely justifies us in relying upon them as being of specific value.

7. *List of Species common to the Devonian and Carboniferous formations.*—Table X. is constructed to show at once the relation between those species said to be common to the Carboniferous and Devonian rocks, in which *every known recognized form* is given, and arranged zoologically, so that comparison may be made at once*.

Table X.—*List of Species that occur in the Lower, Middle, and Upper Devonian rocks of North Devon, and in the Carboniferous rocks generally.*

Classes.	Species.	Devonian.			Carboniferous.
		Lower.	Middle.	Upper.	
Plantæ	Knorria dichotoma, *Hought.*	...	...	*	*
	Adiantites hibernicus, *Forbes*	...	...	*	*
Cœlenterata	Michelinia antiqua, *M'Coy*	...	...	*	*
Echinodermata	Adelocrinus hystrix, *Phill.*	...	...	*	*
	Cyathocrinus pinnatus?, *Goldf.*	*	...	*	*
	—— variabilis?, *Phill.*	...	*	*	*
	Pentremites ovalis	...	...	*	*
Polyzoa	Ceriopora similis	...	*	*	*
	—— gracilis	...	...	*	*
	Fenestella antiqua?, *Goldf.*	*	*	*	*
	—— plebeia?, *M'Coy*	...	*	*	*
	—— prisca?, *Goldf.*	...	*	...	*
	Glauconome bipinnata, *Phill.*	...	...	*	*
	Polypora laxa?, *Phill.*	...	*	*	*
	Athyris oblonga, *Sow.*	...	...	*	*
	Chonetes sordida, *Sow.* (C. Hardrensis, *Phill.*)	*	*	*	*
	Discina nitida, *Phill.*	...	...	*	*

* Consult Table XI., giving generic and specific values between the Old Red Sandstone, the British marine and Foreign Devonian beds of Rhenish Prussia, Belgium, and France, and the number of species (fifty-six) common to the Carboniferous.

TABLE X. (*continued*).

Classes.	Species.	DEVONIAN. Lower.	Middle.	Upper.	Carboniferous.
BRACHIOPODA ...	Lingula squamiformis, *Phill.*	...	...	*	*
	Productus scabriculus, *Mart.*	...	...	*	*
	Rhynchonella acuminata, *Mart.* ...	...	*	...	*
	—— pleurodon, *Phill.*	...	*	*	*
	—— pugnus, *Mart.*	...	*	*	*
	—— reniformis, *Sow.*	...	*	*	*
	Spirifera Urei, *Flem.*..................	...	...	*	*
	Spiriferina cristata, *Schloth.*.........	...	*	*	*
	Streptorhynchus crenistria, *Phill.*...	...	*	*	*
	Terebratula sacculus, *Mart.*	...	*	*	*
	Strophomena rhomboidalis, *Wahl.*.	...	*	*	*
LAMELLIBRANCHIATA	Avicula Damnoniensis, *Sow.*.........	...	...	*	*
	Aviculopecten nexilis, *Sow.*	...	...	*	*
	—— plicatus, *Sow.*	...	*	...	*
	—— transversus, *Sow.*	...	*	*	*
	Conocardium aliforme, *Sow.*.........	...	*	...	*
	Curtonotus unio, *Salt.* (elegans *Salt.*)	...	...	*	*
	Cucullæa amygdalina, *Phill.*	...	*	*	*
	—— unilateralis, *Sow.*	...	...	*	*
GASTEROPODA...	Acroculia vetusta, *Sow.*...............	...	*	*	*
	Euomphalus planorbis, *Vern.*	...	*	...	*
	Loxonema rugifera, *Phill.*............	...	*	*	*
	—— tumida, *Phill.*	...	...	*	*
	Macrocheilus imbricatus, *Sow.*......	...	*	...	*
	Murchisonia spinosa, *Phill.*	...	*	...	*
	—— angulata, *Phill.*	...	...	*	*
	Pleurotomaria expansa, *Phill.*	...	...	*	*
NUCLEOBRANCHIATA	Bellerophon Urei, *Flem.*	...	...	*	*
	—— hiulcus, *Sow.*......................	...	...	*	*
	—— subglobatus, *M'Coy*	...	...	*	*
CEPHALOPODA ...	Goniatites excavatus, *Phill.*	...	*	...	*
	—— serpentinus, *Phill.*	...	*	...	*
	—— spirorbis ?, *Phill.*	...	...	*	*
	Orthoceras cinctum, *Sow.*	...	*	*	*
	—— cylindraceum, *Flem.*............	...	...	*	*
	—— lineolatum, *Phill.*	...	...	*	*
	—— undulatum, *Sow.*	...	*	*	*
	—— striatum, *Sow.*	...	...	*	*
	Poterioceras fusiforme, *Sow.*.........	...	...	*	*
		3	28	47	56

It will be well to analyze this Table, which expresses the entire value of specific agreement.

Plantæ.—Two species of the known thirteen are common to the two formations.

Cœlenterata.—Amongst the Corals, only one species (*Michelinia antiqua*) occurs common to the two systems, although twenty-four genera and fifty-three species are known in the Lower and Middle Devonian slates and limestones of North and South Devon. (*Vide* Tables II., V., VIII.) These, and the *entire series of rocks* which contain the nineteen North-Devon species, are wholly unaccounted for in Mr. Jukes's paper, either upon the hypothesis of the fault or anticlinal. Neither the rocks nor the fossils occur to the south of the Pickwell range, or Upper Old Red Sandstone; and the great series of slates of Mortehoe, Lee, Ilfracombe, and Combe Martin, with the Hangman grits below, hold a distinctive and intermediate position, which his hypothesis cannot account for, even upon physical grounds; and the entire fauna of the Ilfracombe group has also to be accounted for, and correlated with that of Baggy and Marwood ere any relation can be proved to exist. There is not, however, the least doubt that the whole Middle group is a well-determined one, and exists below the Pickwell-Down or Upper Old Red Sandstone series in North Devon.

Echinodermata.—Of the ten known genera, three are common; and of the twenty-one species, only four occur in the Carboniferous, one of which, *Cyathocrinus pinnatus*, I much doubt.

Annelida.—No comparison.

Crustacea.—Six genera and thirteen species are known in, and are entirely confined to, the Devonian rocks of North and South Devon. As before mentioned, both families, genera, and species are peculiar to them in the British and the three Continental areas.

Polyzoa.—The eight genera and twelve species known show nearly 50 per cent. common, viz. four genera and seven species. I give them, because at present they occur in most lists; but I believe that, when carefully examined, this group will require entire reconstruction, both for the Devonian and Carboniferous rocks.

Brachiopoda.—We know of twenty-five genera and ninety-nine species in the British Devonian rocks; eleven of the genera and fourteen species pass up to the Carboniferous series through the Carboniferous Slate or Lower Limestone Shales. Except through the genus *Rhynchonella*, which has four species common, there is only *one representative species* in each of the remaining genera—a significant fact and to be noted in this prolific group, in which the species are usually so great numerically.

Lamellibranchiata.—Out of the twenty genera and fifty-seven Devonian species, eight species *only*, through the two groups (Monomyaria and Dimyaria) unite the two systems; through the *Curtonoti* and *Cucullææ* there may be two or three more. With relation to the Devonian series, however, we have much to learn in this class, which in the Carboniferous rocks numbers 330 species.

Gasteropoda.—Only twelve genera are known; but their specific value is numerically greater than that of the *Lamellibranchiata*, there being 46 species of them; only six of the former and eight of the latter are known above the Upper Devonian beds.

Cephalopoda.—This pelagic class is represented in the Devonian rocks by six genera (all Tetrabranchiata). I have previously noticed (p. 650) their singular local distribution through the large assemblage of species in the genera *Clymenia* and *Cyrtoceras*. We have in our British Middle and Upper Devonian beds fifty-four known forms, *nine* only of which are common to the succeeding Carboniferous, and this through the three genera, *Goniatites, Orthoceras*, and *Poterioceras*. (See Tables IX. and X.)

Pisces.—The 113 described species in the three recognized divisions of the Old Red Sandstone of England, Wales, Scotland, and Ireland, until lately had no known or well-authenticated representatives in the British marine Devonians. We now know of three species :—*Phyllolepis concentricus**, from the Lower Devonian slates of Cornwall; *Holoptychius*, from the Upper beds of North Devon; and *Cœlacanthus*, from the Upper beds of the Old Red Sandstone of Ireland, associated with *Adiantites Hibernicus* and *Anodon Jukesii*.

We have, therefore, clearly shown in Table X. (in which are enumerated all the species known common to the two formations) that fifty-six species out of the 383 known Devonian forms are common to those rocks and the Carboniferous, and that forty-seven of the 383 are allied through the Upper Devonian beds only; *i.e.* they are not known to the *north* of the Pickwell-Down Old Red Sandstone (Upper Devonian); whereas twenty-eight others of the fifty-six (and of the 383 named in Tables I. and II.) occur in the Middle Devonian, *and are* found to the north of Pickwell Down or elsewhere, and also common to the Carboniferous; and *three* only of the fifty-six (or 383) pass through the whole Devonian series (or connect the Carboniferous and Lower Devonian). Two of these three I doubt; they are *Cyathocrinus pinnatus* and *Fenestella antiqua*; and if the *Chonetes sordida* of the Lower or Lynton beds be that species, and not the *C. Hardrensis* of the higher beds and also Carboniferous, we then have scarcely a single species in common between the Lower and Upper Devonian themselves, or between the Lower Devonian and the Carboniferous.

There are therefore fifty-six species common to the whole Devonian formation and to the Carboniferous; *forty-seven* of these fifty-six are species common to the Upper Devonian and Carboniferous; and *twenty-eight* of the fifty-six to the Middle and Carboniferous, and *three* (?) to the Lower Devonian and Carboniferous. *Vide* Table X., where the names and range of the above species are enumerated.

VII. Stratigraphical considerations on the Devonian Fossils.

The many Tables which have been prepared, based upon the known species and their distribution through the Lower, Middle, and Upper Devonian rocks, will enable us to establish some conclusions by comparing them amongst themselves as local groups, and also by comparison with those of other localities.

The chief important question arising from a critical examination of a set of organic remains resolves itself into the determination of the horizon, age, or stratigraphical position to which they should be referred.

The rocks and their fossil contents in North Devon belong to two ages, the Devonian (so called) and the Carboniferous; and to one or the other, or both, we have to refer them.

* Pengelly, Report Roy. Geol. Soc. Cornwall, 1860–65.

Table XI.—*Showing the number of genera and species in the Old Red Sandstone and Devonian series of Great Britain, and the number of species in the Carboniferous rocks common to the two formations; also compared with the Devonian rocks of Rhenish Prussia, Belgium, and France.*

	Old Red Sandstone.		DEVONIAN.					Species common to the Carb. and Dev. Rocks.	FOREIGN.		
	Genera.	Species.	Genera.	Species.	CORN-WALL.	SOUTH DEVON.	NORTH DEVON.		Rhenish.	Belgian.	French.
Plantæ	12	13	4	4	...	...	3	2			
Amorphozoa	...	...	4	9	2	9	1	...	2	1	
Cœlenterata	...	...	25	53	7	51	19	1	18	17	14
Echinodermata	...	...	10	21	2	12	11	4	4	5	
Annulosa	1	1	2	2	...	1	2	...	1		
Crustacea	7	21	6	13	4	12	3	...	9	4	2
Polyzoa	...	...	8	13	4	8	8	7	4	2	2
Brachiopoda	...	...	25	99	31	67	48	14	41	44	28
Lamellibranchiata. { Monomyaria	...	...	3	22	9	9	10	4	3	2	
Lamellibranchiata. { Dimyaria	1	1	18	36	8	11	22	4	5	4	3
Gasteropoda	...	...	12	46	9	37	10	8	13	11	
Nucleobranchiata	...	...	3	9	2	3	6	3	...	3	
Pteropoda	...	...	1	1							
Cephalopoda	...	...	6	52	26	26	9	9	4	7	1
Pisces	43	113	3	3	3	...	1				
	64	149	130	383	107	246	153	56	104	100	50

In the present case the intermediate position of the Devonian series is assumed, although the Silurian is not seen or known in this area; but the upward succession into the Carboniferous is clear and conclusive; and upon this belief I base my premises as to the value of the species contained in the underlying conformable rocks called Devonian.

There are 383 species of fossils known to occur in these rocks in North and South Devon, which have no known or determinable stratigraphical base. The rocks they do repose upon are *probably* Silurian; whether Upper or Lower we know not, or whether conformable or not we cannot say.

The known British Silurian fauna consists of 1154 species*, only one of which (*Atrypa reticularis*), I believe, is common to the Devonian and the Silurian rocks. The seven species of fish that occur in the passage-beds, and on the confines of the Upper Silurian and the Lower Old Red Sandstone, in the typical Silurian area in Hereford and Worcestershire &c. have no value whatever here, and therefore cannot be compared; when it is absolutely proved by stratigraphical demonstration that the lowest Devonian is *truly* and *identically* equivalent to the Lower Old Red Sandstone, we may then say that there are 8 species known to be common to the Devonian and Silurian formations.

There are *no* marine forms in the Old Red Sandstone; but there are 383 in the Devonian rocks of the British Islands.

Now it is well known that many thousands of feet of strata consisting of red, grey, brown, and greenish slates, grits, and sandstones occupy a large tract of country in North Devon, from Lynton to Barnstaple, these marine fossiliferous beds overlying, in part at least, what we have hitherto believed to be the lowest Old Red Sandstone, the equivalents of the Lower Old Red of the Silurian frontier, which is totally void of fossils.

The 383 new forms or species, then (for *one only* seems to have migrated from a Silurian region), we must locate somewhere in time as well as space. In the absence of any physical evidence to show that the strata named "Devonian" in North Devon and elsewhere are or are not contemporaneous with the Old Red Sandstone, their stratigraphical position is assumed, aided by palæontological evidence, and from the circumstance that only 56 species out of the 383 are known in the Carboniferous rocks which overlie the beds containing them in North Devon (Tab. X.). Had the Carboniferous rocks, however, stratigraphically preceded this group, we should have placed them below the Devonian, and have referred the now Devonian species to the Carboniferous as types. We are also now better able to correlate, and to establish more direct contemporaneity between, the Devonian and the Old Red Sandstone, through Fish-remains found in the known Devonian strata both in England and Belgium,—*Phyllolepis concentricus* and *Onchus* having been found in the Lower Devonian slates of Looe and Meadsfoot, *Pteraspis* in the lowest Coblentzian rocks of Devon and Wassenbach on the Laa-

* *Vide* Table I. p. 615.

chersee, *Holoptychius* in the Upper Devonian of North Devon, and *Coccosteus* in the Middle Devonian of the Eifel, to say nothing of the association of numerous species of fish with marine Mollusca, Corals, &c. associated together in the same beds in the Valdai Hills &c., where *Cephalaspis* and eight or nine other genera occur, having species identical with our own Scottish Old Red Sandstone, and 16 species of shells common to our Devonian also *. Thus, then, we have some grounds for placing our marine Devonian rocks on the same horizon as, and contemporaneous with, the recognized divisions of the Old Red Sandstone in other localities; but the physical structure and succession, as exhibited in North Devon alone, is (and was years ago) enough to establish this.

To the Devonian series therefore we assign the 329 species peculiarly Devonian, after eliminating the 56 which are common to that formation and to the Carboniferous; and it is only through the *Upper Devonian* beds that a close agreement takes place between the species of the two groups of rocks, where 45 of the 56 (or 383) pass to the Carboniferous, 25 from the Middle to the Carboniferous, and only 3 species are common to the Lower or Lynton group and the Carboniferous beds †. (Table X.)

But I cannot admit (as stated), because I have failed to detect, that a single form occurs in common between the Silurian and Carboniferous, although they are said to be thus related through the species *Strophomena rhomboidalis*, by Professor Jukes, *loc. cit.*

We must in this case adhere to circumstances and facts as we find them, and receive the opinions and decision of experienced palæontologists until contradicted.

I have contended, aided by the stratigraphical position of the rocks, for the intermediate zoological grouping and value of the forms of life in the Devonian as related to the Silurian through the Trilobites, and notably and distinctly by the individuality of certain well-marked genera not known out of the Devonian series, either in Britain or over all Europe: nor are they known below in the Silurian rocks, or above in the Carboniferous in any area.

The Middle group, which holds so distinct a place in the series in North and South Devon, both by richness in special and peculiar genera, and in number of species, is paralleled in every particular in

* Mr. W. H. Baily, Palæontologist to the Geological Survey of Ireland, at the Bath Meeting of the British Association, 1865, communicated to the Geological Section the first notice of the occurrence of fish in the Old Red Sandstone of the Bristol area; these remains he obtained from the base of a conglomerate bed exposed in the cliff at Portishead, and also from red flaggy beds on the shore between high- and low-water mark. He identified the scales as those "of *Holoptychius nobilissimus* and *Glyptolepis elegans*," associated with plants and bones, and also what appeared to be "the fin-rays of a fish like *Glyptolepis*, or *Platygnathus*, in Yellow Sandstone." These beds would probably represent the upper part of the Old Red Sandstone. The paucity of fish-remains in any portion of the Old Red of this area enhances the importance of this communication, and may yet aid us in determining their position in the series of the Portishead rocks: a fragment of a scale ornamented like those of *Bothriolepis* or *Asterolepis* was also found.

† Two of which are doubtful, if not all.

the three continental areas, where, as with us, the upward stratigraphical succession into the overlying Carboniferous through the Upper Devonian (when represented) is complete. It is the genera of Brachiopoda (*Uncites, Merista, Davidsonia, Stringocephalus, Calceola, Pentamerus*, &c.), the whole of the Cœlenterata (51 species), with all the Amorphozoa (9 species, which are unquestionably Lower and Middle Devonian), the Cyrtoceratites (11 species, all Middle Devonian), added to the rich numerical assemblage of species (vide Tables II., V., VII., VIII., IX.) which do not occur in the succeeding Carboniferous, that establish a distinctness and give a reality to this Middle Devonian group, which nothing but conclusive proof of unconformity here or abroad can ever shake.

I cannot doubt, therefore, that in North Devon the geological age of the fossils is proved by the stratigraphical position of the beds containing them, and that as there is no physical break in the upward rock-succession from the Lynton and Ilfracombe group to the Baggy series through the Pickwell-Down sandstone, neither is there in the zoological continuity and persistency of species that gradually lived on, or passed up, to the Upper Devonian, or Upper Old Red Series of Baggy and Marwood, and to the Croyde beds to the south.

Comparison, then, can easily be made between those species that are common to the Middle and Upper Devonian and the Carboniferous Slate &c. of the same area, believing as I do that the rocks and assemblage of fossils south of Baggy, at Croyde, Braunton, and Barnstaple &c., are the Carboniferous Slates and Coomhola Grits of the south of Ireland, but that in the North-Devon area we have a well-marked Upper-Devonian fauna below that (the Baggy, Marwood, and Sloly series), which, if they did not precede the Irish forms in time, were deposited in a different area.

I maintain, therefore, that the peculiar Devonian genera and species have a most definite value, because we know their stratigraphical place with relation, at least, to the Carboniferous group above; and although no one locality can perhaps be pointed out where fully developed Upper Silurian rocks below, and fully developed Carboniferous Limestone above, with the Devonian slates and limestone can be seen in one section, it does not necessarily follow that, because we have not seen it in its completeness or totality, we should deny all experience, and reject the views of every competent observer, when so much separate evidence exists.

It may be asked what is the history of that great mass of so-called Old Red Sandstone in South Ireland? and why the unconformity amongst the Scotch Old Red Sandstones themselves? what caused that change from the marine Silurian to the barren or non-fossiliferous Old Red of the Silurian area?

The Table constructed by Professor Jukes at pp. 364–5 * is anything but the right way to put the question of recurrence; it is simply comparing the Devonian species with each other in two different areas—comparing forms that lived on through the whole group, from the Lower portion to the Upper, which upon the law of continuity

* Notes for a comparison, &c., p. 578.

should be expected. Out of the 17 species therein given, there are but 8 known in any part of the Carboniferous rocks in any area; they are the following:—*Actinocrinus tenuistriatus, Cyathocrinus variabilis, Athyris concentrica, Rhynchonella pleurodon, R. pugnus, Spiriferina cristata, Strophomena rhomboidalis, Streptorhynchus crenistria.*

The 17 enumerated species, taking them as they stand, are known to most observers to occur in the North Devon Devonian rocks; but we have yet to learn that the fossils or rock-masses occupying the areas north and south of Pickwell Down are on the same general horizon, and are equally Carboniferous Slate; until this be the case, none of the 17 forms enumerated can be compared. Every name in the column marked South, except perhaps Barnstaple, and every species save the 8 given above, are recognized as Upper Devonian localities and species. Assigning to them therefore a north and south position and distribution geographically, by virtue of a so-called "*central* band" of Old Red Sandstone, whose position is neither central nor dubious in North Devon, shows upon paper a comparison that is not to be found in the physical structure of the country. Admit that all North Devon is Carboniferous Slate, and then the above 17 and all the other fossils are of that age; until then, 9 of them, viz. *Petraia pleuriradialis, Fenestella antiqua, Pleurotomaria aspera, Bellerophon globatus, Athyris concentrica, Orthis interlineata, O. striatula, Spirifera lævicosta,* and *Phacops latifrons,* will stand as Devonian species; and let me add that, of the whole 17 in the Table, the doubtful *Chonetes Hardrensis* is the only one common to the Lower or Lynton group and the Carboniferous Slate either of Devon or Ireland.

At p. 366 of same paper, it is stated that our choice is "now, however, limited to the period of the Old Red Sandstone and that of the Carboniferous Limestone, unless we assign to them [the fossils] a hitherto undefined period between those two, or *suppose them* to be *older* than those of the Old Red Sandstones" (the *whole of that formation according to Prof. Jukes's views,* but which I would call *Upper* Devonian, or *Upper* Old Red Sandstone; therefore no one would suppose that the Carboniferous preceded the Devonian).

The fact that the Devonian fauna contained some species belonging to genera peculiar to or only previously known in the older Silurian rocks, such as *Phacops, Homalonotus, Bronteus, Cheirurus,* and *Harpes* among the Crustacea, the genus *Spirifera* and *Pentamerus* among the Brachiopoda, &c., but *species* of which do not occur in the Devonian or Carboniferous, tends to clearly establish passage and connexion at some unknown locality; and our one connecting species, *Atrypa reticularis* (numerically so great), which was so common in the whole of the Upper Silurian seas, would tend to show strong grounds for determining the Lower Devonian to be contemporaneous with the Lower Old Red Sandstone of the Silurian region, which is there conformable to the Silurian rocks, but totally distinct in life-remains a few feet above the passage-beds.

I have shown what species occur in common between the Devonian and Silurian, and what are common to the Lower Old Red, accumulated probably under freshwater conditions, within the general area I have previously noticed, such being due to a series of geographical changes dependent on the relative position of masses of land and water, thus producing stratigraphical unconformity, and partial zoological breaks; yet, nevertheless, sufficient life-evidence is left to enable us, through the Fish, Silurian genera of Trilobites, and Brachiopoda, to link on and establish continuity, if not close affinity, or even contemporaneity, and also to lead us to the conclusion that the Devonian series as a group were deposited in a different geographical area, and that the physical and palæontological conditions were much the same here as over the region occupied by them in France, Belgium and Prussia, through the whole period of its accumulation; added to which the ichthyic evidence in the Lower, Middle, and Upper Devonian beds in the continental areas is marked and decided.

Professor Jukes states, p. 368, *that "by the hypothesis I now propose, the place of these marine Devonian beds will be fixed stratigraphically* between the top of the Old Red Sandstone and the base of the Coal-measures, in North Devon as in Ireland." From this assumption, or proposition, and the way in which it is put, I entirely dissent on eight grounds.

1st. Because it is assumed that all the known Devonian species of North Devon occur south of, or above, the Upper Old Red Sandstone of Pickwell Down, his *Old Red Sandstone*; whereas 60 known Devonian species, and thousands of feet of strata in regular sequence are *below this* line.

2ndly. By this view we are led to believe that no older or lower beds whatever, containing fossils, exist to the north of the line assumed; we are, however, enabled to divide the whole group below into a Lower and a Middle series, the latter of which rests upon a set of red sandstones and grits as marked, definite, and important as those that overlie the Pickwell Sandstones, these are the Hangman grits.

3rdly. That the Lower or Lynton slates (Lower Devonian) nearly 1500 feet thick, and themselves divisible into three series, in their turn rest upon the arched red sandstones of the Lynn valley and the Foreland rocks.

4thly. This hypothesis only accounts for the already well-known position and group of the Upper Devonian series, which here in North Devon (south of Pickwell Down) overlie, as they do in the south of Ireland, a series of red, green, and yellow sandstones &c. (the Upper Old Red Sandstones), *all that are there known.*

5thly. It is assumed that an extensive fault, or concealed anticlinal (before noticed), traverses the country from west to east, somewhere along the latitude of Pickwell Down, thereby causing the beds properly called Upper Devonian to be repeated to the north, which are therefore stated to be the same beds as those south of Morte Bay, thus attempting to make the Lower or Lynton, and Middle or Ilfracombe series of the same age and to hold the same stratigraphical position as the Upper Devonian at Baggy &c.

6thly. We could find no trace of either fault or anticlinal; and the structure of the country, together with the palæontological evidence, is diametrically opposed to this hypothesis, *the interposition or interpolation of the great Middle group of slates and limestones with their definite fauna being fatal to this hypothesis*; it cannot be accounted for either on the ground of the fault or anticlinal, yet must be if it be even allowed. This series in North Devon possesses 13 genera peculiar to it, and not known in any higher group.

7thly. I conceive it to have been an error to compare the British Devonian with the Irish types in the Carboniferous Slate, where only one-third of the species are known to exist, the fauna of *that* area either being derived from the typical Devonshire, or being a remnant of the same that once existed there. The lower part of the Irish Old Red Sandstone, the base of which has nowhere been seen, may not impossibly represent in time the Middle and Lower Devonian (Middle and Lower Old Red Sandstone) of North Devon, where beds of red sandstone of no inconsiderable thickness (void of life) exist, both at the base of the Middle or Ilfracombe beds (Hangman grits) and the base of the Lower or Lynton slates (Foreland sandstones &c.).

8thly. The true Old Red Sandstone, as a whole, in one or other of its three members (neither of which contains marine fossils), may be the conformable base to the great Carboniferous series in some or many areas; but that it is so to the exclusion of the marine group called the Devonian can only be believed by admitting that the two series were synchronously deposited over every known area where they both occur. This hypothesis would perhaps answer for very widely separated geographical areas, where one or the other rested upon the Old Red Sandstone as its base, or where either the one or the other was not represented either in time geologically, or space chronologically; but we can scarcely receive and apply that doctrine to an area (our own) where the base of the Carboniferous itself rests conformably upon the Upper Devonian series, acknowledged to be the marine representative of the Upper Old Red Sandstone of our own and other areas, itself resting (as in Ireland and North Devon) upon the non-fossiliferous Upper Old Red. Such views cannot be applied to any geographical area of so limited an extent as that now occupied by the two groups (the Carboniferous and Devonian) in the British Islands, the zoological differences being so great in one and all, where they occur and are tested on biological grounds. The doctrine of synchrony and difference of nature of sea-bottom must be stretched to the utmost to establish a province or provinces of organic remains within a few miles of each other, and that laterally, that would account for differences of such magnitude as those which exist in the physical conditions and the fauna of the two united systems.

In Britain and Ireland alone, and chiefly in the very area we are discussing, there are 383 species of Devonian fossils (as compared with 1748 species of Carboniferous); and of these 383, only 56 are common to the two systems (*vide* Tables II., IX., X., XI.); and this ratio holds good for Europe, so far as we know. Had such difference existed over a vastly wider area, then the difference in the fossils of the Carboniferous and Devonian groups might be accounted for upon the hypothesis that they were accumulated under very different conditions physically and chronologically, and in a totally different area or province; but that the Upper Devonian series of North Devon, and those of South Ireland, South Wales, and France (the Boulonnais), as well, perhaps, as the lower part of the Carboniferous (call them what we will), were deposited synchronously, making what reasonable allowance we please for locality, province, and difference of nature of sea-bottom, there cannot, I think, be any reasonable doubt; but we cannot parallel the *Lower and Middle groups* of the Devonians here and on the continent with the Carboniferous under any hypothesis.

I by no means pretend to decipher, or to propose any different or new theory relative to, the life-break that took place between the Upper Silurian and Old Red Sandstone, where in Shropshire, Herefordshire, &c. there is no unconformity or sudden break, their physical passage being uniform and complete, but accompanied by a total extinction of the Silurian marine species, dependent, perhaps, upon the relative positions of masses of land and water, causing the marine condition of that area to become one of fresh water: all that we can say amounts to this, that we cannot account for that complete change, except through unconformity, of which we have no actual evidence. The succeeding Old Red must have been deposited in a rising and circumscribed area of greatly broken condition, occupying a vast duration of time, sufficient to allow of the introduction of a new marine fauna to the south and east, either through the agency of depression along a given line, east and west, about the latitude of the Mendip Hills and the south of Ireland; or a barrier existed along the same line, against which the marine deposits of the Devonian series were deposited, and that with an ex-extensive southern expansion. In no other way can we, I believe, account for the physical change and zoological conditions of the marine Devonian rocks.

Professor Jukes has shown a physical break between the two members of the Old Red Sandstone in Ireland,—the lower, of great thickness, being conformable to the Ludlow group, whilst the upper division, of some 4000 feet, rests unconformably on the Lower, passing up and being conformable to the Carboniferous. We are not yet certain what these may be the equivalents of in the South-Welsh or, perhaps, North-Devon area.

Mr. Geikie has shown the same for the Pentland and Lammermuir Hills, where, he states, the base of the Old Red Sandstone is conformable to the Upper Silurian (Ludlow beds); a break occurs between them in the red and yellow sandstones and associated igneous rocks of the Middle, and then upon these another unconformity of the Upper Old Red Sandstone, which at the top gradually passes into the Carboniferous. There is, in fact, no division of the British strata where the geological sequence or succession is so remarkably broken and incomplete as the Old Red and Devonian series, illustrating lapses of unrepresented time, which are proved either by the great and complete change in, or total absence of, life-remains.

I have endeavoured, however, to show that it is possible to parallel the division of the Old Red proper with its chronological equivalents, the marine Devonian series, which were deposited in a different, although contiguous, geographical area.

I contend therefore that the Devonian system, as a group of strata, both physically and palæontologically, may be (as long ago proposed) naturally and conveniently divided into a Lower, a Middle, and an Upper series, and that there is valid reason for believing that this system equalled in time the whole of the deposits of the Old Red Sandstone proper; but we have no real means of establishing arbitrary lines of agreement, or of strictly correlating the received division of the one to that of the other, for the want of clear palæontological agreement and evidence; all that can be said is, that, in the sequence of rock-masses, the Old Red Sandstone and marine Devonian, be they absolutely equivalent or contemporaneous or not, occupy a place above the Silurian on the one hand and below the Carboniferous on the other. The evidence of succession is clear in Wales, Hereford, and Shropshire as regards the Old Red Sandstone; in the Devon area, on the other hand, it must be assumed, as we have no visible base-line uniting the Lower Devonian with the Silurian, though, for aught we know to the contrary, they may overlie Silurian rocks in the Lynton area, in North Devon; but the testimony of palæontological research has established beyond any doubt that in Devonshire and Western Europe there exist three natural groups, which stratigraphically and zoologically succeed each other, viz.:—a Lower or Lynton, equalling in time and position the Lower Old Red Sandstone of the Silurian area; a Middle series, the Ilfracombe beds of North Devon and their equivalents (the Newton Bushel and Torquay slates and limestones) in South Devon, which probably equal the Middle Old Red Sandstone of Herefordshire, Gloucestershire, and Glamorganshire; and a true Upper Devonian series, resting in North Devon upon the Morte-Bay Upper Old Red Sandstones (of Pickwell Down, Dulverton and Wiveliscombe), which also is equivalent to the Upper Old Red of the Pembroke area in South Wales; and it is upon these Pickwell-Down red sandstones that the slates, grits, and arenaceous flaggy beds of Baggy, Marwood, Sloly, and Croyde conformably rest, which contain the marked assemblage of Upper-Devonian forms. They are three distinctly marked physical and palæontological groups, true as to rock-succession, and equally well characterized by organic remains, especially the Middle or Ilfracombe group, with its Cœlenterate and Mollusca fauna: that this order of succession exists is incontestably proved by the clear interpolation of the middle fossiliferous slates and limestones, and the extensively developed series of unfossiliferous slates of Lee, Rockham Bay, Mortehoe, and Woolacombe, and it is also strengthened by the non-faulted range of Pickwell Down. No fault or anticlinal along the line delineated by Professor Jukes can account for the total absence of the Lynton and Ilfracombe groups to the south of the Pickwell-Down range, which area is now occupied by the well-defined Upper Devonian series *in situ* upon it.

No fault can account for the absolute contrast that exists between the fossiliferous sandy grits and slates that are in position on the south side of Pickwell, and the barren glossy slates of Mortehoe &c. that underlie the red grits and sandstones of Pickwell Down at Potters Hill, and also the still thicker slates and associated continuous bands of organic limestones of Ilfracombe and Combe Martin, which strike continuously on to Croydon Hill, in West Somerset; these ought to be accounted for (although they are not) by such hypotheses, as for thirty miles they strike and hold their place and position without inversion, although disturbed by extensive undulations.

On zoological grounds the evidence is equally strong and conclusive. No single coral out of the *nineteen* species in this area is known out of this Middle group in higher beds; and only *ten* out of the twenty-five species of Brachiopoda pass up to the Upper Devonian strata south of Pickwell, and *four* to the Carboniferous: whether these facts have any parallel in the South-west of Ireland or not, they are yielded by the structure and condition of North Devon. There is yet another thick group of sandstones underlying the Ilfracombe and West-Somerset Middle slates and limestones—the Hangman Grits, from 1800 to 2000 feet thick; they have no equivalent whatever to the south of the Upper Old Red Sandstones, and certainly are not the Pickwell group repeated, with the Middle series troughed in through undulation. These ought also to be accounted for to the south of the supposed fault. Again, if the Lower or Lynton beds are the same (or upon the same general horizon) as those of Baggy, Marwood, and Croyde &c. &c., to the south, no system of faults can account for or do away with the well-marked intermediate position of the Middle Devonian group; and no anticlinal situated so far to the south of the great mass of the country as Pickwell could divide the series without accounting for the Carboniferous series of Venn, Swinbridge, &c., which should become evident to the north at Lynton, or trough in between, which they do not.

Professor Jukes, again, in his paper, "Notes for Comparison between the Rocks of the South-west of Ireland and those of Devon," &c. &c., pp. 10 and 11, would infer, or lead those to believe who had not seen the country, that the rolled or undulating beds along the north coast, at Morte Bay &c., are confined to the *lowest groups*, which, he says, are "probably the Morte Slates and beds below them." These quartzose Morte slates are not the lowest, they are the highest of the Middle group, and overlie the fossiliferous Ilfracombe series proper, and hold their place all across North Devon into West Somerset. The whole of the fossiliferous slates and limestones of Ilfracombe and Lynton are below these and the red sandstones of Pickwell; neither will the rolling therein mentioned do away with the fossil evidence tending to disprove that "the beds of Lynton, Combe Martin, and Ilfracombe may belong to the Carboniferous Slate rolled to the north by contortions, and somewhat differing lithologically from those further south." No rolling has destroyed the value of the *intermediate fossiliferous Middle* or Ilfracombe and Combe-Martin group; for of the seventy species found in these beds, six only recur in the Carboniferous series of any area, viz. *Cyathocrinus variabilis, Fenestella antiqua, Rhynchonella pleurodon, R. pugnus, Streptorhynchus crenistria,* and *Avicula vetusta.* All these are also in the intermediate Upper Devonian series in North Devon. Thus, then, these beds on the north coast, *which are below* the red beds of Morte Bay, do "disclose facts which have no parallel in the south-west of Ireland;" but there is no doubt as to their stratigraphical place, or the zoological value assigned to them.

If we admit the physical succession of the North-Devon rocks to be established, and that they constitute three well-defined groups, this of necessity destroys the views of Professor Jukes, who believes that the uppermost bed of the Old Red Sandstone was in existence before any of the beds containing marine Devonian fossils were deposited; and his Old Red Sandstone is the non-fossiliferous red series which strikes from Morte Bay through Garmon Down, Span Head, Dulverton Common, to Haddon and Main Down (Wiveliscombe), which red sandstones, according to the hypothetical fault, are the Foreland beds to the north repeated, caused by the supposed great downthrow existing between these two points; consequently, upon this hypothesis, the Foreland grits and sandstones and the Lynton slates, with the overlying fossiliferous Ilfracombe group, and the non-fossiliferous Mortehoe slates, are, or should be, above his Old Red Sandstone, both being the same by virtue of the fault: this, I maintain, is not borne out either on physical or zoological grounds. I doubt not for one moment that the red sandstones in question may be the equivalents of the Welsh and Irish Upper Old Red Sandstone with the fossiliferous Upper Devonian series resting upon them and the surrounding or associated Carboniferous Slates and Coomhola Grits also; but I do not admit the existence of the fault, and I endeavour to prove that we have in North Devon a complete succession of the three groups, determined physically and palæontologically.

The relation that the Upper red sandstones of Pickwell &c. have to the overlying fossiliferous Upper Devonian slates, sandstones, and grits is the same relatively that the thick Middle group of sandstones of the Hangman, Trentishoe, Martinhoe, &c. have to the Middle Devonian or fossiliferous calcareous slates of Ilfracombe and Combe Martin above them; and on equally good grounds we are enabled to establish a base for the Lynton slates and gritty limestones upon the non-fossiliferous red sandstones of the Foreland.

This order of succession is not only a true one, but it is in accordance with the reading of the succession in Europe; it is based both upon the position of the rock-masses of North Devon, and upon their associated groups of fossils. The physical conditions coinciding with the zoological evidence, it is that group, as a whole, to which must be collated or equated the succeeding Carboniferous species, to which by succession they are allied, constituting one life-system, up to the close of the Permian period. It is impossible to examine the distinctive fauna of the South and North Devon Devonian rocks, taken collectively and compared with their equivalents in Rhenish Prussia, Belgium, and France, and not to perceive that it is in the North Devon area, where the sequence is clear, that the question of life-succession must ultimately be determined; for in South Devon we have as yet no known Upper-Devonian fauna, which series was so conclusively established in this northern area, at Baggy, Marwood, and Croyde &c. above the Pickwell sandstones, and at Petherwin, Landlake, &c. in North Cornwall, by Mr. Salter, in the year 1863*.

Upon examination of Table IX., where every known species in the Northern area (including Petherwin) is given, the importance of the *Upper-Devonian fauna* will be at once perceived, and its relation to the Carboniferous appreciated. This Table shows the occurrence of 194 species in the Lower, Middle, and Upper Devonian series of North Devon and Petherwin; and in the Upper-Devonian column 110 are given, of which 40 of all classes pass up to and connect the Carboniferous; and, taking or assuming the Barnstaple or passage-series in North Devon to represent the lower part of the Carboniferous, we have in *this area* 30 species in common between the two, and 40 in all as compared with the Carboniferous generally *in any area*.

Having, I trust, clearly demonstrated the succession and value of the Lower and Middle Devonian Rocks, and added some little to what was previously known of their conditions, I am compelled to notice, in support of the views advocated, the relations which the fossiliferous Upper Devonian series bear to the so-called Upper Old Red Sandstone of Pickwell Down &c., because it is asserted by Professor Jukes that the uppermost bed of this range was in existence before any of the beds containing marine Devonian fossils were deposited. No one can doubt the fact that, resting upon the upper beds of the Red Sandstones of Pickwell Down at Vention and George Ham, (at the southern part of Morte Bay), we have the lowest members of the Upper Devonian group conformably succeeding the green, red, and grey micaceous Upper Old Red Sandstones above named; but it must not be believed that these are the *lowest marine* Devonian beds. I have endeavoured to show, as others have done before (and, I be-

* The carefully prepared paper by Mr. Salter (Quart. Journ. Geol. Soc. vol. xix. 1863) upon this series south of Baggy, in which the whole question is discussed, and its correlation with the South-Wales beds given, with also special reference to the Irish group, prevents my entering upon them in any form: all the species known in the Upper Devonian series are given in the Tables II. and IX., and their relation to the Carboniferous series of North Devon, or the Carboniferous Limestones of any area, is also given. I have appended a note upon the passage-beds between the Old Red Sandstone and Lower Limestone Shales of the Avon section, where I am disposed to believe the Upper Devonian series is represented by about 1000 feet of grits, shales, and impure limestones, and many species which occur in the Marwood group in North Devon, but which do not range higher into the Carboniferous series above, in the Bristol section.

lieve, successfully), that thousands of feet of fossiliferous slates and limestones occur, in regular sequence through all North Devon from north to south, or from the Foreland to Barnstaple. Had Professor Jukes stated that upon the uppermost beds of the Upper Old Red Sandstone at Pickwell Down rested those containing the Upper-Devonian marine fossils, or in part the equivalent of his Carboniferous slate and Coomhola grits, he would have read the real structure of the country; now we are asked to believe, through the agency of an unknown and supposititious fault with a northern downthrow, or an anticlinal running east and west from Morte Bay to Wiveliscombe, that these Upper Devonian beds (his Carboniferous slates) are repeated in the Lynton area, being rolled, undulated, or faulted to the north.

Upon this hypothesis, therefore, there is no such group as Devonian in North Devon, the whole Lower and Middle series with their characteristic fossils and clearly defined stratigraphical place being swept away, and substituted by the Carboniferous Slate, but *only* through similarity of aspect, and not identity, as based either upon physical or palæontological grounds. On the other hand, there may be grounds for endeavouring to establish contemporaneity between the Upper Devonian series of North Devon and the Carboniferous Slates of the south of Ireland upon the principle of geographical rather than chronological distinction; and the aspect of the beds both in North Devon and Ireland, and their zoological relations one to the other through certain classes, especially the Brachiopoda (*vide* Tables IX. and X.), is clear, and to be expected when we know that the Devonian preceded the Carboniferous in time. And it is admitted that the Petherwin, Baggy, Marwood, Sloly and Croyde beds are older than the Carboniferous Slates, and not clearly represented in the south of Ireland (*vide* Tables IX. and X., and Professor Jukes's "Notes for a comparison" &c. &c., pp. 17, 22, 27). I am disposed, therefore, from careful examination of the Upper Devonian fauna in North Cornwall and North Devon, and of that of the Boulonnais and Belgium, to collate the species in the Irish Carboniferous slate and Coomhola series with the English types rather than adapt the latter to the Irish.

There are in the Upper Devonian rocks of North Devon south of Pickwell Down, including Petherwin, 136 species*, representing 57 genera: 30 of these 136 species, in this area, may be Carboniferous, assuming that the Barnstaple beds are of that age; but no more than 40 are known to pass up to the Carboniferous Slate and Carboniferous Limestone in any area; the remaining 96 are exclusively Upper-Devonian species that lived earlier in time than the Carboniferous†, and underlie the Coomhola Grits and Carboniferous Slate, so

* Omitting the Petherwin, there are 110 true North-Devon forms; the additional Petherwin species occur only in that area amongst Carboniferous-slate and Carboniferous-limestone species.

† Professor Jukes gives a list of 84 species at pp. 22–27, but places them in the Carboniferous Slate on the *assumption* only that they are so; a Roman letter indicates (as stated at p. 17) the Old-Red-Sandstone localities, but *not yet* Carboniferous-slate localities. My Table IX. and that list will correct each other.

far as we know at present, everywhere. The value of Mr. Salter's paper is lost if we reject his careful determinations relative to the Upper Old Red and Devonian; if they be controverted, then we will convert the term Upper Devonian into Carboniferous Slate; but upon the nomenclature as it now stands, Mr. Salter's observations and my own go far to suggest, if not to prove, that the Coomhola species may yet be Upper Devonian; and this is supported by the fact that *Cyrtina heteroclyta* and *Spirifera disjuncta* occur in the gritty beds of Reenydonegan Point, Bantry Bay, one a strictly Middle Devonian form, and the other neither known in the Carboniferous Slate nor above the Upper Devonian in England or in any part of Europe. There may be confusion yet in the Irish series; and the comparison made between the thick Carboniferous slates of Cork, and the equally thick sandy slates and limestones of the Upper Devonian series of Baggy and Croyde in North Devon, may yet require considerable revision; that these Irish and North-Devon Upper Devonian beds are intermediate between and connect the Upper Old Red Sandstone and the Carboniferous rocks, there can be no doubt; and although the Coomhola grits appear stratigraphically to belong to the Carboniferous rocks of Ireland, yet it is found that they contain many Devonian species; and notably we find close resemblance between the two, both in structure and associated fossils, especially so in the Baggy, Marwood, and Pilton group; and they may readily be mistaken; but, taken as a whole, there cannot be any doubt as to the distinctness of the faunæ of the two, although connected by gradual passage. The species, then, of the Upper Devonian of North Devon may be on the "same general horizon" as those of the Coomhola series in Ireland; but that our lowest beds of this group, or the Petherwin and Landlake limestones and slates &c., are chronologically below the Baggy group and the Irish grits, there cannot be any doubt. We may yet expect to find a true Upper-Devonian fauna in the slates and grits that overlie the Upper Old Red Sandstone of the south of Ireland; and it will have to be collated to the English type; for that we have a large assemblage of well-marked forms in our Upper Devonian beds not yet accounted for in the Irish series is certain; and that we have a definite Middle- and Lower-Devonian fauna in North Devon, distinct from the Upper- and not known in Ireland, whatever may be the cause, is equally certain.

It has been questioned whether or not the "Stringocephalus-limestones of either North or South Devon can be shown to exist below anything that can be identified as Old Red Sandstone." No doubt can exist as to the stratigraphical position of the slates and grits that contain this and associated shells abundantly in North Devon; its position here, as in Rhenish Prusssia, the Eifel, and as the Calceola-slates of the Boulonnais, is in the heart of the Middle or Ilfracombe group; it is abundant in places, especially so in Combe-Martin Bay, Hagginton, &c.; and *when* it is proved that the intermediate mass of slates &c. of the Ilfracombe series are *Carboniferous Slate*, then will *Stringocephalus Burtini*, *Uncites gryphus*, *Calceola sandalina*, *Davidsonia Verneuilii*, and many other equally characteristic species cease to be typical continental and British Middle-Devonian shells. The limestones and gritty slates of Combe Martin occupy in North Devon the same subordinate place in that series (being near the base), as they do at Ecaussines, in Brabant, and they are unquestionably the equivalents in this country of the Paffrath and Münster-Eifel beds in the Rhenish provinces.

I have endeavoured to show reasons why these beds reposing upon the Hangman grits occupy a place far below the so-called Old Red Sandstone of Pickwell Down*.

In South Devon we have no Upper Devonian rocks yet known, and consequently no fossils referable to them.

It has also been asked if "the rocks of South Devon are not a mere expansion of the [so-called] *Carboniferous Slates of North Devon*, with a change in the fauna depending upon difference of province." No one who has examined the fossils or the rock-masses of the two areas north and south of the granitic mass of the Dartmoor can doubt their identity in time, either through organic remains, or through similarity of physical structure, the chief and only difference being the greater development of the organic limestones in the south over that of those in the northern area. There is no change or difference in the fauna of the two regions; and of the 238 species known in the Middle Devonian of South Devon 53 occur in the same series in North Devon, and that chiefly through the corals and Brachiopoda; and 21† of these 238 are known in

* It is still an open question whether the Upper Devonian beds are represented in the Avon section or not. There is a series of grey shaly marls and impure limestones beneath the Bone-bed which exists at the base of the Lower Limestone Shales; in one of these shaly beds are found *Modiola Macadami*, *Avicula Damnoniensis*, *Cucullæa trapezium*, *C. Hardingii*, *Filicites dichotoma*, *Knorria dichotoma*, *Naticopsis plicistria*, and other forms recognized in the Upper Devonian beds of the Marwood series in North Devon. Underlying the bed containing the above, there occurs 100 feet of alternating limestones, shales, and marls, including about 30 feet of passage-beds into the Old Red Sandstone, which is recognizable by quartzose conglomerates. None of the above forms occur higher, in the Carboniferous Limestone, not even in the intermediate and immediately succeeding argillaceous Lower Limestone Shales; but true Carboniferous species are associated with them, such as *Spirifera bisulcata*, *Streptorhynchus crenistria*, *Rhynchonella pleurodon*, *Orthoceras gregarium*, *Lingula mytiloides*. All the above facts were carefully noted and described by W. W. Stoddart, Esq., F.G.S., in a communication read at the Bath Meeting of the British Association, 1865, Trans. of Sections, p. 71. I have since examined and measured the entire section underlying the red crystalline limestone band which forms so conspicuous a feature below the Fish- or Bone-bed; and whatever these impure limestones, grits, and shales may be, they are a very distinct group from either the red conglomerates and marls below, or the overlying argillaceous limestones, which constitute the well-defined so-called Lower Limestone Shales, which are 500 feet thick: this passage-series may, and probably does, *represent* the greatly developed Upper Devonian beds of Baggy and Marwood above the Upper Old Red Sandstone of Pickwell Down; before the chief mass of thick-bedded flaggy Old Red Sandstone and marls are reached, the ground is occupied by a highly siliceous variegated marly series, measuring 1000 feet, which is indicated by the valley east of the railway-tunnel.

† 3 Polyzoa, 8 Brachiopoda, 3 Lamellibranchiata, 4 Gasteropoda, and 3 Cephalopoda.

or pass up to the Carboniferous generally. But the relationship between the fossils of the southern area and those of the continental Middle Devonian is more remarkable; for of the 238 species in England 90 are common to the two, almost every species of coral being the same, and the majority of the Brachiopoda also. Rather, then, should we expect to find that the species in the Carboniferous Slate are expansions of the Middle Devonian, the change in the fauna, when complete, being due to a difference of province or area as well as of time. We therefore look to the Devonian for the types with which to compare our Carboniferous fauna, and they will be found in North and South Devon.

If I am right in substantiating the succession in North Devon, it is impossible that the Devonian slates and limestones of South Devon can be an expansion or extension requiring nearly contemporaneous deposition—a condition to be perhaps readily accounted for in the case of the Carboniferous Slate and Carboniferous Limestone, which were doubtless formed under very different local conditions, and in one area. Such an hypothesis can scarcely be applied to the prior existing, lower, older, and conformable Middle Devonian slates and limestones of either North or South Devon, with an almost totally different fauna; the parallel hypothesis may be drawn and applied with relation to the Upper Devonian beds of Baggy and Marwood &c. and the Coomhola group. They perhaps were deposited on the same general horizon in time, under different geographical conditions, and now rest upon (in the Irish and English areas) a set of sandstones which constitute the base of the Upper marine Devonian series, let them be called by what name we please. It is their position as well as their palæontological value I contend for, both of which, if rightly viewed, give not only a natural but a true solution to the upward succession of the North Devon rocks. There is nothing in Ireland below our Upper fossiliferous marine Devonian series (Irish Carboniferous slate); and in endeavouring to make that the base of the whole of the Old Red Sandstone I believe that Professor Jukes has committed an error, and also in endeavouring to establish for Ireland a fossiliferous base for the Old Red Sandstone. Our fossiliferous Lynton and Ilfracombe series may, and probably do, represent in time the thick Irish series of red sandstones, gritstones, and clay slates, the base of which it is admitted has never been seen, and on the top of which repose their Carboniferous Slates, Coomhola Grits, and our Upper Devonian in part.

I believe, therefore, that we have in North Devon, and in the Lynton and Ilfracombe series only, the fossiliferous representative of these barren Irish Lower Old Red Sandstones, deposited under different conditions in a different area, although apparently allied geographically, accounted for upon the same principle that Professor Jukes advances relative to the lowest Carboniferous groups, and dependent upon chronological and geographical distribution, agreement, or distinction.

I therefore still ask whether the fossiliferous slates, sandstones, and grits that repose upon the Upper Old Red Sandstone of Ireland under the names of Carboniferous Slate, Glengarriff Grits, &c. are not, or may not prove to be an expansion of, the well-known well-marked typical English fossiliferous Upper Devonian series that occurs on the southern flanks of Pickwell Downs &c., which no one doubts passes insensibly, conformably, and inseparably into the Carboniferous (Carbonaceous) beds above in that area, where they overlie and are conformable to the so-called Old Red Sandstone*, which occupies the same position in South Wales and Ireland, but which at its base graduates down (in North Devon) through the conformable and underlying Morte slates into the well-marked Ilfracombe and Combe-Martin series, the Hangman grits, and the Lynton beds below them, all through which a life-succession and physical aspect are determinable, distinct, and readily separable from the beds called Upper Devonian and Carboniferous above.

When physical facts and fossil evidence can be put forward that will tend to show that the Ilfracombe and Lynton series are not below the Upper Old Red Sandstone of Pickwell Down, and are not the Lower and Middle Devonian, by an assemblage and facies of recognized organic remains as zoologically distinct as the Carboniferous are from the Permian which succeed them, and not till then, can any new reading be proposed for the physical structure of North Devon.

After very careful investigation into the physical structure of North Devon, as well as a critical examination of the organic remains contained in its diversified rock-masses, I can come to no other conclusion than that the series of sandstones, slates, and limestones ranging from the Foreland and Lynton on the north to Pilton and Barnstaple on the south are one great and well-defined system, and equally well divisible into three groups, a Lower, Middle, and Upper Devonian series, each equally well characterized by a fauna, the zoological facies of which are sufficiently distinct to determine them one from the other. Let this Devonian system be equated to what it may, it is nevertheless a great life-group—a system based upon clear stratigraphical succession of strata and an associated and well-marked marine fauna. This is borne out and testified by its extended and equivalent groups in Europe, where in Nassau, Rhenish Prussia, and Belgium the Lower and Middle series are precisely the same as our own in North and South Devon.

In Great Britain, the *North-Devon and West-Somerset* rocks must be regarded as the types with which we must compare those of South Devon and the Continent; for here only can the succession be satisfactorily determined; and although the preservation of the fossil fauna is more obscure than in the south, still every day adds to its comparative completeness, and to the identity of the two areas.

In North Devon and West Somerset only do we get the lowest known beds; and although these are much obscured by the Lynton anticlinal, and perhaps an extensive fault affecting the Foreland sandstones, it is clear that no fossil-bearing slates or limestones underlie

* Not the *whole,* but the "Upper."

these red grits and sandstones. I consider the Devonian deposits as a whole to be equivalent in time with, or chronologically the same as, the Old Red Sandstone as a whole—and that as it is convenient to divide the series composing the mass of the latter into Lower, Middle, and Upper Old Red by stratigraphical sequence and the fossil fishes which characterize the groupings, so it is also equally convenient and natural to make a threefold division of the marine Devonian Rocks as characterized by the assemblage of organic remains in, and by the physical characters of, each, and especially so through the middle or intermediate group and its great limestone coral-bearing series, this holding good for Europe as well as Britain.

I believe we may yet be able to demonstrate that the marine Devonian series of West Somerset and North Devon was deposited in a different area, a different province of life, from that of the Old Red Sandstone; it is a great marine system totally distinct from the Silurian below, and even from its contemporaneous, or synchronously deposited Old Red Sandstone, and that, through its upper members, when or where developed, it gradually passed into the succeeding Carboniferous group—which is incontestably seen and proved to be the case in the North-Devon area.

We have yet to learn what were the conditions and what the physical changes that took place at the close of the marine Silurian epoch and the commencement of the Old Red Sandstone proper, by which so complete a change took place that almost every species and vestige of invertebrate life changed or passed away, or is not preserved to us, through the whole of that interval of time which witnessed the deposition of the normal Old Red Sandstone series. I believe we can come to no other conclusion than that in the typical Old-Red area the marine Silurian sea was slowly and gradually changed, or was succeeded by long-continued and slow elevations and oscillations of the land, thus converting the old marine area into one of freshwater conditions of great extent. The contour of the area over which the Old Red Sandstone of England and Wales extended would favour and lend considerable weight to this view. The oval basin-shaped region or tract occupied by this formation extended from Much-Wenlock on the north to Haverford West and Milford Haven in South Wales, along the junction of the Silurian and Old Red strata at its western boundary, and thence in an easterly direction or strike to Pembroke, Caldy, Worms-Head and across the Channel to the Mendip Hills, and thence again deflected north, along the eastern margin of the Bristol Coal-field, where the still older Palæozoic rocks and Old Red Sandstone, as well as the Carboniferous series, all dip west, this condition being continuous along the strike of the Malvern and Abberley Palæozoic series and onwards to Bridgenorth. This extensive area, the only one in England occupied by the true normal Old Red Sandstone, though not so extensive as that originally occupied by the Wealden when produced across the English Channel into the Boulonnais, may have been, and indeed very probably was, during a long interval of time, subject to freshwater conditions, either estuarine or lacustrine, with slow but continuous elevation of the land over the district traced out. There is nothing in the physical structure of the country to forbid this supposition, and on palæontological grounds nothing to disprove it. No form of invertebrate life can be pointed out, over this great area, that lived on beyond the deposition of the passage-beds on the confines of the two systems. The fishes and Pœcilopod Crustacea (both of which are allied to fresh water forms) are not known beyond the old margin; and those species of fish that do occur are sparingly found in the cornstones of Hereford and South Wales.

Either, I believe, we must admit that the total extinction of the Silurian species at the commencement of the deposition of the Old Red Sandstone was due to those conditions I have endeavoured to trace, or that the marine Devonian series must have been deposited and accumulated in an area having little or no community with the previously existing Silurian sea, but went on synchronously with the Old Red Sandstone, though in a different province, and under marine conditions; and we have not, I think, any great difficulty in approximately determining the position and probable extent of that area. I am disposed to believe that these marine Devonian strata were accumulated in a definite region, defined by a barrier which may have existed south of the Mendip Hills, and continuous or parallel with that range towards France and Belgium and the Rhenish provinces. Physicists may yet determine this; but it is south, or along the course of the Bristol Channel north, of the Foreland, that, I believe it may be determined, the equivalent strata in time, the marine Devonian rocks, were deposited. In other words, the southern British equivalents of the Old Red Sandstone (the Devonians) were deposited in a different and marine area, whilst the typical Old Red Sandstones were being accumulated in an area to the north of the prescribed barrier, and are of purely freshwater origin, the contour of that area being governed by the previously existing and older Palæozoic Rocks: the base of the one is seen in the Silurian area; and its upper members under many aspects may be examined in Wales, Somersetshire, and Gloucestershire, and under a different condition still in North Devon and Ireland.

It is from the remarkable contrast and difference that exists in the lithological and physical characters of the rock-masses of the typical Old Red Sandstone in its various localities as compared with what we believe to be its representative and equivalent in time, viz. the Devonian in North and South Devon and in the European areas, that we are led to examine into the causes for so complete a discrepancy; and looking at the exact bearing and well-defined strike of this westerly remnant of the North-Devon Devonian rocks under the waters of the St. George's Channel, or Atlantic Ocean, I am led to believe that an extensive coast-line or barrier existed to the north of what is now the coast of West Somerset and North Devon, at Lynton, Porlock, and Minehead, and thus construct a different geographical area or province of deposition and accumulation for the fossiliferous marine Devonian series. This sea and area would appear to have been extensive, if we correlate and connect our beds with their equivalents in Belgium, and to the north, in the latitude of Düsseldorf and Arnsberg, [in the north of Rhenish Prussia,] and on the east to the Taunus and Hundsrück ranges over the Coblentzian area, thence south to Luxembourg, Mezières, and the Ardennes &c., and continuously on, with interruptions, to the Boulonnais, under the Paris basin, joining the narrow strip that reposes near Angers, Vannes, and Quimper, in Brittany, upon the Silurian series. Patches of Devonian rocks on the extreme north coast of Brittany would help us to construct this southern boundary to the Mid-European Devonian deposits or area.

It is not improbable that the Devonian rocks of the Pyrenees and of the Asturias, which strike east and west parallel to the British series, may have formed also a still more southerly extension of the same. They occupy an immense area in the north of Spain and south of France. On palæontological grounds also the British, Irish, Belgian, Prussian, South French, Pyrenean, and Asturian series may have formed, and probably did form or constitute, a connected and contemporaneous series of marine deposits—one definite hydrographical area; for the facies of the fauna in all the districts is the same.

Somewhere, then, at no great distance south of the Mendip Hills, I would suggest that an extensive barrier or ridge existed at the time of the deposition of the Lower Old Red Sandstone, perhaps an axis of depression synchronous with movements of elevation to the north, in the Silurian area, which governed the conditions of the deposition of the Old Red Sandstone, and destroyed the marine fauna at the close of the Silurian period. To the south of this barrier, which severed the groups and cut off communication with the northern area, were deposited the marine equivalents of the Old Red Sandstone (the Lower and Middle Devonian slates and limestones); in other words, this barrier, let it have been what it may, would produce two hydrographical areas—one marine, to the south, the other freshwater, to the north, or in the Silurian area (Wales, Herefordshire, Shropshire, Gloucestershire, &c.). A total change took place in the marine fauna through its passage-series to the succeeding and conformable Lower Old Red Sandstone, when the few Fish and Crustacea in common to the two series almost, if not entirely, disappeared; and the vast accumulation of sandstones marks an epoch and an area in one sense apparently lifeless; for we have only two or three species, and these land and freshwater, and found only in the upper part of the Old Red.

The structure of North Devon does not aid us in one desired point, there not being, as in the typical district, a recognizable base to the Lower Devonian slates of Lynton,—the Silurian, if there, being deeply seated and beneath the Foreland sandstones. We cannot, however, have any doubt, or hesitate to come to the conclusion, that the red, grey, and variegated sandstones and grits that constitute the structure of the country from the Foreland to Porlock, Minehead and Dunster, and the western side of the Quantocks belong in *time* to this lower part of the Old Red Sandstone; neither can we fail to clearly determine that south and south-west of Lynmouth, after passing the anticlinal, an entirely new marine fauna sets in, accompanied by an equally new set of physical conditions, the species comprising the fauna in this North Devon area having but one form in common with all the Silurian species, viz. *Atrypa reticularis*. We are therefore, I believe, from our knowledge of the structure of the country, justified in assuming that along its now northern borders, washed by the waters of the Bristol Channel, and somewhere south of the Mendip Hills, an axis of movement or a barrier of some kind existed, stretching under what are now the secondary rocks of Somerset, Dorset, Hampshire, Sussex, and Kent, on to the French, Belgian, and Rhenish areas, over which we have one and the same kind of physical conditions, one and the same fauna, one and the same recognizable and adapted general succession.

The accompanying Table of equivalent strata in different areas has been drawn up with the view of endeavouring to coordinate the groups one to the other, taking their physical structure, and the distribution of the fossils of North and South Devon as the types of the Devonian system, adapting the European and Irish series to them as the type. It is still a matter of great doubt as to whether the true Old Red Sandstone series of England, Wales, and Scotland can in any way be really coordinated with the marine Devonian of Devonshire. All that can be said is, that they both occupy a place above the Silurian and below the Carboniferous, and that they are not found together in any area. The barren Foreland sandstones at the base of the Lynton slates I have, as before stated, placed as Lower Devonian sandstone. The red grits and sandstones which succeed these (the Hangman grits), and on which repose the Combe-Martin and Ilfracombe slates, I have placed at the base of, and classified with, the Middle Devonian series as Middle Devonian sandstone, and the equally well-defined and (to these) conformable red sandstones of Pickwell Down I have placed at the base of the Upper Devonian strata as Upper Devonian sandstone, which is the whole of the Old Red Sandstone of Prof. Jukes*. The groupings of the Rhenish Prussian, Belgian, and French series are correlated with our Devonshire beds, the whole of which I believe belong to and were deposited in and over one general area, and contemporaneously.

* Neither of these three Sandstones contains any organic remains, except the uppermost beds of the Hangman Grits near Combe Martin, in which occur *Myalina* and *Natica*, &c., as before stated.

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Table XII.—*Showing the Groupings of the Palæozoic Rocks of North Devon, and their equivalents in South Devon, Cornwall, South Wales, Scotland, South Ireland, and the three European areas.*

	North Devon.	South Devon.	Cornwall.	South Wales.	Scotland.	South Ireland.	Rhenish Prussia.	Belgium.	France.
Carboniferous Series.	Barnstaple beds (part). Carboniferous series of Sedgwick and Murchison.	Carboniferous beds.	Carboniferous series, Boscastle &c.	Carboniferous, Tenby &c.	Carboniferous series.	Carboniferous limestones, Carboniferous slates.	. . . .	. . . .	. . . .
Upper Devonian, or Upper Old Red Sandstone.	Pilton, Braunton, Croyde, Marwood, Sloly, and Baggy beds, with the Pickwell-Down Sandstones at the base (Morte-Bay series).	No representative?*	Petherwin limestones and slates, Tintagel and De la Bole slates.	Pembroke [illegible] section, in part, Yellow sandstones, Serpula-beds, and [illegible] Upper Old Red Sandstone.	Yellow and Red Sandstones, Dura-Den beds, *Holoptychius* &c., Lammermuir Hills, Fifeshire sandstones.	Coomhola grits, yellow sandstones, &c., Upper Old Red Sandstone of the Cork area, with plant-remains, *Anodon*, and Fish &c.	Verneuilii-Schiefer, Clymenia-Kalk and Goniatite limestones and shales (Buch), Cypridina-Schiefer (Sandberger), Kramenzelstein (Dunker).	Syst. Condrusien (Dumont) inférieur.	Psammites de Condros, Slates of Famienne, Boulonnais beds.
Central or Middle Devonian. Middle Old Red Sandstone.	Mortehoe, Woolacombe, Rockham, and Lee Slates. Ilfracombe and Combe-Martin Slates, Grits, Sandstones, and Limestones. The Hangman Grits at the base.	Dartmouth slates, Dartington, Ogwell, Torquay, Newton, and Plymouth Limestones, Lummaton and Ramsleigh &c.	Padstow, Looe grits (=Hangman beds), Polperro.	Old Red Sandstone (in part).	Caithness flagstones &c., Elgin and Findhorn Rivers with *Asterolepis*, *Cheirolepis*, *Dipterus*, *Osteolepis*, *Coccosteus*, *Pterichthys*, &c.	The great mass of unfossiliferous grits and sandstone of Dingle. Dingle beds (Kerry), base not seen.	Eifel limestone (Römer), Agger- and Lenne-Schiefer (Dunker)=Calceola-Schiefer, Rhenish Gramovelle (Römer).	Système Eifélien.	Givet limestone, Calceola-slates.
Lower Devonian, or Lower Old Red Sandstone.	Heddon's-Mouth, Woodabay, Lee, Valley-of-Rocks, Watersmeet, Lynton, and Lynmouth Slates, &c. The Red Grits and Sandstones of the Foreland, Countesbury, Glenthorn, &c. &c., at the base.	Meadsfoot slates with *Phyllolepis concentricus*, Yealmpton-Creek and Black-Hill &c. &c. slates, Looe Island.	St.-Veep, Polruan, Polperro, and Fowey grits and slates.	Lower part of Cornstones &c., Old Red Sandstone.	Forfarshire flagstones &c. (Ross and N.E. Highlands), *Onchus*, *Cephalaspis*, *Pteraspis*, &c.	Glengariff grits, Killarney, Dingle, no fossils.	Ardennes-Schiefer, Coblentz-Schiefer, Wissenbach slates, Spirifer-Sandstein (Sandb.), Aeltere Rheinische Grauwacke (Rœmer), Système Coblentzien et Syst. Ahrien (Dumont).	Syst. Ahrien, Syst. Coblentzien.	Système Rhénan.

* Beds of Upper Devonian age probably occur near Newton Bushel.

ł their e-*Showing the Groupings of the Palæozoic Rocks of North Devon, an*

ʼH WAI	SOUTH DEVON.	CORNWALL.	SOUT
›us, Ten	'arboniferous beds.	Carboniferous series, Boscastle &c.	Carbonifer
section, ndstones Upper ə.	ʼo representative ?*	Petherwin limestones and slates, Tintagel and De la Bole slates.	Pembroke Yellow sa beds, and Sandston
ındstone	)artmouth slates, Dartington, Ogwell, Torquay, Newton, and Plymouth Limestones, Lummaton and Ramsleigh &c.	Padstow, Looe grits (=Hangman beds), Polperro.	Old Red Sa
rt of Red Sa	ʼleadsfoot slates with *Phyllolepis concentricus*, Yealmpton-Creek and Black-Hill &c. &c. slates, Looe Island.	St.-Veep, Polruan, Polperro, and Fowey grits and slates.	Lower pa &c., Old

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PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the Names of the Authors in capital letters.

EXPLANATION OF THE PLATES.

ERRATA ET CORRIGENDA.

Page xxxi, line 6, *after* seventh volume *insert* of our Transactions.
,, 8, line 20, *for* 7000 *read* 700.
,, 9, last line but two, *for* palpable *read* probable.
,, 19, line 32, for *seriale* read *serialis.*
,, 25, line 13, *for* 40 *read* 41.
,, 40, line 9, *for* I *read* he.
,, 109, line 20, *before* river-deposits *insert* Tertiary.
,, 115, to title of map facing this page *add* Quart. Journ. Geol. Soc. vol. xxiii.pl. iv.
,, 139, line 1, *for* Admiralty Registrar *read* of the Admiralty Registry.
,, 143, line 10, after *Dictyopteris* add and *Iridinæ.*
,, 149, last line *add* T. R. J.
,, 154, line 23, for *Africana* read *pustulifera.*
,, 170, *as note to* Prince Alfred's Rest *insert* about four miles from the Sunday's River Mouth.
,, 170, Acanthopholis, *dele* *? from the last column *and insert* *† in the second column of localities.
,, 171, last line of text, *add* T. R. J.
,, 174, after the last line, *add* 9. *Cidaris pustulifera.*
,, 226, last line, add the last line of 228.
,, 228, *dele* the last line.
,, 240, last line, the fossil referred to as possibly a *Hippurite* has been determined by Mr. Etheridge to be a new species of *Cœloptychium,* Goldfuss.
,, 265, title of paper, *for* of the Tertiary *read* of the Chalk and Tertiary.
,, 473, line 6 from bottom, and elsewhere *for* rotula *read* rotulata.
,, 484, line 16, *add* (Fig. 3).
,, 521, line 9 from bottom, *for* No. 3 *read* (*b*).
,, 527, line 26, *for* facts *read* considerations.
,, 544, line 18, *for* Amberleya alpinus *read* Amberleya alpina.
,, 558, line 15, for *fasciæ* read *fascia.*
,, 571, line 23, *dele* †; and line 24, *for* ‡ *read* †.
,, 571, note † *add* Brit. Assoc. Rep. for 1837, Trans, Sections, p. 94.
,, 571, note ‡, this note is a continuation of note †.
,, 572, line 12 from bottom, *insert* as note to *Austen,* Proc. Geol. Soc. vol. iii. p. 123. See also Geol. Trans. 2nd series, vol. vi. p. 433.
,, 576, line 20, *after* Harz *insert* (Quart. Journ. Geol. Soc. vol. xi. p. 399).
,, 576, line 13 from bottom, *after* England *insert* (Quart. Journ. Geol. Soc. vol. xii. p. 38).
,, 578, notes * and §, add Journ. Royal Geol. Soc. Ireland, vol. i. p. 103.
,, 580, explanation of map, *for* Croydon Beds *read* Croyde Beds.
,, 590, line 2, *for* erous *read* numerous.
,, 681, footnote, *dele* p. 578.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

Note on the EXPLORATIONS *made in the* CAVERNS *of* FURFOOZ, *in the* PROVINCE *of* NAMUR. By M. E. DUPONT.

[Notice sur les fouilles scientifiques exécutées dans les cavernes de Furfooz (province de Namur), par M. Edouard Dupont. Bulletin de l'Académie Royale de Belgique, 2e série, tome xx. p. 244.]

M. DUPONT, who, in conjunction with M. Van Beneden, was entrusted with the examination of the caverns in the province of Namur, laid before the Academy in this communication the result of his explorations of seven caverns at Furfooz, in that province, named respectively Trou des Nutons, Trou du Frontal, Trou Rosette, Trou de la Gatte (chèvre) d'Or, Trou qui igne (Trou fumant), Trou Reuviau, and Trou Saint-Barthélemi.

A general section of the deposits which fill these caves presents the following beds, in descending order :—

1. Reconstructed (*remaniées*) beds, containing different objects dating from the Historic period.
2. Yellow clay, containing numerous angular fragments of limestone. From this bed portions of human skeletons, bones of the Reindeer, Glutton, Elk, Bear, Chamois, Wild Goat, Beaver, &c., have been obtained. Remains of human industry, consisting of flint knives, worked bones, fragments of a coarse pottery, and traces of hearths were also discovered.
3. Beds of stalagmite.
4. A stratified sandy argillaceous deposit without either subangular blocks or bones, often containing concretions of limestone or marlstone.
5. Beds of rolled pebbles, coming from the Ardennes. These have only furnished one tooth of *Ursus spelæus* and some remains of the Horse.
6. Glauconitic gravel with traces of peaty matter, bones of Beaver and other animals, but without any indications of the existence of man.

The most important bed, however, is the clay with angular blocks, containing human and animal bones, as well as the remains of a rude industry, in great abundance. These bones and instruments carry us back to a very remote period. The inhabitants of the cave were the contemporaries of several species of animals which now only inhabit, some the extreme north, others the summits of the Alps and the Pyrenees; while their industry indicates a state of civilization less advanced than that of the celebrated establishments of the stone-age in Denmark and Switzerland. This civilization, M. Dupont considers, may be compared to that which M. Lartet and Mr. Christy observed in the south of France, and the remains of which were mingled with a fauna equally comparable to that of Furfooz.

In the caverns of the environs of Dinant, the same bed, consistent in all its characters, may be observed; and its stratigraphical analogies with the beds which the French geologists call the *diluvium rouge* of the Paris basin lead the author to suppose that at some future time it will be possible to correlate these two deposits. [A. S.]

The CAVERNS *of the* BANKS *of the* LESSE *and the* MEUSE, *explored up to* OCTOBER, 1865. By M. E. DUPONT.

[Étude sur les cavernes des bords de la Lesse et de la Meuse, explorées jusqu'au mois d'Octobre, 1865; par M. Edouard Dupont. Bulletin de l'Académie Royale de Belgique, 2e sér. tome xx. p. 824.]

A FURTHER exploration of the escarpments of the River Lesse by the author led to the discovery of other caverns in the neighbourhood of Dinant, which he describes in this communication.

Amongst these, the cavern of Chaleux (*Trou de Chaleux*), about 55 feet above the river-level, has yielded some important evidence. An excavation made in the middle of the cavern showed that immediately above the limestone floor was a deposit of alternating sands and clays (9 and 10), overlain by a bed of gravel (8), this last being beneath a bed of sandy clay (7) containing angular fragments of limestone, remains of *Ursus spelæus*, and the argillaceo-calcareous nodules which characterize an analogous deposit in the Paris basin. The little bed of gravel marks an important horizon; for it is the characteristic of the argillaceo-sandy level of the caverns and the Quaternary formation; and being formed of small fragments of sandstone and rolled psammite, it affords incontestable proof of the action of "external waters" in the stratification of the deposit. Moreover two flint knives were obtained from it; and as the superposed bed contains the remains of *Ursus spelæus*, the discovery considerably increases the known antiquity of Man upon the banks of the Lesse.

Nearer the entrance of the cave, and extending some distance down the escarpment of the river, occurs a continuous bed (6) of fragments of the Carboniferous Limestone in which the cavern is situated. Above this, on the outside slope, and extending above the sandy argillaceous deposit of the interior, is a bed (5) composed of sand, dust, and ashes, and showing numerous traces of the coexistence of man with the Reindeer. Bones of animals which have served as food for man, human bones, and worked bones are abundant. More than 30,000 flints—knives, chips, blocks, and cores—were discovered in this thin bed of 12 inches, besides ashes and numerous fragments of sandstone, schist, &c. This bed is overlain by a mass of calcareous blocks (4) like those of the previous bed (6), this again being capped by the ordinary yellow clay (3), which contained, besides some bones and teeth of the horse, about 50 flint knives. This yellow clay assumes a reddish tint (2) at the entrance, where it is surmounted by a sandy clay (1) analogous to Loess.

From the sandy bed (No. 5) M. Van Beneden has determined 11 species of mammifers—namely, the Reindeer, Goat, Ox, Horse, Lion, Brown Bear, Fox, Badger, Polecat, Hare, and Water-rat. Most of these animals have evidently served as food for the inhabitants of the caverns, all of the bones being completely broken. The Horse seems to have afforded the principal food; for no less than 937 molar teeth have been obtained from this one cave. Bones of the *Arvicola amphibia* are also very abundant; and as they are found principally near the hearths, they too may possibly have formed part of the repasts. Many of the bones bear distinct traces of incisions made with flint instruments. The presence in this bed of the bones of Man the author considers difficult of explanation; but as they are usually found entire, and do not occur mingled with the other bones near the remains of the fire-places, he considers it difficult to see in them the proof of cannibalism on the part of the ancient population. Some of the implements are made of phthanite obtained from a bed in the limestone of the country. All the rest are of external origin; and the author inclines to the opinion that they were introduced from Champagne—a conclusion at which M. Nyst had independently arrived from an examination of the shells.

These last consist of 54 Tertiary marine shells, which M. Nyst has examined. 25 of them are perforated near the mouth, but M. Dupont hesitates to say whether by friction or by some sharp instrument. During last summer, among the ashes of an ancient hearth, the workmen discovered the forearm of an elephant. The author, however, considers that the inhabitants found it in a fossil state, and that, either for the purpose of worship, or as an object of curiosity, they carried it into the cavern.

Besides these, a quantity of different objects, such as part of a great Ammonite, pieces of elephants' teeth, three teeth of a whale, a vertebra belonging to a species of the genus *Carcharias*, besides the 54 Eocene shells, &c., have been procured.

The author then, after a recapitulation of the beds and the principal objects of interest in the cavern, describes in detail two other caverns on the same escarpment, the Trou des Nutons, and Trou de Frontal.

This last, M. Dupont describes as a cavern of great importance. The floor is covered with a coarse stratified greenish sand, containing traces of peaty matter, and bones of the Beaver. This deposit passes into a thick deposit of rolled pebbles of Ardennais origin, from which were obtained a tooth of *Ursus spelæus*, and teeth of the Horse. This bed is again overlain by a little bed of grey sand, which is beneath a stratified sandy argillaceous deposit containing the characteristic calcareous nodules. Above this is a greyish-yellow sand, considered by the author to be the Loess, this being surmounted by loose stones. All the bones, with the exception of those already mentioned, were obtained from the yellow clay with angular fragments of limestone. The bones belonging to 13 skeletons were found entire, together with a quantity of flint knives, some Eocene shells pierced in such a manner as to make them capable of being suspended as ornaments, and an urn of a coarse description of hand-made pottery. Remains of the Brown Bear, Reindeer, Chamois, Beaver, Horse, &c. were discovered; and as they are fractured, and some of them burnt, they probably formed part of a human repast.

M. Dupont finally comes to the conclusion that this cavern has served for the sepulture of men who inhabited the country after the deposition of the stratified sandy clay, and before the deposition of the yellow clay with angular fragments of limestone, and the deposition of the Loess; and he claims for this cavern the interpretation suggested by M. Lartet for the celebrated burying-place at Aurignac—that the inhabitants had made there their funeral repasts, just in the same manner as many savage nations do at the present day.

In conclusion, the author gives some details of other caverns in the escarpment of Furfooz, noticing especially the Trou Magrite, and the Grotte de Montfat. [A. S.]

Geological Map *of the* Seine. By M. Delesse.

[Carte géologique souterraine du Département de la Seine. 4 feuilles. Echelle 1: 25,000: Savy, Paris.]

The system followed by M. Delesse in this map is the same as in that of the town of Paris. The strata are indicated by colours, as in ordinary geological maps, the Drift-deposits being omitted. If the strata which compose the subsoils were removed one after another, commencing with the most modern, there would be successively exhibited as much of the surface as corresponds in extent to each of them. The outcrops coloured on the map show the different periods of the formation of the subsoils of the environs of Paris; and their surface-contour and position above the level of the sea have been represented by means of horizontal curves.

In this manner are indicated the upper surface of the chalk, of the plastic clay, of the white marls overlying the "calcaire grossier," of the travertin of St. Ouen, of the green clays, of the Fontainebleau sands, and, finally, the lower surface of the Drift-deposits.

It is therefore easy to determine, by the aid of this map, what stata will be met with in sinking at any point in the environs of Paris; for the colours indicate in succession the beds met with immediately below the Drift. Moreover, when the place in question lies between two horizontal curves describing the surface-contour of the different strata, it is easy to calculate, by proportion, the distance at which each of them would be reached below the surface. [A. D.]

On Secondary Fossils *from* Eisenerz. By D. Stur.

[Proceed. Imp. Geol. Inst. Vienna, November 1866.]

A pyritized specimen of *Ammonites floridus*, Wulf., from 2 to 3 inches in diameter, an upper Triassic form, well known to occur in the shell-marble of Bleiberg and in the horizon of *Halobia Haueri* in several Alpine localities, has been lately found in a matrix of nearly black, opaque marl far beneath the horizon of the "Sauberger" Limestone, in which pygidia of *Bronteus* have been repeatedly found. The geological structure of the environs of Eisenerz, together with fragments of yellow molybdate of lead (quite identical with those of Bleiberg in Carinthia) lately found there by miners, leads to the supposition that the Ammonite in question, as also these lead-ores, have been accidentally transported from Bleiberg to Eisenerz.

[Count M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Extension *of the* "Calcaire grossier de Mons" *into the* Valley *of the* Haine. By Messrs. F.-L. Cornet and A. Briart.

[Notice sur l'extension du Calcaire grossier de Mons dans la vallée de la Haine; par MM. F.-L. Cornet et A. Briart. Bull. de l'Acad. royale de Belgique, 2me série, t. xxii.]

Since the publication of their former paper on the "calcaire grossier de Mons" the authors have continued their researches, and the interest which that communication evoked has induced them, in this notice, to lay before the Academy the results of some further explorations. In 1865 about 150 species had been obtained from the rubbish of the Goffint well; now more than 300 Gasteropods and Lamellibranchs, 10 Bryozoa, 4 Echinoderms, 7 Corals, and about 25 Entomostraca and Foraminifera have been collected by the authors, and are waiting for detailed descriptions.

About 400 yards to the east of the Goffint well, along the road from Mons to Obourg, a well was sunk in 1865 by M. D. Coppée. After passing though a thin bed of Quaternary grey sand, which here, as everywhere in the environs, overlies the Tertiary and Cretaceous formations, the lower Landénien green sands were reached. At a depth of 11½ feet these sands were found to lie in a depression of the "calcaire grossier," the junction being marked by irregular masses of flint and limonite. These depressions at the base of the Landénien are very common throughout the province and the neighbouring cantons, from which the authors infer that the "Calcaire grossier de Mons" was deposited prior to the great period of denudation which has been thought to have occurred between the end of the Cretaceous period and the deposition of the Tertiary strata. The Coppée well has been sunk 78 feet in the "calcaire grossier." The mineralogical characters of the specimens obtained from it are very similar to those of the rocks from the Goffint sinkings, and the fossils, which are not abundant, are all, except the Bryozoa and Foraminifera, in the state of casts.

In the previous paper, a section was noticed near the cemetery of Mons, the fossils of which were in the collection of M. Toilliez. The "calcaire grossier," which was met with 50 feet from the surface, and extended to a depth of 225 feet, contained fossils referred to the following genera:—*Melanopsis*, *Cerithium*, *Eulima*, *Bithynia*, *Rissoa*, *Nematura?*, *Turbo*, *Delphinula*, *Turritella*, *Arca*, *Cardita*, and *Pectunculus*. Below the "calcaire grossier," 72 feet of hard limestone, containing numerous blocks of flints, were traversed.

Specimens of *Haplophragmium grande*, d'Orb., *Ataxophragmium obesum*, Reuss, and *Cristellaria rotulata*, have been found, besides other undetermined Foraminifera which are usually obtained from the upper and white chalk of the province. Numerous fragments of a shell have also been discovered, which appear to belong to an *Inoceramus* (*Catillus Cuvieri*, d'Orb.), which ranges from the upper grey chalk of the *Nervien* to the *Maestrichtien* system. With these Cretaceous species others are found, identical with those from the Goffint well; but the authors are of opinion that these belong to a superior formation, having accidentally been brought up by the boring-apparatus. Below this a soft white chalk of subgranular texture was met with, containing flint identical with that from the yellow limestone, and with the same abundance of Foraminifera and *Catillus*. The yellow limestone, with flints of the Lebréton (Toilliez) sinking, cannot be correlated with any *bed* of the province, although in some places a *zone* of very hard compact white chalk exists immediately below the Maestrichtien system; and the authors are of opinion that this yellow limestone corresponds to a part of the upper white chalk of Spiennes, and that its yellow tint and hardness are due to some mineralogical peculiarity. The "calcaire grossier" of this section thus rests upon the white chalk without the intervening Maestrichtien system.

The authors then describe other sections to the south-west of Mons, in all of which the "calcaire grossier" was found, noticing especially the section presented by an artesian well sunk at Marais, in the commune of Cuesmes. Here, after passing through 88 feet of glauconitic sand, a yellow limestone (*calcaire grossier*) was reached, containing the new *Trochocyathus* so abundant in the Goffint well. This limestone overlies the Upper Chalk of Ciply, from which Bryozoa, *Fissurirostra Palissi*, Woodward, and *Thecidea papillata*, Bronn, have been collected.

A very important section in regard to the extension of this "calcaire grossier" is then described by the authors. It is exposed in a railway-cutting to the west of Boussu, on the road to Hainin. Below some sands, with limonite, a friable yellowish limestone is exposed, from which *Corbis*, *Lucina*, *Arca*, *Trochocyathus*, n. sp., and another coral, besides many of the Foraminifera and Entomostraca characteristic of the Goffint well were obtained. With these species, which belong to the "calcaire grossier de Mons," the authors discovered a *Cidaris*, and another undetermined Echinoderm, the cardinal region of *Terebratula carnea*, Sow., and a *Thecidea papillata*, Bronn. The admixture of the last two species, which are Cretaceous, with the rest, is suggested to be due to the denudation of the anterior beds by the waters of the sea in which the "calcaire grossier" was deposited. In the present state of our knowledge of the valley of the Haine, the authors hesitate to say whether the mass of "calcaire grossier" of Mons has any relation to that of Hainin, although the results furnished by the different sinkings executed to the north and south of the canal incline them to think that the connexion does not exist. The conclusion which has been arrived at from a consideration of the sections which have been described is, that not only does this new Tertiary stage fill up a depression of the calcareous formation in the environs of Mons, but that it extends more to the west in the valleys of the Haine and Trouille, below the Landénien sands and ancient alluvium which occupy a large portion of those valleys. [A. S.]

On the Fossil Flora *of* Eubœa. By Prof. Unger.

[Proceed. Imp. Geol. Inst. Vienna, July 1866.]

The richest locality of fossil plants in this island is Kumi, where 56 species, for the most part new, were collected in 1860 in a few days. Since then several thousand specimens have been obtained from the same locality, and the number of species has increased to 114. The deposits in which they occur, like those of Pikermi, in Attica, well known for the abundance and variety of mammalian remains yielded by them, belong to the upper portion of the Middle Tertiary series. The vegetable remains from the Marls of Kumi may be supposed to have belonged to species which grew on the Ægean continent (now the Ægean Sea), at the time when the mammals of Pikermi lived on its surface. The greater number of the 51 mammalian species hitherto stated to be represented among the fossil fauna of Pikermi are Carnivora, Ruminants, and Pachyderms. The living species coming next to them, as the spotted Hyæna, the two-horned Rhinoceros, the Zebra, the Giraffes, and many Antelopes, are peculiar to the African fauna, so that the later Middle Tertiary mammalian fauna of Greece must have been impressed with a decidedly South African character. Among the 114 vegetable species of Kumi, 47 (above 40 per cent.) are most nearly allied to forms now living in South Africa and in the Cape region. The genera *Euclea*, *Royena*, *Rhynchosia*, *Omphalobium*, the *Myriceæ*, and the *Proteaceæ*, represented in the flora of Kumi, strikingly remind one of the present Table-land and Port-Natal flora.

[Count M.]

On Fossil Insects. By Dr. Mayr.

[Proceed. Imp. Geol. Inst. Vienna, February 19, 1867.]

The author has examined the collection of *Formicina* from the Tertiary Shales of Radoboj, Croatia, in the Museum of the Imperial Geological Institute, which had been named according to Prof. Heer's determinations. This examination has proved *Formica obesa Radobojana*, Heer, to be the male, and *Myrmica pusilla*, Heer, to be the female of a species of *Œcophylla*, a genus spread over the whole tropical zone in the Old World and in Australia. The *Poneræ*, Heer, are partly *Formicidæ*, and partly *Myrmicidæ*. Three new species, *Liometopum antiquum*, *Hypoclinea Haueri*, and *Lonchomyrmex* (a new genus) *Freyeri*, have been made known by Dr. Mayr.

[Count M.]

On the TERTIARY FLORA *of* BILIN, NORTH BOHEMIA. By Prof. C. VON ETTINGSHAUSEN.

[Proceed. Imp. Geol. Inst. Vienna, February 5, 1867.]

PROF. C. VON ETTINGSHAUSEN has published, in the Transactions of the Imperial Academy of Vienna (vol. xxvi.), the first part of his description of this flora, comprising the Thallophytes, the Cryptogams, Monocotyledons, Coniferæ, and Julifloræ, illustrated by thirty plates. The flora of Bilin is contained in four deposits, namely, (1) polishing shales of Kutschlin; (2) freshwater limestones of Kostenblatt; (3) menilites and opals of the Schichow valley; and (4) plastic clays, bituminous shales, and sphærosiderites. Taken as a whole, the Tertiary flora of Bilin is richer in species and more varied in character than any other known local flora in the Austrian empire. The species described in this first part are distributed thus:—*Ulvaceæ* 1, *Florideæ* 2, *Characeæ* 1, *Hyphomycetæ* 2, *Pyrenomycæ* 18, *Equisetaceæ* 1, *Polypodiaceæ* 7, *Salviniaceæ* 3, *Gramineæ* 17, *Cyperaceæ* 2, *Butomeæ* 4, *Juncaceæ* 1, *Smilaceæ* 1, *Muscaceæ* 1, *Naiјadeæ* 3, *Typhaceæ* 3, Palms 2, *Cupressineæ* 7, *Abietineæ* 4, *Taxineæ* 1, *Casuarineæ* 2, *Myricaceæ* 3, *Betulaceæ* 8, *Cupuliferæ* 23, *Ulmaceæ* 7, *Moreæ* 25, *Artocarpeæ* 5, *Plataneæ* 1, *Balsamifloræ* 1, *Salicineæ* 5, *Polygoneæ* 2, *Nyctagineæ* 1.

[COUNT M.]

On the CRETACEOUS FLORA *of* NIEDERSCHÖNA, SAXONY. By Prof. C. VON ETTINGSHAUSEN.

Proceed. Imp. Geol. Inst. Vienna, January 17, 1867.]

THIS flora is remarkable in its offering remains of the most ancient Dicotyledonous plants hitherto known. The plants are terrestrial and of an unmixed tropical character, numbering forty-two species, distributed as follows:—Ferns 4, Gymnosperms 5, Monocotyledons 2, Apetals 16, Gamopetals 1, Dialypetals 11. The Gymnosperms and Apetals are numerically to the Dicotyledons of higher organization as 2 to 1. The same proportion exists between the extinct genera and those of the recent period. Thirteen species of the flora of Niederschöna are met with in other deposits, and among them are characteristic species of the Cretaceous period. One species occurs likewise in the Wealden, and another in Tertiary strata. The prevalence of *Proteaceæ* and *Leguminosæ* connect this flora on the one hand with that of New Holland, and on the other with that of the older Tertiary period, It differs from both in containing so large a number of Gymnosperms and Ferns, connecting it with Secondary floras of a more remote date. Very few analogous forms are known as existing species, but a larger number are found fossil in Tertiary deposits.

[COUNT M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

The SILURIAN CEPHALOPODA *of* BOHEMIA. By M. J. BARRANDE.

[Système Silurien du centre de la Bohême. Par Joachim Barrande. 1re Partie: Recherches Paléontologiques, vol. ii. Classe des Mollusques. Ordre des Céphalopodes. Texte: 4to, 1867, pp. 712. Planches: 1re série, nos. 1 à 107, 1865; 2e série, nos. 108 à 244, 1866.]

THIS Monograph of the Silurian Cephalopoda of Bohemia is divided by M. Barrande into two parts, of which the first only has been published. This consists of a description of 16 genera or principal subgenera, which are represented in the Bohemian basin by 447 forms. These are classified by the author according to the following Table, those which are marked with an asterisk not being found in Bohemia:—

Fam. GONIATIDÆ.

Goniatites, De Haan. | *Bactrites*, Sandberger.

Fam. NAUTILIDÆ.

FIRST SERIES. Simple Aperture.	SECOND SERIES. Compound Aperture.	HETEROGENEOUS FORMS. Simple Aperture.
Trochoceras, Barr. & Hall.		
Nautilus, Breyn.	*Hercoceras*, Barr.	*Nothoceras*, Barr.
Gyroceras, Kon.		
* *Lituunculus*, Barr.	*Lituites*, Breyn.	
* Subg. *Discoceras*, Barr.	Subg. *Ophidioceras*, Barr.	
Cyrtoceras, Goldf.	*Phragmoceras*, Brod.	
(*Orthoceras*, Breyn.)	*Gomphoceras*, Sow.	*Bathmoceras*, Barr.
Ascoceras, Barr.	*Glossoceras*, Barr.	
Aphragmites, Barr.		

In the second part will be described the forms which belong to the genus *Orthoceras*, and the other straight shells which may be associated with that type either as subgenera or as constituting independent genera, namely:—*Gonioceras*, Hall; *Endoceras*, Hall; and *Tretoceras*, Salter. M. Barrande first defines the limits by which he has circumscribed the generic types, and applied specific names to the forms: he then remarks upon their vertical and horizontal distribution in the two great Palæozoic zones, northern and central, and ends by pointing out fluctuations which time has shown in some of the results obtained by Palæontology.

Most of the genera which are not included in the author's classification are considered to have been founded upon incomplete observations upon the form and natural development of the characters which constitute the shell of the Palæozoic Cephalopods. For instance, the position of the siphon, sometimes in the centre, sometimes near one of the sides, and sometimes upon an intermediate point of the ventro-dorsal diameter has been regarded by scientific men as a differential character of high importance ; and upon that consideration alone not only different types but even supposed distinct families have been founded. The author, on the contrary, from an examination of the family of Nautilidæ (*Phragmoceras*, *Gomphoceras*, *Ophidioceras*, and *Lituites*), asserts that the various forms of these different types prove that the siphon does not possess that fixity of position which has been supposed, either in species of the same genus or, indeed, in individuals of different ages in the same species. For in those types in which the position of the gastric region of the mollusk is evident the ventral side and the siphon are more or less independent of each other, and their distance may attain not only the half but even three-quarters of the ventro-dorsal diameter of the shell. On applying this principle, several generic denominations introduced into science must disappear. Among them M. Barrande cites the following:—*Sycoceras*, Pictet, *Cryptoceras*, D'Orb., *Nautiloceras*, D'Orb., *Aploceras*, D'Orb., *Melia*, Fischer, and *Cameroceras*, Conrad.

The study of the genera *Phragmoceras* and *Gomphoceras* has produced another important fact relative to the significance of the curvature of the shells in their medial plane :—

In *Phragmoceras* the majority of the species are curved in such a manner as to present the excurrent tube, or the ventral side of the mollusk, upon the concave side of the shell. Other species, on the contrary, agreeing with the former in their generic characters, have the ventral side, or excurrent tube, upon the convex side.

By contrast, in *Gomphoceras* the greatest number of species show the ventral side of the mollusk corresponding to the relatively convex side, while in some the tube is found to the right of the concave side. Thus in *Phragmoceras* the endogastric species predominate and the exogastric species are rare, while in *Gomphoceras* the contrary is the case. This consideration has led the author to think that the same phenomena will manifest itself in other genera, and has induced him to subdivide each genus into two parallel series, according to the endogastric or exogastric curve of the species. The inevitable result of this conclusion is that generic names which have been founded upon this distinction will disappear, such as the type *Cyrtocerina*, recently established by Mr. Billings.

The form of the transverse section in the Nautilidæ furnishes one of the most apparent characters of the shell. This form, however, is not invariable in each genus, neither is it possible to take each variation as the fundamental basis of a particular generic type. In certain species the modification simply indicates the age of the individuals; for in *Cyrtoceras* the transverse section is circular in the young specimen, while it becomes elliptical or oval or subtriangular in adult age. Genera, therefore, such as *Campyloceras*, M'Coy, *Trigonoceras*, M'Coy (*Orthocera paradoxicum*, Sowerby), *Temnocheilus*, M'Coy, and *Trematodiscus* (subgenus), which have been founded on differences of the form of the transverse section, are merged in their proper places among the old-established genera.

The aperture of the shell of the Nautilidæ is sometimes simple, or like the transverse section, and sometimes complex, or contracted into two orifices. This difference seems to furnish a character as easy as it is certain for the distinction of the genera of this family. The genera which correspond in the two series of the Table (p. 9) are alike in every other respect, and are only separated by the contrasting form of their aperture. The contrast seems to the author to indicate a different conformation of the important organs which surround the head of the Cephalopod, and even of the head itself, which appears to have been sometimes free and sometimes imprisoned in the shell. In consequence of these conclusions the author has combined with the genus *Cyrtoceras* the forms named *Oncoceras* and the genus *Streptoceras* of Mr. Billings.

The singular appearances produced in the siphon of certain Nautilidæ, and especially in the siphon of *Orthoceras*, by organic deposit, has led to the formation of several genera, such as *Actinoceras*, *Ormoceras*, *Huronia*, *Endoceras*, &c. All these appearances can be traced to the normal and habitual forms of the elements of the siphon; consequently these generic denominations have been carried by the author to the synonomy of the genus *Orthoceras*.

The type *Trochoceras* is extended to contain those Nautilidæ the shell of which presents a double curve. Among the extreme forms some are bent in contiguous volutions, and are strongly turreted. Others, on the contrary, are simply bent, like *Cyrtoceras*, without completing a turn of the spire, and their second coil (*i. e.* their curve in helix) is not manifest, except by a defect of symmetry. Thus the genus *Trochoceras* represents among the Nautilidæ three types, distinguished by three names among the Ammonitidæ, namely:—

Turrilites, Lam., with contiguous volutions.
Heteroceras, D'Orb., with contiguous volutions, except the last, which is extended in a straight line.
Helicoceras, D'Orb., with separate volutions.

This extension of the genus *Trochoceras* may appear carried too far, if it is compared with that of the genera with a single coil, among which are maintained:—

Cyrtoceras, a type simply bent, with less than a turn of the spire.
Gyroceras, a type coiled, with disjointed volutions.
Nautilus, a type coiled, with contiguous volutions.

The author admits that, from a purely theoretical point of view, he should have eliminated the type *Gyroceras*, the forms distinguished by that name being joined to those which have been called *Lituites*.

M. Barrande, while treating of the specific denominations which he has adopted for the 850 to 900 new forms of Cephalopods discovered in Bohemia, mentions the great difficulty he has found in determining forms which he should consider specifically independent. In almost all cases specific names have been preferred to the names of varieties, which are always found inconvenient in practice, especially when several exist in the same species.

The general results of the geological and geographical distribution of the Cephalopods can be sketched and more plainly indicated by the particular distribution of each type in proportion to its richness in specific forms. Thus a study of the genus *Cyrtoceras*, of which the author has nearly 460 forms, leads to certain conclusions and considerations which, with but very little modification, could be applied to the whole of the Palæozoic Cephalopods.

One of the most interesting results of these researches is that these mollusks present a very different order of development in the two great Silurian zones of Bohemia—the northern and the central. In the primordial fauna no vestige of this order of mollusks has been discovered. This horizon seems to be the starting-point from which is manifested the difference in the relative level upon which appear successively the different types of Cephalopods, and in the relative epoch of the greatest specific richness of each, as also in the maximum of the total richness of the family of Nautilidæ. The contrast is the more remarkable because the generic types of this family, so unimportant in the number of their species, are represented as well in the northern as in the central zone, and establish between their faunas a connexion not otherwise met with, which appears to indicate their relative contemporaneity.

The author then contrasts the first appearance of the several genera in the three Silurian faunas of the two zones, summing up by observing that in the northern zone the maximum richness is attained in the second fauna, and is followed by a very marked diminution in the third fauna; while, on the contrary, in the central zone the minimum is found in the second fauna, and the maximum is reached in the third fauna in the most pronounced manner. M. Barrande concludes by indorsing the opinion of MM. d'Archiac and de Verneuil, that the genera which have the greatest horizontal diffusion on the globe, and are most often the richest in species, are also those which have the greatest vertical range in the geological series. At the same time this law has some remarkable exceptions.

In a concluding chapter, M. Barrande points out the progress which palæontology has made since the publication of the memoir by MM. d'Archiac and de Verneuil on the fossils of the old deposits of the Rhenish provinces*. By a series of comparisons of the species from the Palæozoic strata, he shows that the entire class of mollusks

* Trans. Geol. Soc. 2nd ser. vol. iv. p. 303.

attained during the Silurian period the maximum of its relative development—so much so that Prof. J. D. Dana has given to that period the name of the "Age of Mollusks."

This comparison of the Palæozoic systems, which regards them as units, does not assist in settling the law of the development of animal forms, because the successive systems, in all probability, represent very unequal lengths of time. M. Barrande considers that for the determination of the true laws of the numerical increase and decrease of animal forms coexisting on the globe, it is indispensable to subdivide the duration of each system into units of equal time, just as each country is subdivided into units of surface for the purpose of comparing the density of their population.

Taking the general fauna as units, the third Silurian fauna presents the appearance of the maximum development of animal forms during Palæozoic times. It is especially the third fauna of Bohemia which contributes to establish this numerical preponderance, by its contingent of no less than 2400 species of that age. Moreover, starting from the third fauna, a marked decrease is observed in the number of species, either in ascending to the upper horizon, or in descending to the lower. In every case, the Permian, or Dyas, fauna presents an incontestable and very pronounced minimum, to which the Devonian and Carboniferous faunas gradually lead. This minimum fauna indicates, by its extreme numerical reduction, the end of the Palæozoic era, although it contains the representatives of nearly all the fundamental types of the animal series. On the other side, immediately below the second fauna, which is distinguished as much by its specific richness as by the appearance of most of the generic types, another minimum is found in the Primordial Silurian fauna. But this minimum is characterized by the extreme predominance of a single class of animals—the Crustacea—which is itself represented almost exclusively by Trilobites. In the midst of these Crustacea appear some rare forerunners of the Mollusca and Radiaria. [A. S.]

On Eocene Fossils *from* Kiew, W. Russia. By T. Fuchs.

[Proc. Imp. Geol. Inst. Vienna, June 4, 1867.]

A series of Eocene fossils from Kiew has lately been transmitted for determination to the Imperial Museum of Vienna by M. C. Theofilaktoff, Professor of Geology at the University of Kiew, together with a map and section. The whole Tertiary deposit rests partly on Cretaceous strata, and parly on Granite ("Steppe-Granite"). Prof. Theofilaktoff remarks of these fossils that they bear a greater resemblance to those of Volhynia than to any occurring in the Lower Tertiaries of Kiew.

The following are the fossils which have been determined from the several divisions of the Kiew Tertiaries:—

1. *Sandstone of Butschak* (Lower Subdivision).

Terebellum sopitum, *Brander* (T. convolutum, *Lam.*). Calcaire grossier, Sables moyens.
Cassidaria nodosa, *Dixon* (C. carinata, *Lam.*). Calc. gross., Sabl. moy.
Cytherea ambigua, *Desh.* Sables infér.
Cardium hybridum, *Desh.* Sables infér.
Lucina Volderiana, *Nyst.* (Belg. Sables de Wawre, Calc. de Gobertange.) Calc. gross.
Cardita sulcata, *Brander* (C. cor-avium, *Lam.*). Sables moy.
Limopsis auritoides, *Galeotti.* (Belg. Jette, Laeken.) Sables moy.
Arca decussata, *Nyst.* (Latdorf, Boom, Baesele, Weinheim, Kreuznach.) Oligocene.
Pinna margaritacea, *Lam.* Calc. gross., Sable moy.
Pecten corneus, *Sow.* (Belg. Laeken, Jette, Forêt, Calc. d'Assche.) Calc. gross. Sabl. moy.

2. *Lower Sandstone of Traktomirow.*

Cassidaria nodosa, *Dixon.* Calc. gross., Sabl. moy.
Pyrula nexilis, *Brander* (non *Lam.*). (Barton, Latdorf, Olig. infér). Sables moyens.
Anatina rugosa, *Bell.* (Nizza.)
Lucina gigantea, *Desh.* Calc. gross.
Pinna margaritacea, *Lam.* Calc. gross., Sabl. moyens.

3. *Lower Blue Clay of Kiew.*

Pinna margaritacea, *Lam.* Calc. gross., Sabl. moyens.
Vulsella deperdita, *Lam.* Calc. gross.
Pecten corneus, *Sow.* (Belg. Laeken, Jette, Forêt). Calc. gross., Sabl. moy., Calc. d'Assche.
Spondylus Buchii, *Phil.* (S. Teissenbergensis, Schfhtl). Latdorf, Kressenberg.
Ostrea flabellula, *Lam.* Calc. gross.
„ gigantea, *Sow.* Calc. gross.

A parallelism of the Kiew Eocene fossils with those of the Paris basin is liable to some difficulties. In the sandstones of Butschak and Traktomirow, we find two forms characteristic of the "Sables inférieurs," associated with others from the "Sables moyens" and the "Calcaire grossier," or their Belgian analogues ("Systêmes Bruxellien and Laekénien"). Such forms are:—*Terebellum sopitum, Cassidaria nodosa, Pyrula nexilis, Lucina Volderiana, L. gigantea, Cardita sulcata, Limopsis auritoides, Pinna margaritacea, Pecten corneus.* The occurrence of Oligocene forms, as *Arca decussata,* and many others whose identification, notwithstanding their striking resemblance, must be left to further investigation of more abundant material, deserves attention. Such forms are:—*Cardium,* sp. (very abundant), resembling *C. catenulatum,* Bronn, from Weinheim and Cassel; *Cardium,* sp. nov., resembling an undescribed species from Cassel; *Voluta,* sp., analogous to *V. Tiemseni,* Boll., from the same locality; and *Fusus,* sp., reminding one of *Fusus brevicauda,* Phil., from Latdorf. The fauna of the Blue Clay of Kiew includes forms of the "Sables moyens" and the "Calcaire grossier" (with the only exception of *Spondylus Buchi,* Phil.), known also to exist at Latdorf and Kressenberg, besides a great diversity of well-preserved Foraminifera. It must be remarked that most of the Eocene species of Kiew are not mentioned in the list of Ukranian Eocene species published in 1836 by M. Dubois.

[COUNT M.]

On the GEOGRAPHICAL *and* GEOLOGICAL DISTRIBUTION *of the* REINDEER, *the* BISON, *and the* AUROCHS. By J. FR. DE BRANDT.

[Proceed. Imp. Geol. Inst. Vienna, June 4, 1867.]

IN a paper communicated to the Imp. Academy of St. Petersburg, M. Brandt gives the results of his investigations on the geographical range of the Reindeer, the Bison (*Bos bison* and *B. bonasus*), and the Aurochs (*Bos primigenius* or *Taurus sylvestris*), and on the distribution of the fossil remains of these animals. There are no well-defined limits between M. Lartêt's palæontologico-chronological periods, severally characterized by the existence of *Ursus spelæus*, the Mammoth, the Reindeer, and the Aurochs. M. Garrigou's three periods are more natural, but do not quite represent the real state of things. According to M. Brandt's views, the Lower, Middle, and perhaps the Upper Tertiary faunas of Central Europe, which are indicative of a warmer climate, were followed by an immigration from Northern Asia, progressing from the north-east to the south-west. At this epoch (and perhaps already during the Tertiary period) Northern Asia was occupied by the same mammalian fauna as at present, with the addition of some few species since extinct (Mammoth, Shaggy Rhinoceros, Aurochs, Bison, Musk-Ox, Gazelle, Argali, Musk-Deer, Capricorn, Reindeer, Stag, Roe, Boar, and perhaps already Tiger and Hyæna); and this fauna may have persisted there through an indefinite, and probably a very long period. The contemporaneity of man with this fauna is not yet proven; but it is, to some extent, probable. The next period commences with the migration from North-eastern Asia into Central, Western, and Southern Europe, caused and favoured by a general depression of temperature, and continues down to the extinction of the Mammoth. The whole of the fauna of this period could not exist so completely in any European region as in its native country; however, the existence of man during this period is no longer doubtful. A third period, encroaching on historical times, ranges from the extinction of the Mammoth and of the Woolly Rhinoceros down to the extinction of the Reindeer in Central Europe (in Scotland during the 12th century). The fourth period is characterized by the extinction of the Aurochs and of the *Cervus megaceros* in Central Europe, and by the notable diminution of the Bison, the Elk, the Beaver, the Bear, the Lynx, &c., and ends about the middle of the 16th century. During the fifth or present period, the diminution of wild mammalian species, by the action of man and the general use of fire-arms, is continuously progressing.

[Count M.]

On Palæozoic Strata *in* Russian Poland.
By MM. F. Roemer *and* Degenhart.

[Proceed. Imp. Geol. Inst. Vienna, April 2, 1867.]

The central mountain-group of Russian Poland spreads between Sandomir and Malagoszcz, with a length of about 18 and a breadth of from 2 to 3 German miles. The Devonian deposits represented in this group follow thus in descending order:—

1. Black bituminous limestones and calcareous marls, with *Posidonomya* (?) *venusta*, *Cypridina serrato-striata*, *Phacops cryptophthalmus*, and *Goniatites retrorsus*.

2. Light-green coralliferous limestone, with *Calamopora cervicornis*, *Alveolites suborbicularis*, *Stromatopora polymorpha*, *Atrypa reticularis*, *Rhynchonella acuminata*, *Bronteus flabellifer*, &c.

3. Brownish-grey sandstones near Kielce, with *Orthis Kielciensis*, Roem.

4. Dark-coloured marly shales in the iron-mines of Dabrowa, near Kielce, with *Spirifer ostiolatus*.

5. Dark-coloured sandstones, purple marl-shales, and beds of compact dark-grey limestones, with *Orthis lunaris*, *Atrypa reticularis*, *Pentamerus galeatus*, *Strophomena depressa*, &c.

6. Quartzites of Lysagora, without organic remains.

The first division evidently represents the uppermost Devonian horizon, as the fifth division represents the middle one. The Permians are represented about 1½ mile north-east of Kielce by genuine "Zechstein," with *Productus horridus*; this is the extreme easterly termination of the "Zechstein" deposits of Germany and Lower Silesia. The Trias is conspicuously represented by variegated sandstones (with *Myophoria fallax*), by Keuper (Pusch's northern sandstone formation with red clays, abundance of argillaceous Sphærosiderites, some vegetable and occasionally animal remains, extending over an area of more than 50 German square miles), and Muschelkalk. *Pecopteris Ottonis*, Goepp., (a form frequent in the Keuper of Upper Silesia) has been met with again in the Keuper of Miedzieczo.

[Count M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On NULLIPORA ANNULATA. By Professor A. E. REUSS, For. Corr. G.S.

[Proceed. Imp. Geol. Inst. Vienna, December 18, 1866.]

ALTHOUGH very common in the Upper Trias and in the Muschelkalk, and even in places constituting whole beds by itself, the affinities of this fossil are still doubtful, partly on account of its rare occurrence in an entire and well-preserved condition. Some varieties have been taken for segments of the stems of Crinoids. Its discoverer, Prof. Schafhäutl hinted at its resemblance to *Ceriopora*, but nevertheless ranked it among the Bryozoan genus *Nullipora*. He subsequently made it the type of his new genus *Diplopora*, and divided it into a number of species, which are no more than different conditions of the same form. Prof. Gümbel made it a species of the Anthozoan genus *Chætetes*; Stoppani described it as *Gastrochæna obtusa*; and Dr. Eck, without deciding about its nature, gave it the name of *Cylindrum annulatum*. A close examination of a number of specimens from different localities threw no light on its intimate structure, or on its true nature. *Cylindrum annulatum* is certainly closely related to the Bryozoa, with which, however, it has nothing more in common, in regard to its internal structure, than *Nullipora*, *Chætetes*, or *Gastrochæna*. In fact its interior is hollow, and but accidentally filled up with calcareous matrix (see Schafhäutl, Lethæa, pl. lxv. *e*. fig. 18), and not filled up with cellular substance as Schafhäutl supposed when he stated it to be analogous to *Ceriopora* and *Cricopora*. The cellular cavities in the interior of the septa have no direct mutual communication; they are disposed in circular ranges; their orifices (Dr. Carpenter's "junctural interspaces") open into the central cavity of the stem, and the channels into these inner orifices; these channels are disposed in alternating double ranges, and end outwardly in the pores of the surface. All these characters denote an affinity with the complicated forms of *Dactylopora* (see Dr. Carpenter's 'Introduction to the Study of the Foraminifera,' pl. x. figs. 17, 18, *Dactylopora reticulata*, and figs. 24, 29, *D. cylindracea*). Prof. Schafhäutl's distinct species are merely more or less well-preserved specimens of *Dactylopora annulata*; while *Gastrochæna obtusa*, Stopp., and *Cylindrum annulatum*, Eck, may perhaps, after closer examination, prove to be distinct species of the same genus.

[COUNT M.]

The Silurian Pteropods *of* Bohemia. By M. J. Barrande.

[Système Silurien du Centre de la Bohême. Par Joachim Barrande. 1ère Partie: Recherches Paléontologiques. Vol. iii. Classe des Mollusques. Ordre des Ptéropodes. 4to. pp. 179, and 16 Plates. 1867.]

Before describing the genera and species of Pteropods which characterize the Silurian deposits of Bohemia, M. Barrande gives an historical *résumé* of the successive discoveries of the genera of this order from the year 1818, when Sowerby published the figures and descriptions of two species of the genus *Conularia*, up to the present time, when nine genera of Palæozoic Pteropods are admitted by the author, namely:—

	Species.
Conularia, Miller, Sowerby	83
Tentaculites, Schlotheim	52
Hyolithes, Eichwald	84
Hemiceratites, Eichwald	3
Coleoprion, Sandberger	4
Pterotheca, Salter	7
Salterella, Billings	3
Styliola, Lesueur, Ludwig	9
Phragmotheca, Barrande	1
	246

These nine genera may be arranged in two divisions, according to their relative importance. The principal or cosmopolitan genera, those which are distinguished by the great number of their species, by their great vertical extension in the Palæozoic series, and by their great horizontal diffusion over the surface of the globe, are *Conularia*, *Hyolithes*, and *Tentaculites*. To these the author joins *Pterotheca*, because of its appearance on the two continents, namely, in the United States, Canada, England, Ireland, and Bohemia. The five other genera enumerated in the table are considered secondary or local, because of the relatively small number of their species, and especially because of their limited diffusion, both vertically and horizontally.

All these types are not met with in any one of the Palæozoic regions. Bohemia occupies the first place, possessing seven of the nine genera enumerated; while the Rhenish Provinces, with five genera in the Devonian deposits, occupy the second place. The United States, the British Isles, and Russia, although containing the greatest Palæozoic deposits, have not yet furnished more than four types each.

The two genera (*Hemiceras* and *Salterella*) which are wanting in Bohemia are characterized by a peculiarity which caused the author to hesitate before admitting them among the Pteropods, and which consists in the extraordinary thickness of the partitions of the shell, whilst the internal cavity is extremely reduced. This was the more to be observed, since the remarkable tenuity of the testaceous envelope in *Conularia*, *Tentaculites*, *Coleoprion*, *Hyolithes*, &c. was one of the principal reasons which induced scientific men to class these types among the *Pteropods*. The thickening of the shell of

Hemiceras by these internal concentric layers did not prevent Bronn, in 1849, from placing them in their present position; and in 1863, Mr. E. Billings and Prof. J. D. Dana followed his example with the fossils named *Salterella*, which present an analogous structure of their shells. M. Barrande considers that these views are well borne out by the observations which he published in 1855, upon the existence of an organic deposit, in the form of concentric plates, obstructing the internal cavity of *Conularia fecunda.*

The existence of partitions in certain species of the different genera of Pteropods, establishes a connexion between their shells and those of the Cephalopods. But the constant absence of the siphon in the first-named order prevents its being confounded with the second, of which all the shells are invariably provided with this organ.

The same preponderance which has been observed in the number of genera of Pteropods which Bohemia possesses applies in like manner to the number of species; for while in the United States, the British Isles, and Russia, the greatest Silurian regions of the northern zone, 69 species may be enumerated, Bohemia possesses no less than 68 distinct species, or 27 per cent. of the total number of known forms (246) in the Palæozoic world.

Table of the Distribution of the Genera of Pteropods in the whole of the two great Palæozoic Zones.

	Silurian Faunas.			Devonian.	Carboniferous.	Permian (Dyas).	Trias.	Lias.
	I.	II.	III.					
Conularia, Mill.	—	*	*	*	*	*	—	*
Hyolithes, Eichw.	*	*	*	*	—	*	—	—
Pterotheca, Salt.	—	*	*	—	—	—	—	—
Phragmotheca, Barr.	—	—	*	—	—	—	—	—
Coleoprion, Sandb.	—	—	*	*	—	—	—	—
Tentaculites, Schloth.	—	*	*	*	—	—	—	—
Styliola, Lesu.	—	—	*	*	—	—	—	—
Salterella, Bill.	*	—	—	—	—	—	—	—
Hemiceras, Eichw.	—	*	—	—	—	—	—	—

The remarkable concentration of the species of this order in the Silurian system, and their rapid diminution in the subsequent systems, are in complete harmony with the results obtained from the author's study of the Cephalopoda. On the other hand, while the *epoch* of the maximum specific development of the Palæozoic Nautilidæ corresponds to the Third Silurian fauna, that of the greatest specific richness of the Pteropods is manifested in the Second Silurian fauna.

In comparing the two great Palæozoic zones with regard to the number of species of Pteropods which are proper to them, it is found that the northern zone has furnished 161, while but 80 are known in the central zone. But the 161 species represent the contributions of fifteen countries, which consequently possess each, on an average, 10·73 species. On the other hand, the 80 species of the central zone, coming only from four countries, give to them an average of 20 species, or nearly double the proportion of those from the northern zone.

M. Barrande, however, states with regard to these results that they are principally due to the introduction of the contingent which Bohemia has furnished to the palæontological enumeration, and may therefore be modified or reversed by discoveries in other countries at present unexplored.

The Pteropods, like the Trilobites, tend to confirm the line of demarcation between the Palæozoic and Mesozoic eras, and by the distinctive characters of their specific and generic forms furnish a ready means of recognizing the principal stratigraphical divisions of the different systems.

In conclusion, M. Barrande calls attention (1) to the remarkable contrast between the great numbers of the most ancient representatives of this order in the Silurian seas (that is to say, soon after their first appearance) and the small number of species which now exist, and (2) to their extraordinary disappearance during the whole of the Mesozoic era, although they reappear in the Tertiary formation and have in the existing fauna certain forms very analogous to those from the Palæozoic series.

If this intermittence be only apparent, and attributable to the exclusive existence of species unprovided with a shell during this immense lapse of time, it will not be less interesting to inquire why the order of Pteropods is the only one which, during this long "struggle for existence," successively carried, resigned, and resumed its testaceous covering. [A. S.]

On the Eruption *at* Santorino. By Chev. von Hauer.

[Proceed. Imp. Geol. Instit. Vienna, May 15, 1866.]

Prof. Zepharovich has recorded the occurrence of crystallized hornblende in a specimen from the new centre of eruption on George I. Point. Dr. Stache has minutely examined the felspathic substance included in the cellular interstices of these lavas, its specific gravity being 2·66. Analyses of the following varieties have been made in the laboratory of the Imperial Geological Institute:—A. From the old crater of Nea Kaimeni; greyish-black, with fine pores; the main substance grey, with isolated small crystals of felspar, magnetic oxide of iron, and alternating grey and black stripes, according to the admixture of more or less felspar. B. From the banks of the freshwater lakes of Nea Kaimeni, behind the bathing-houses; black pitchstone-like lava, with traces of parallel lamellæ and a very small amount of disseminated white vitreous felspar. C. From the slope beneath Thera (Santorino), close to the level of the sea; black cellular obsidian slag, with traces of parallel structure.

The results obtained are:—

	A.	B.	C.
Density (small pieces at 18° C.)	2·566	2·544	2·507
Silica	67·05	67·25	68·12
Alumina	15·49	23·03 (Alumina and Oxydulated iron)	14·52
Oxydulated iron	5·77		5·73
Lime	3·41	3·36	3·68
Magnesia	0·77	0·70	0·64
Potash	2·34	5·11* (Potash and Soda)	2·23
Soda	4·65		4·96
Loss by incandescence	0·47	0·55	0·43
	99·94 (*sic*)	100·00	100·31

The iron is calculated as oxydule; but a part of it is certainly oxydo-oxydule, all the specimens analyzed acting on the magnetic needle, while another part has been changed into oxide in consequence of decomposition. The analytic results prove these specimens to be identical with the lavas of the last eruption.

A specimen of older eruptive rocks from Santorino (D) was of different composition, containing a less proportion of silica and a greater of basic substances than the lavas of the present eruption (A, B, & C). It is very compact and hard, with an uneven fracture, and varying between dark grey and black. It is rather equally interspersed with small concretions of granular olivine and white vitreous felspar. The first of these two minerals is more or less decomposed, with superficial reddish and brownish tints. Magnetic oxide of iron, although scarcely visible, must be disseminated through the whole rock, as it possesses a rather notable amount of magnetic power. The presence of hornblende and augite could not be ascertained. A specimen of white and very light pumice (E) was collected near the bathing-houses of Nea Kaimeni.

The analytic results are:—

	D.	E.
Density	2·801	——
Silica	55·16	60·09
Alumina	15·94	13·14
Oxydulated iron	9·56†	6·34
Lime	8·90	2·95
Magnesia	5·10	0·46
Potash	1·45	4·39
Soda	3·21	6·00
Loss by incandescence	1·07	5·41
	100·39	98·78

Heated in a retort, the pumice (E) emits water, hydrochloric acid, and chloride of ammonium, without any trace of sulphuric acid. Like D, it is but slightly attacked by acids, and fuses easily into a black pitchstone-like slag.

The general result is, that the whole of the substances ejected by volcanic eruption in the Bay of Santorino are nearly related to the pyroxenic andesites. The rocks enumerated under this designation by Mr. Roth generally contain between 55 and 67 per cent. of silica;

* Calculated from the loss of weight.

† Together with some oxide and oxydo-oxydule; no trace of manganese.

and soda is predominant in them, exactly as in the eruptive rocks of Santorino. The more basic among them are closely related to some Icelandic lavas. [COUNT M.]

On HALIANASSA COLLINII, *H. v. Meyer*. By CHEVALIER F. VON HAUER and Professor E. SUESS.

[Proceed. Imp. Geol. Inst. Vienna, April 6, 1867.]

A NEARLY complete skeleton (head excepted) of this Tertiary Cetacean has been lately found in a quarry near Hainburg, on the Danube, east of Vienna and close to the Hungarian frontier. The whole length of the preserved portion of this skeleton is $7\frac{1}{2}$ feet; it lies with the back upwards, and the normal arrangement and connexion of its parts has suffered but little disturbance. The vertebral column shows 18 vertebræ with the ribs attached, the ribs of the left side having generally retained their normal situation, while those of the right are more or less deranged and broken. There are 23 vertebræ *in situ*; and all of them, not excepting even the hindmost, possess rather distinct transverse processes. The point of connexion of the pelvic rudiment is not discernible. The left scapula is perfectly preserved, and the cervical vertebræ probably lie concealed beneath it; a certain number of them may also have been dislocated, as indications of them have been found near the caudal portion of the skeleton. One vertebra, and a cervical rib of uncommon breadth, with its terminal portion well preserved, appears beneath the scapula. The anterior extremities have remained in their normal situation and connexion, the whole of the cubitus and radius and one-half of the ulna being well preserved. Some metacarpal bones have been found scattered about. One-half of the rudiment of the pelvis is perfectly preserved, showing the iliac and the ischian portions distinctly separated from each other, and between them a rudimentary articular cavity. The head is entirely wanting; but portions of it and of a well-preserved lower jaw were found some years ago in the Tertiary sands of Linz (Upper Austria). The crystalline limestones of the hills near Hainburg are surrounded everywhere by marine Neogene deposits, overlain by a stratum of gravel of more recent date than the diluvial loam, locally varying in thickness from a few inches to from 6 to 12 feet. These circumstances indicate that, during the Tertiary period, the coast of the south-west termination of a long and narrow isthmus, projecting from the Little Carpathians, was surrounded by a number of insular limestone-reefs. The remains in question have been found close to one of these reefs, in the sandy shore of the former Tertiary sea, near the northern end of the cliffs of the present Hundsheim Hill. The lowermost strata in this locality are calcareous sands, several feet thick, alternating with sandstones with calcareous cement from 4 to 6 feet thick; they are overlain by an alternation of similar sands with conglomerates like sandstones, and above these is a cliff of coarse and compact quartzose conglomerate with calcareo-argillaceous cement. These strata, having a dip of about 10°, lie unconformably on the crystalline limestone of the Hundsheim Hill; they are slightly vaulted within the quarry itself. The skeleton was found on the limit between the deepest sand-stratum exposed and the layer of compact sandstone immediately above it. The vertebral column, the ribs, and a considerable portion of other bones, lying in the upper, looser, reddish intermediate stratum, could easily be detached from the matrix. The inner portion of the dorsal spines, the costal arches, &c. were imbedded in compact sandstone. The anterior extremity lay towards the mountain-range, the caudal one towards the Danube. It could not be made out whether the head had been destroyed by former workings in the quarry, or whether it was separated from the body and transported further away before the animal had been drifted to the shore. Tho other fossil remains associated with those of *Halianassa* are characteristic of the fauna of the Leithakalk. The Echinoderms among them (*Clypeaster acuminatus*, Desh., *C. crassicostatus*, Ag., and *C. Partschi*, Mich.) are also met with in the faunæ of Kalksburg, near Vienna, and of Kemenese, in Hungary. Besides these, *Pholadomya Alpina*, Math., *Pecten aduncus*, Eichw., *Anomiæ, Ostreæ, Nulliporæ,* and a tooth of *Listriodon splendens*, Myr. (a Mammalian form particularly characteristic of the marine littoral zone of the Leithakalk), have been determined. The remains of *Halianassa* hitherto found in several contemporary strata of the Vienna basin may, with a certain degree of probability, be regarded as belonging to one species. Further investigations must take place before this identity can be asserted as to the *Halianassa* whose remains, according to Prof. Suess, are characteristic of the lower sands, with *Cerithium margaritaceum* of Gaudendorf. The geological age of the sands and sandstones of Linz in which the remains of *Halianassa* have been found is still uncertain; and consequently the question whether one or more species of this Cetacean genus lived during the Tertiary period still awaits final decision. [COUNT M.]

On the JURASSIC FOSSILS *of* BALIN, GALICIA. By Dr. LAUBE and Professor REUSS.

[Proceed. Imp. Geol. Inst. Vienna, February and June 1866.]

1. *Gasteropods, by Dr. Laube.*—Fifty-two species are at present known to occur in the brown Jurassic strata of Balin, distributed among 21 genera. Of these species, 3 are also found in France, in horizons falling between the Lower Oxfordian and the "Bajocien" of French geologists. Nine species occur likewise in the English Jurassic deposits, and 8 in those of Swabia, the former being assigned by English geologists to the Inferior and Great Oolite, those of Swabia ascribed by Prof. Quenstedt to the subdivisions *d–e* of the Brown Jura. It may be inferred, from the coexistence of these species within a single stratum of moderate thickness, that the subdivisions of "Bajocien" and "Bathonien," as established by M. d'Orbigny, are not generally applicable. The number of new species from Balin amounts to 19; they are:—

Deslongchampsia loricata.
Patella æquiradiata.
Helcion rugosum.
—— Balinense, *Stol.*
Natica pertusa, *Stol.*
—— cornelia.
Chemnitzia dilatata.
Mathilda euglypha.
Turbo Davidsoni.
Trochus Balinensis.
Trochus eutrochus.
—— Smyntheus.
—— faustus.
Onustus Heberti.
Solarium Hörnesi.
Pleurotomaria semiornata, *Stol.*
—— Chryseïs.
Alaria tumida.
—— ornatissima, *Stol.*

2. *Bivalves, by Dr. Laube.*—Of the 108 species known to occur at Balin, 59 have been found in Normandy, in the "Bathonien," "Bajocien," and even "Callovien" subdivisions; 71 are identical with those of the Great and Inferior Oolite, and 40 with those of the Middle Brown Jura of Swabia. Their coexistence within a stratum of moderate thickness is another argument against the general importance of the subdivisions of Jurassic deposits established and maintained by French geologists. The 22 new species from Balin are:—

Eligmus contortus.
Placunopsis fibrosa.
—— oblonga.
Plicatula lyra.
Lima strigillata.
—— Lycetti.
—— complanata.
—— globularis.
Hinnites sublævis.
Macrodon ornatum.
Isoarca ovata.
Isoarca depressa.
Cardiodonta Balinensis.
Corbis obovata.
Opis ceratoides.
Astarte galiciana.
Ceromya columba.
Myacites Polonicus.
—— Balinensis.
Saxicava crassula.
—— Deslongchampsi.
Gastrochæna pholadoides.

3. *Echinoderms, by Dr. Laube.*—This Class is represented at Balin by a small number of forms, generally agreeing with those of the French and English Jurassic strata, and leading to the same conclusions as the Gasteropods and the Bivalves. The new species are:—

Pygaster decoratus.
Stomechinus cognatus.
Pseudodiadema subpentagonum.
Magnosia Desori.
Hemicidaris Apollo.

4. *Bryozoa, Anthozoa, and Spongiaria, by Prof. Reuss.*—Of the 19 species of Bryozoa, 12 of Anthozoa, and 5 of Spongiaria stated to occur in the strata of Balin, 20 are already known from other localities. Among them all the species of Bryozoa (with the exception of two, whose determination still remains uncertain) and 3 of Spongiaria are identical with those from the "Bathonien" deposits of Ranville, near Caen; 6 species of Anthozoa (the 6 others being new) are found either in the Great or in the Inferior Oolite of England and France. The shells of Mollusca incrusted by these Bryozoa belong partly to the "Bathonien," partly to the "Bajocien," and even to the "Callovien" subdivisions, or to 4 species common to the whole of these three subdivisions. It may be inferred from these facts that these three subdivisions, more or less distinctly limited in other localities, are united near Balin into one indivisible stratum, whose characters coincide perfectly with those of the

Jurassic basin of France and England, while it bears but little analogy with the Brown Jura of Germany, and totally differs from the Alpine Jurassic deposits, of which a representative exists at a short distance, south of the low region on the banks of the Vistula.

[COUNT M.]

DESCRIPTION *of a* SECTION *of the* BRENNER RAILWAY, *from* BOTZEN *on the* SOUTH *to* INNSBRUCK *on the* NORTH. By Prof. E. SUESS.

[Proc. Imp. Geol. Instit. Vienna, June 4, 1867.]

THE Imperial Southern Railway Company has presented to the Imperial Geological Institute a geological section of the route from Botzen to Innsbruck, worked out under the direction of the Inspector of Constructions (Mr. Thommen), together with a collection of illustrative specimens. This section is the more instructive, as the line, with the exception of two comparatively slight deviations north and south of the Brenner, runs straight from south to north at right angles to the general strike of the central Alpine chain.

It begins with reefs of quartziferous porphyry, showing many steep planes of cleavage, so as to assume locally (as near Trent) a schistose appearance, and overlying a dark-purple, thick-bedded, somewhat tuff-like rock, possibly belonging to the Verrucano group.

On the right slope of the valley near St. Verena, compact bright-grey argillaceous slate with seams of quartz (strike S.W., dip about 60° S.E.) is seen cropping out from beneath the dark-red rock. Near Collmanus the folded argillaceous slate is overlain by the dark-red rock, and this by the porphyry, with lines of cleavage striking N.N.W. and dipping 60-70° S.W. Above the porphyry appear the dolomitic peaks of the Schlern. Two layers of diorite imbedded in the argillaceous slate are seen between Klausen and Brixen. The right moraine of the ancient Eisack glacier advances as far as the junction between the railroad and the postroad; and the workings have laid bare, beneath the detritus of the moraine, the polished and rounded surfaces of the light-coloured granite constituting the mountain-mass between the point of junction and Ober-Mauls. Near this place appear contorted, dark-grey, lustrous, argillaceous slates, striking from east to west across the valley with a very steep northern dip. Light-grey highly metamorphosed limestone, divided into thin layers by nearly vertical joints, is seen east of Mauls. Many traces of a splintery green talcose rock, and blocks of serpentine and hornblende, appear along the interior or northern limit of the limestones. The fine terminal moraine above the church of Mauls is decidedly of less remote date than the large Eisack moraine near Sterzing. Two terraces of detritus, one above the other, run through the bottom of the valley, the cuts into the valley above Weitenstein having exposed irregular accumulations of blocks resting on stratified sand and gravels.

The next rock marked on the section is mica-schist, with quartz in regular stripes (strike E. to W., dip 60° N.). Its dip becomes vertical in the reef on which the castle of Sprechenstein is built. This reef strikes east to west across the valley, ending westward, close to the opposite slope, in the steep cliff of the Reisenstein Castle; and it continues eastward into a range of mountains soon rising to a considerable height.

The cliff of Sprechenstein, of the great crystalline central mass of the Tauern, begins eastward near the Gross-Glockner. The lines of cleavage in it are vertical, or have a very steep southward dip. Above Sterzing, the railroad has cut through considerable deposits of *gravel* from the Eisack; beneath it appear dark-coloured gneiss-like slates, dipping N.E. 45°, in its steeper parts mica-schists dipping north, in which garnets are said to have been found.

Near Strassberg, in the vicinity of an old Roman road, a cut led to the following deposits in descending order:—stratified sand and silt, 38 feet; ancient humus with isolated pebbles, 1½ foot; sand with Roman (?) remains, 3 feet; small gravel, 1 foot; and coarse rolled pebbles, 4 feet. Several pales, forced into the deeper layers, were found beneath the ancient humus, as also (according to reports) traces of carbonized straw. The tunnel by which the course of the river Eisack is turned runs through hard quartzose slates, overlain by thick accumulations of detritus, which abound in the deeper portions of the Pflertsch valley. These accumulations, through which the railway is chiefly excavated in this locality, consist of fragments of the above-mentioned slate, and of rhombohedral fragments, frequently not more than an inch in diameter, of the limestone constituting the ridge of the mountain above the slate. The great Pflertsch tunnel has been made entirely through this slate, which dips N.W. and W.N.W., beneath the rocks of the Pflertsch valley, and are followed by micaceous slates and chloritic rock, with numerous contorted layers of quartz. The tunnels of Pontigl and Schellenberg have proved the occasionally micaceous limestone of the upper Pflertsch valley to be divided into comparatively thin layers imbedded in the quartzose slate, which dips about 30° or 40° N. or N.W. A white marble, in very thin layers, with a steep W.N.W. dip, is seen above the Brenner post-house. Beneath it occurs light-coloured quartzose mica-schist, dipping gradually steeper until it rests vertically on the flanks of the Griesberg, a mass of hard gneiss with large crystals of felspar. Enormous loose blocks of this gneiss were found in the terminal moraine of the Ven valley. Similar quartzose slates prevail on the northern slope of the central chain, their dip varying between N.E., N., and S.W.; in some places they contain graphite. The Tertiary deposits are represented by blue plastic clay and sands.

The Castle Hill of Matrei, pierced by two tunnels and as many shafts, shows two portions of thin-bedded limestone, abruptly bent and imbedded in serpentine. Remains of trees were found in a yellow argillaceous substance (evidently the result of decomposition) intercalated in the form of a wedge between serpentine and limestone. Doubtful vestiges of gneiss and mica-schist appear once more on the left side of the valley beneath Matrei, the railway, with its numerous cuttings and tunnels, continuing its progress to Innsbruck through the laminated limestone on the right side.

[Count M.]

ALPHABETICAL INDEX

TO THE

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

[The fossils referred to are described; and those of which the names are printed in italics are also figured.]

THE END.

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