THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

VOLUME THE TWELFTH.

1856.

PART THE FIRST.
PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:
LONGMAN, BROWN, GREEN, LONGMANS, AND ROBERTS.
PARIS:—FRIED. KLINCKSIECK, 11 RUE DE LILLE; BAUDRY, 9 RUE DU COQ, PRES LE LOUVRE; LEIPZIG, T. O. WEIGEL.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCLVI.

List

OF THE

OFFICERS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

Elected February and June 1856.

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Prof. A. C. Ramsay, F.R.S.
Warington W. Smyth, Esq., M.A.
Henry Clifton Sorby, Esq.

Assistant-Secretary, Curator, and Librarian.

T. Rupert Jones, Esq.

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lxx., line 9 from top, *for* o Alet *read* d'Alet.
239, in description of woodcut, *read* *b*. Anthracite-schist (*), and grey and purple, &c.
243, line 10 from bottom, for *c* read *b*.
244, line 7 from top and the following lines, *read* In the lower or first group there are six pairs of large imprints, gradually coming nearer to the central line, and somewhat closer also to each other, as far as *c*, which may have been a point of rest, and is nearer to the groove than any of the others.
244, add to the note *after* central line; the wider track would then indicate a relaxation, and not an increase, of effort.
247, line 8 from bottom, *read* Church Stretton; and W. of.
254, line 16 from top, *for* Marguise *read* Marquise.
Part II. p. 14, lines 5, 16, and 20 from bottom, *for* pianzite *read* piauzite.
15, line 22 from top, for *phodadiformis* read *pholadiformis*.
20, line 13 from bottom, *for* Sau-alps *read* Sau-alp.

Directions to the Binder.

The Binder is directed to place opposite page 46 the page numbered 46*; and at page 350 the loose slip relating to Prof. Naumann's paper on gneiss, &c.

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EXPLANATION OF THE PLATES.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEBRUARY 15, 1856.

REPORT OF THE COUNCIL.

The Council, in laying their annual statement of the affairs of the Society before its Members, beg to express their opinion that it evinces a continuance of the same satisfactory state to which, on former occasions, they have directed attention. The number of Fellows, it is true, has suffered a diminution of nine; but this is mainly to be attributed to the numerous deaths which have occurred since the last anniversary. The Society from this cause has lost twenty-six ordinary Fellows, and seven have resigned during the same period, making a loss of thirty-three. Twenty new Fellows have been elected in the past year, and four elected in the previous year have paid their subscriptions in this; making, in all, 24, which, deducted from 33, leaves a loss to the Society of 9, as before stated. One Foreign Member has died, and one has been elected during the year. The total number of the Society at the close of 1854 was 884, and 875 at the close of 1855.

The expenditure during 1855 has exceeded the income by £97 12*s*. 4*d*.: but in the income is included £191 12*s*. 9*d*., the balance at the beginning of the year. The actual excess of expenditure is, therefore, £289 5*s*. 1*d*., which has principally been occasioned by increased expenditure on the Quarterly Journal and the forthcoming Volume of the Transactions. The Council confidently hope that the Fellows will not regret an outlay, whose purpose is to further those objects for which they are associated. At the same time they would remark that the expenditure on this head would be materially lightened, were it met by a greater disposition on the part of the Fellows to purchase the Society's publications. Were this the case, the Council would have it in its power to do justice to the Memoirs read before the Society by more liberal illustration.

Among those whose loss the Society has to deplore during the past year is George Bellas Greenough, the first President of this Society, and ever its liberal patron. At his death, which occurred in April 1855, he bequeathed to the Society all his title to the Geological Map of England which bears his name, and which will ever be a monument of his extensive knowledge and untiring perseverance; he also bequeathed all his Books, Maps, Charts, Sections, and Engravings relating to Geology. He further bequeathed to the Society the sum of £500 to defray the expense of finding accommodation for the Collections. This sum of £500 has been for the present invested in the Funds; so that the amount of the Funded Property of the Society, which at the close of 1854 was £4014 15*s*. 8*d*., is now £4578 19*s*. 2*d*. In addition to this the Society holds two Exchequer bills of £100 each.

Amongst the many Donations received since the last anniversary, the Council would call especial notice to the "Natural History of Deeside," by the late Dr. McGillivray, printed at the expense of Her Majesty, and presented by His Royal Highness Prince Albert, Fellow of this Society. Many other copies of this beautifully executed work have been liberally distributed among the Fellows by His Royal Highness.

The Council have to report that the 11th volume of the Quarterly Journal has been completed; and that the 1st part of volume 12th will very shortly appear, although its publication from unavoidable circumstances has been retarded.

The Council have also to state that the 4th part of the 7th volume of the Transactions is in the press, and will shortly appear. The Supplement to the Catalogue of the Library, of which six sheets are now printed, will also soon be ready for publication.

In conclusion the Council beg to state, that they have unanimously awarded the Wollaston Palladium Medal to Sir William E. Logan, Director of the Geological Survey of Canada, for his valuable contributions to geological knowledge in his elaborate papers on the origin and structure of the Coal-beds in England, and for his subsequent labours in Canada, in carrying out the Geological Survey of that country; and particularly for the admirable Geological Map of Canada, constructed by himself from materials of his own collecting, and exhibited at the Universal Exhibition in Paris, last year.

They have also awarded the balance of the proceeds of the Fund to M. G. Deshayes, for his great exertions in the extension of our knowledge of Tertiary Geology, and for his Palæontological works illustrative of the Tertiary Basin of Paris, and to assist him in the publication of the forthcoming continuation of his Work "Sur les Coquilles fossiles du Bassin de Paris."

Report of the Library and Museum Committee.

Library.

During the past year the principal addition to the Library has been the magnificent bequest of Mr. Greenough of the whole of his collection of Geological Books and Maps: these have not yet been arranged in our Library, but, as the Council has appointed a special Committee to consider of the best plan for the arrangement of that collection, it is not necessary for us to enter into the consideration of this important matter.

The other additions which have been made to the Library during the year have all been worked into their places both in the shelves and the Catalogue; among these we call attention to the large number of parts of the Journals of various Scientific Societies, both English and Foreign, which have been obtained by application to those Societies, or by exchange of our own publications for them, and the Geological and Mineralogical contents of which will be found under the list of the Donations published in our Journal by the Assistant-Secretary. The system of exchanging publications with other Societies has answered so well, that we strongly recommend its continuance and extension as opportunities occur.

The additional shelves ordered by the Council have been placed in the Assistant-Secretary's room, and have served to receive the additions constantly reaching the Society; they will probably be sufficient to hold the usual additions of the next two years, if another receptacle be prepared for Mr. Greenough's books: the re-arrangement of the serials brought on by the moving part from the old to the new shelves has taken up a good deal of Mr. Jones's time.

The mounting of such Maps as are likely to be often referred to, including all those lately received from the Ordnance Geological Survey, has been continued, and two new Map-Cases have been added to hold them; and a Stand has been added to hold large Portfolios.

The printing of the Supplemental Catalogue has been proceeded with; six sheets are already printed, containing nearly all the books, and the printers are at work on the part containing the rest of the Books and the Maps; and the MS. Catalogue of the Charts is already prepared. This, when completed, will include all the additions to the Library during the ten years ending with 1853.

As the MS. additions to the volume of the Catalogue of reference in the Library, which contains the Periodicals, are now included in the printed Supplement, it is desirable that a portion of that volume should be re-arranged for greater convenience of reference.

In the Lower Museum a Case has been added to receive Maps and Charts, and is already partly occupied.

Application was made to the Board of Ordnance for the revised sheets of the Survey of England, and for the Block-Plan of London, which application has been refused by letter of 4th June 1855.

Museum.

The additions to the British Collection include a large collection of specimens from Bovey Tracey, presented by Dr. J. G. Croker, which have just been received, and are not yet placed; also a set of Fossil Plants from Studland, presented by Mr. W. R. Brodie; and a very interesting series of Ferns, &c., from the Yellow Sandstone of Ireland, presented by the Rev. Prof. Haughton, F.G.S.; also specimens of Allophane from the chalk-pit of Charlton, Kent, presented by Dr. Krantz.

During M. E. Renevier's stay in London he examined all the specimens from the Gault in our collection, and compared their names with those in use on the Continent, especially with those of Pictet and Roux, in their "Mollusques fossiles des Grès Verts de Genève."

Agreeably to the order of the Council, an interleaved copy of Mr. Morris's Catalogue of British Fossils has been placed in the Museum, to serve as a means of cataloguing our collection; and a beginning has been made in it by Mr. S. V. Wood, in the Tertiary series, and by Mr. D. Sharpe in the Cretaceous series. It is to be hoped that other Fellows of the Society will lend their assistance towards carrying out this most desirable object.

Mr. Gawan has been employed during the year assisting Mr. Jones, both in the necessary attention to the Museum and in the arranging the Library and preparing a catalogue of Mr. Greenough's books; and Mr. Jones reports most favourably of the assistance which he has received from him.

The following interesting additions of foreign specimens have been received:—

Cryolite, Tantalite, and Eudiatite-rock, from Evigtok, Greenland; presented by J. W. Tayler, Esq. The specimens of Tantalite are particularly fine.

The Rev. Mr. Hislop, of Nagpoor, has continued to send us valuable collections of Fossil Plants and other Organic Remains, from the Nagpoor Territory, and which we hope will soon be examined by several Fellows of the Society, who have promised their assistance towards their publication in the Society's Journal.

Mr. J. W. Mudge has presented an interesting collection of Tertiary Fossils from Prome, which, added to those which the Society has before received from Col. Turton and Mr. Crawfurd, make up a most interesting series from that locality.

Daniel Sharpe.
S. P. Pratt.

January 30, 1856.

Comparative Statement of the Number of the Society at the close of the years 1854 *and* 1855.

	Dec. 31, 1854.		Dec. 31, 1855.
Compounders		137	131
Residents		203	201
Non-residents		475	474
		815	806
Honorary Members	15		15
Foreign Members	50		50
Personages of Royal Blood	4—69		4—69
		884	875

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1854 *and* 1855.

Number of Compounders, Residents, and Non-residents, December 31, 1854				815
Add, Fellows elected during former years, and paid in 1855	Resident	2		
	Non-resident	2		
		— 4		
Fellows elected, and paid, during 1855	Resident	13		
	Non-resident	7		
		—20		
		—		24
				839
Deduct, Compounders deceased		7		
Residents		7		
Non-residents		12		
Resigned		7		
		—		33
Total number of Fellows, 31st Dec. 1855, as above				806
Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1854				69
Add, Foreign Member elected during 1855				1
				70
Deduct, Foreign Member deceased				1
			As above	69

Number of Fellows liable to Annual Contribution at the close of 1855, with the Alterations during the year.

Number at the close of 1854		203
Add, Elected in former years, and paid in 1855		2
Elected and paid in 1855		13
Non-residents who became Resident		4
		222
Deduct, Deceased	7	
Resigned	6	
Compounded	1	
Became Non-resident	7	
	—	21
As above		201

Deceased Fellows.

Compounders (7).

John Brogden, Jun., Esq.
C. Colclough, Esq.
G. B. Greenough, Esq.
Rt. Hon. Sir W. Molesworth.
E. W. W. Pendarves, Esq.
Rev. Richard Sheepshanks.
John Ward, Esq.

Residents (7).

Sir H. T. De la Beche.
Lord de Mauley.
Rt. Hon. Sir T. F. Lewis, Bt.
Philip Pusey, Esq.
W. D. Saull, Esq.
J. H. Vivian, Esq.
Thos. Weaver, Esq.

Non-residents (12).

W. A. Cadell, Esq.
J. E. Cliffe, Esq.
L. L. Dillwyn, Esq.
Rt. Hon. Sir H. Ellis.
J. D. Gilbert, Esq.
Rev. J. P. Higman.
Rev. E. James.
Prof. J. F. W. Johnston.
Josias Lambert, Esq.
Christopher Rawson, Esq.
George Stephenson, Esq.
Alfred Thomas, Esq.

Foreign Member (1).

M. G. Fischer de Waldheim.

The following Persons were elected Fellows during the year 1855.

January 3rd.—Alexander Halley, M.D., Queen Anne Street.
—— 31st.—Rev. Thos. J. Prout, A.M., Christ Church, Oxford.
February 21st.—Edward Hull, Esq., A.B., Geological Survey of Great Britain.
April 4th.—E. Ward Jackson, Esq., Bayswater; James E. Saunders, jun., Esq., Finsbury Circus; Edward L. J. Ridsdale, Esq., Tonbridge; and G. Henry Wathen, Esq., Clifton, Bristol.
—— 18th.—John George Blackburn, Esq., Oldham; and Rev. Wm. Charles Kendall, Newmarket-upon-Trent.
May 2nd.—William Foster White, Esq., St. Bartholomew's Hospital; C. S. Mann, Esq., Eltham; Lucas Barrett, Esq., Tottenham Court Road; and John D'Urban, Esq., Gordon Street.
—— 16th.—Edward H. Hargraves, Esq., Upper Spring Street.
—— 30th.—Rev. John Knowles, Croydon; and James M'Cann, Esq., Liverpool.
June 13th.—George D. Gibb, M.D., Guildford Street.
Nov. 7th.—William Harrison, Esq., Blackburn, Lancashire.
—— 21st.—James G. Sawkins, Esq., Swanage.
Dec. 5th.—John Lubbock, Esq., High Elms, Farnborough; Henry Conybeare, Esq., Abingdon Street; and Richard Hayter Jarvis, Esq., Dorset Square.

The following Person was elected a Foreign Member.

June 13th.—Dr. Carl Friedrich Naumann, Leipsic.

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

British Specimens.

Iron Ore from Waltham on the Wolds; presented by J. A. Knipe, Esq.
Specimens of Allophane from the Charlton Chalk Pit; presented by Dr. Krantz.
Fossil Freshwater Shells from Fisherton, near Salisbury; presented by J. Brown, Esq., F.G.S.
Specimens of Ferns, &c., in the Yellow Sandstones of Ireland; presented by the Rev. Prof. S. Haughton, F.G.S.
Specimens of Fossil Leaves from Studland, Dorset; presented by W. R. Brodie, Esq.
Lignite and Rock-specimens from Bovey Tracey, Devon; presented by Dr. Croker.

Foreign Specimens.

Fossils from Algoa Bay; presented by J. S. Bowerbank, Esq., F.G.S.
Fossil Plants from the Pachmadi Hills; presented by the Rev. Messrs. Hislop and Hunter.
Suite of Fossils from Prome; presented by J. W. Mudge, Esq.
Fish-remains from Mokattam, Egypt; presented by L. Horner, Esq., F.G.S.
Specimens from the Nummulitic formation of Switzerland; presented by M. E. Renevier.
Specimens from Silurian Rocks of Beechy Island; presented by Dr. Armstrong.
Specimens of Scandinavian Limestones with Beyrichiæ; presented by T. R. Jones, Esq., F.G.S.
Specimens of Cryolite, Tantalite, and Eudiatitic rock, from Evigtok, Greenland; presented by J. W. Tayler, Esq.
Vegetable-remains and other Fossils from the Nagpur Territory; presented by the Rev. Mr. Hislop.

Charts and Maps.

The Charts, &c., published by the Admiralty during the past year; presented by John Washington, Esq., by direction of the Lords Commissioners of the Admiralty.
Twenty-six Charts published by the Depôt de la Marine; presented by the Director-General of the "Depôt de la Marine."
Geognostische Karte des Thüringer-Waldes, von H. Credner; 4 sheets and Memoir; presented by Herr Justus Perthes.
Golpe de vista da America do Sul, by J. D. Sturz; presented by the Author.
Section of the Greensand at East Compton, Dorset, by J. Hicks, Esq.; presented by the Author.
Topographical Map of London and its Environs, by R. W. Mylne, Esq., F.G.S.; presented by the Author.
Geologische Übersichts-Karte der Schweiz, von B. Studer und A. Escher; presented by M. S. M. Ziegler.
Deux Vues Géologiques pour servir à la Description Géologique du Danemark représentant les Falaises de Stevens-Klint et de Möens-Klint, par C. Püggaard; presented by the Author.
Map of the Vestiges of Assyria, in 3 sheets; presented by the Asiatic Society of Great Britain.
Map of St. Thomas, with MS. Index of Geological Features, by H. B. Hornbeck, M.D.; presented by the Author.
Tableau Synoptique des Terrains et des principales Couches Minérales qui constituent le Sol du Bassin Parisien, par M. Chas. d'Orbigny; presented by the Author.
Geological Map of Wisconsin, by J. A. Lapham; presented by the Author.

A Leptometer, invented by M. le Dr. Guido Sandberger; presented by Dr. Sandberger.

The following List contains the Names of the Persons and Public Bodies from whom Donations to the Library and Museum were received during the past year.

Admiralty, Lords Commissioners of the.
Albert, His Royal Highness Prince, F.G.S.
American Academy of Arts and Sciences.
American Philosophical Society.
Ansted, Prof. D. T., F.G.S.
Armstrong, Dr.
Arnott, N., M.D., F.G.S.
Art-Union of London.
Ashley, J. M., Esq.
Ashmolean Society.
Asiatic Society of Bengal.
Asiatic Society of Great Britain.
Athenæum Journal, Editor of the.

Baker, J. G., Esq.
Barlow, P. W., Esq., F.G.S.
Barrande, M. J., For. M.G.S.
Basel Natural History Society.
Belcher, Captain Sir Edward, R.N., C.B., F.G.S.
Belgium, Royal Academy of Sciences of.
Berlin, German Geological Society at.
Berlin, Royal Academy of Sciences at.
Berwickshire Naturalists' Club.
Bianconi, Signor J. J.
Binney, E. W., Esq., F.G.S.
Boston Natural History Society.
Bowerbank, J. S., Esq., F.G.S.
Breslau Academy.
British Museum, Trustees of the.
Brodie, W. R., Esq.
Brown, J., Esq., F.G.S.

Calcutta Public Library.
Canadian Journal, Editor of the.
Candolle, M. A. de.
Catullo, Prof. T. A.
Caus and Co., Messrs.
Cautley, Col. Sir P. T., K.C.B., F.G.S.
Chapman, E. J., Esq.
Chemical Society of London.
Civil Engineers' Journal, Editor of the.
Clarke, Rev. W. B., F.G.S.
Copenhagen, Royal Society of.
Critic, Editor of the.
Croker, Dr.

D'Archiac, M. le Vicomte A., For. M.G.S.
Darwin, C., Esq., F.G.S.
Davidson, Thomas, Esq., F.G.S.
Dawson, J. W., Esq., F.G.S.
Delesse, M. A.
Deslongchamps, M. E.
Dijon, Academy of Sciences of.
Dilke, C. W., Esq., F.G.S.
D'Orbigny, M. C.
Dublin Geological Society.

East India Company, The Hon.
Edinburgh, Royal Society of.
Egerton, Sir P. G., Bart., M.P., F.G.S.
Everest, Rev. Robert, F.G.S.

Fairbairn, Wm., Esq., F.G.S.
Faraday, M., D.C.L., F.G.S.
Favre, M. A.
Forbes, D., Esq., F.G.S.
Forchhammer, Dr. J. G., For. M.G.S.
Forrester, J. J., Esq.
France, Geological Society of.
Frankfort Society of Sciences.
Franklin Institute of Pennsylvania.

Geinitz, Dr. Hans Bruno.
Geographical and Commercial Gazette, Editors of the.
Gillis, Lieut. J. M., A.M.
Glasgow Philosophical Society.
Goebel, Herr von A.
Graty, M. A. M. du.

Greenough, G. B., Esq., V.P.G.S.
Greg, R. P. jun., Esq., F.G.S.
Griffin and Co., Messrs.

Halle Society of Natural Science.
Hamilton, W. J., Esq., Pres.G.S.
Harkness, Prof., F.G.S.
Hauer, Herr F. R. v.
Haughton, Rev. Prof. S., F.G.S.
Hébert, M. E.
Hewitt, H. jun., Esq.
Hicks, J., Esq.
Hislop, Rev. S.
Holmes, Prof. F. S.
Hombres-Firmas, M. le Baron de.
Hooker, J. D., M.D., F.G.S.
Hornbeck, H. B., M.D.
Horner, L., Esq., F.G.S.
Hörnes, Dr. M.
Horticultural Society.
Hunter, Rev. R.

Indian Archipelago Journal, Editor of the.
Institute of Actuaries.

James, Lieut.-Col. H., R.E., F.G.S.
Jennings, F. M., Esq., F.G.S.
Jones, T. R., Esq., F.G.S.

Knipe, J. A., Esq.
Krantz, Dr.

Lancashire and Cheshire Historic Society.
Langel, M. A.
Lapham, J. A., Esq.
Lea, J., LL.D.
Leeds Philosophical Society.
Leidy, J., M.D.
Linnean Society.
Literary Gazette, Editor of the.
Liverpool Literary and Philosophical Society.
Logan, Sir W. E., F.G.S.
Lombardy, Imperial and Royal Institute of.
Longman and Co., Messrs.
Lyell, Sir Charles, F.G.S.
Lyon, Commission Hydrométrique de.

Madrid Royal Academy of Sciences.
Manchester Philosophical Society.
Mantell, R. N., Esq.
Marcou, M. Jules.
Martins, M. Ch.
Meyer, Herr Hermann von, For. M.G.S.
Montagna, M. C.
Moore, J. C., Esq., F.G.S.
Mortillet, M. G. de.
Moscow Imperial Society of Naturalists.
Mudge, J. W., Esq.
Munich, Bavarian Academy of Sciences of.
Murchison, Sir R. I., F.G.S.
Museum of Practical Geology.
Mylne, R. W., Esq., F.G.S.

New York Lyceum of Natural History.
New York, University of the State of.

Orleans Academy of Sciences.

Palæontographical Society.
Paris, Academy of Sciences of.
Paris, École des Mines de.
Paris, M. le Directeur-Général du Depôt de la Marine de.
Paris, Muséum d'Histoire Naturelle de.
Perrey, M. A.
Perthes, Herr Justus.
Petermann, Dr. A.
Peters, Herr K. F.
Philadelphia Academy of Natural Sciences.
Photographic Society.
Pictet, Prof. F. J.
Prussian Government.
Puggaard, M. C.

Reeve, L., Esq., F.G.S.
Renevier, M. E.

Roemer, Dr. Ferd.
Royal Agricultural Society.
Royal Astronomical Society.
Royal College of Surgeons.
Royal Geographical Society.
Royal Institution of Great Britain.
Royal Irish Academy.
Royal Society of London.
Ryckholt, M. le Baron de.

Sandberger, Dr. F.
Sandberger, Dr. G.
Scarborough Philosophical and Archæological Society.
Schmidt, Dr. Carl.
Scottish Meteorological Association.
Sedgwick, Rev. Prof., F.G.S.
Sheffield Literary and Philosophical Society.
Sherz, M. T. D.
Siena, Accademia del Fisiocritici de.
Silliman, Prof., M.D., F.G.S.
Smithsonian Institution.
Society of Arts.
Statistical Society.
Stockholm Royal Academy of Sciences.
Suess, M. Edouard.

Tayler, J. W., Esq.
Taylor, R., Esq., F.G.S.
Thomson, T., M.D.
Trask, J. B., Esq.
Trimmer, J., Esq., F.G.S.
Turin Royal Academy of Sciences.

Vaud Society of Natural Sciences.
Verneuil, M. E. de, For. M.G.S.
Vienna Geological Institute.
Vienna Imperial Academy of Sciences.

United States Patent Office.

Wailes, B. L. C., Esq.
Wathen, G. H., Esq., F.G.S.
Wetterau Society.
Wright, Dr. T.

Yorkshire Philosophical Society.

Ziegler, M. S. M.
Zeisczner, Herr C.

List of PAPERS *read since the last Anniversary Meeting, February 16th,* 1855.

1855.

Feb. 21st.—Evidences of the Occurrence of Glaciers and Icebergs in the Permian Period, by Prof. A. C. Ramsay, F.G.S.

March 7th.—On the Geology of the Ballarat, Eureka, and Creswick Creek Gold-fields, Victoria, by M. H. Rosales; communicated by W. W. Smyth, Esq., F.G.S.

——— On the Geology of Part of the Peel River District, Australia, by M. F. Odernheimer; communicated by Sir R. I. Murchison, V.P.G.S.

——— On the Occurrence of Obsidian Bombs in the Auriferous Alluvium of Australia, by the Rev. W. B. Clarke, F.G.S.

——— On the Occurrence of Fossil Mammalian Bones in the Auriferous Alluvium of Australia, by the Rev. W. B. Clarke, F.G.S.

——— Notes on the Geology of New South Wales, by the Rev. W. B. Clarke, F.G.S.; in a Letter to Sir R. I. Murchison, V.P.G.S.

1855.

April 4th.—On the Palæozoic Rocks of the Thüringerwald and the Hartz, by Sir R. I. Murchison, V.P.G.S., and Prof. J. Morris, F.G.S.

April 18th.—On the St. Cassian Beds between the Keuper and the Lias in the Vorarlberg, by Prof. Merian; in a Letter to Sir R. I. Murchison, V.P.G.S.

———— On Fossils from the Keuper at Pendock, near the Malverns, by the Rev. W. S. Symonds, F.G.S.

———— On Cretaceeous Rocks near Natal, South Africa, by Capt. Garden; with a Notice of the Fossils, by W. H. Baily, Esq.; communicated by R. Godwin-Austen, Esq., F.G.S.

———— On the Geology of Natal, by P. C. Sutherland, M.D.; in Letters to Sir R. I. Murchison, V.P.G.S.

May 2nd.—On the Physical Geography and the Pleistocene Phænomena of the Cotteswold Hills, by E. Hull, Esq., F.G.S.

———— Notice of the Occurrence of Coal near the Gulf of Nicomedia, by D. Sandison, Esq., Her Majesty's Consul at Brussa; forwarded by the Foreign Office.

———— On the Anthracitic Schists and Fucoidal Shales of the Lower Silurians in the South of Scotland, by Prof. R. Harkness, F.G.S.

May 16th.—Geological Notes on the British Possessions in North America, accompanied by a Geological Map, by A. K. Isbister, Esq.; communicated by Sir R. I. Murchison, V.P.G.S.

———— Notes on the Geology of Georgia, U.S., by W. Bray, Esq.; communicated by the President.

———— On the Geology and the Coal-bearing Rocks of New Zealand, by C. Forbes, Esq.; communicated by Sir H. T. De la Beche, F.G.S.

———— Notes on the Geology of New Zealand, by J. C. Crawford, Esq.; communicated by the President.

———— Description of the Skull of the *Dicynodon tigriceps*, by Prof. Owen, F.G.S.

May 30th.—Notice of the Occurrence of a Bore at Port Lloyd, Bonin Islands, by P. W. Graves, Esq., H.M. Consul-General for the Sandwich Islands; forwarded by the Foreign Office.

———— On the probable Extension of the Coal-Measures beneath the South-eastern Parts of England, by R. Godwin-Austen, Esq., F.G.S.

June 13th.—On the Remains of the Dicynodon from South Africa, by Prof. Owen, F.G.S.

———— On a Fossil Sirenoid Mammal from Jamaica, by Prof. Owen, F.G.S.

———— On the Brown-Coal Formation of Germany, by Prof. Beyrich; with Observations by W. J. Hamilton, Esq., Pres. G.S.

———— On the Section of the Metamorphic and Devonian Rocks at the Eastern end of the Grampians, by Prof. Nicol, F.G.S.

1855.

June 13th.—On Fossils and Drift-wood collected in the Arctic Archipelago by Capt. M'Clure and Lieut. Pimm, by Sir R. I. Murchison, V.P.G.S.

——— On the Raised Beaches of Argyllshire, by Capt. E. J. Bedford; communicated by Sir R. I. Murchison, V.P.G.S.

——— On Sand-worn Granite, by R. W. Fox, Esq.; communicated by Sir R. I. Murchison, V.P.G.S.

——— On the Red Soil of India, by Dr. W. Gilchrist; communicated by Sir R. I. Murchison, V.P.G.S.

——— On the Umret and other Coal-fields of India, by the Rev. Stephen Hislop; communicated by J. C. Moore, Esq., Sec. G.S.

——— On the Earthquakes at Brussa, by D. Sandison, Esq., H.M. Consul at Brussa; forwarded by the Foreign Office.

——— On some Fossil Seeds from Lewisham, by J. D. Hooker, M.D., F.G.S.

——— On some Fossil Seeds from the Bovey Lignite, by J. D. Hooker, M.D., F.G.S.

November 7th.—On the Newer Tertiary Deposits of the Sussex Coast, by R. Godwin-Austen, Esq., F.G.S.

——— Report on the Coal of the North-Western Districts of Asia Minor, by H. Poole, Esq.; communicated by Sir R. I. Murchison, V.P.G.S.

November 21st.—Notice of the Boring at Kentish Town, by Joseph Prestwich, Esq., Sec. G.S.

——— Notice of the Upper Silurian Rocks of Lesmahago, in the South of Scotland (in which Mr. Slimon has discovered Fossil Crustaceans), by Sir R. I. Murchison, V.P.G.S.

——— Description of some Fossil Crustaceans from Lesmahago, in the South of Scotland, by J. W. Salter, Esq., F.G.S.

December 5th.—On the Tilestones, or Downton Sandstone, in the neighbourhood of Kington, and their fossil contents, by R. W. Banks, Esq.; communicated by Sir R. I. Murchison, V.P.G.S.

——— On the last Elevation of the Alps, with Notices of the Heights at which the Sea has left Traces of its Action on their Sides, by Daniel Sharpe, Esq., Treas. G.S.

December 19th.—On the Remains of the Musk-Buffalo from the Gravel near Maidenhead, by Prof. Owen, F.G.S.

——— Note on some Gravel Beds near Maidenhead, by Joseph Prestwich, Esq., Sec. G.S.

——— On some of the Geological Features of the Country between the South-Down and the Sea, by P. J. Martin, Esq., F.G.S.

1856.

January 9th.—On the Physical Geography of the Tertiary Estuary of the Isle of Wight, by H. C. Sorby, Esq., F.G.S.

——— On the probable Permian Character of the Red Sandstones of the South of Scotland, by E. W. Binney, Esq., F.G.S.

1856.

January 23rd.—On the Cryolite of Evigtok in Greenland, by J. W. Tayler, Esq.; communicated by Prof. Tennant, F.G.S.

——— On remarkable Mineral Veins, with a Notice of Cobre Copper Lode, near Santiago de Cuba, by D. T. Ansted, Esq., F.G.S.

February 6th.—Experimental Researches on the Granites of Ireland, by the Rev. Prof. Haughton, F.G.S.

——— On the Raised Beaches of the Western Isles of Scotland, by Capt. J. E. Bedford; communicated by Sir R. I. Murchison, V.P.G.S.

——— On the Section exposed in the Excavation of the Docks at Swansea, by M. Moggridge, Esq.; communicated by Sir R. I. Murchison, V.P.G.S.

——— On the late Eruption of Mauna Loa, Hawaii, by W. Miller, Esq., H.M. Consul at the Sandwich Isles; forwarded by the Foreign Office.

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 Sir R. I. Murchison and Professor Phillips, retiring from the office of Vice-President.

2. That the thanks of the Society be given to J. C. Moore, Esq., and Joseph Prestwich, Esq., retiring from the office of Secretary.

3. That the thanks of the Society be given to Daniel Sharpe, Esq., retiring from the office of Treasurer.

4. That the thanks of the Society be given to Dr. Bigsby, the Earl of Enniskillen, Dr. Hooker, Dr. Percy, and J. W. Salter, Esq., retiring from the Council.

5. That the thanks of the Society be given to W. J. Hamilton, Esq., retiring from the office of President.

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 Officers and Council for the ensuing year:—

OFFICERS.

PRESIDENT.

Daniel Sharpe, Esq., F.R.S. and L.S.

VICE-PRESIDENTS.

Sir P. G. Egerton, Bart., M.P., F.R.S.
R. A. Godwin-Austen, Esq., B.A., F.R.S.
Sir Charles Lyell, F.R.S. and L.S.
Col. Portlock, R.E., F.R.S.

SECRETARIES.

Robert W. Mylne, Esq.
Warington W. Smyth, Esq., M.A.

FOREIGN SECRETARY.

Samuel Peace Pratt, Esq., F.R.S. and L.S.

TREASURER.

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

COUNCIL.

Prof. Thomas Bell, F.R.S. and L.S.
Col. Sir P. T. Cautley, K.C.B., F.R.S. and L.S.
Earl of Ducie.
Sir P. G. Egerton, Bart., M.P., F.R.S.
Thomas F. Gibson, Esq.
R. A. Godwin-Austen, Esq., B.A., F.R.S.
William John Hamilton, Esq., F.R.S.
William Hopkins, Esq., M.A., F.R.S.
Leonard Horner, Esq., F.R.S.L. and E.
Sir Charles Lyell, F.R.S. and L.S.
John C. Moore, Esq., M.A.
Prof. John Morris.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.
Robert W. Mylne, Esq.
S. R. Pattison, Esq.
Prof. John Phillips, F.R.S.
Col. Portlock, R.E., F.R.S.
Joseph Prestwich, Esq., F.R.S.
Samuel Peace Pratt, Esq., F.R.S. and L.S.
Prof. A. C. Ramsay, F.R.S.
D. Sharpe, Esq., F.R.S. and L.S.
Warington W. Smyth, Esq., M.A.
Henry Clifton Sorby, Esq.

Trust Accounts.

Receipts.	£	s.	d.	£	s.	d.
Balance at Banker's, 1st of January 1855, on the Wollaston Donation Fund	31	2	0			
Balance at Banker's, Geological Map Fund	7	15	0			
Total at Banker's, Jan. 1st, 1854				38	17	0
Dividends on the Donation Fund of 1084*l.* 1*s.* 1*d.* Red. 3 per Cents.				30	9	9
				£69	6	9

Payments.	£	s.	d.
Award to MM. G. and F. Sandberger	30	17	0
Cost of Engraving Wollaston Medal, awarded to Sir H. T. De la Beche		5	0
Paid on account of Geological Map: Mr. Greenough, Balance of 1854	7	15	0
Balance at Banker's (Wollaston Fund)	30	9	9
	£69	6	9

We have compared the books and vouchers presented to us with these Statements, and find them correct.

THOS. F. GIBSON,
ALFRED TYLOR, } *Auditors.*

Feb. 2, 1856.

Valuation *of the Society's Property; 31st December*, 1855.

Property.	£	s.	d.	£	s.	d.
Due from Messrs. Longman and Co., on Journal, Vol. XI.				57	7	6
Due for Subscriptions to Journal				44	6	0
Due for Authors' Corrections in Journal				8	11	0
Balance in Banker's hands				117	16	0
Balance in Clerk's hands				1	11	0
Funded Property, 4578*l.* 19*s.* 2*d.* Consols, at 90				4121	2	0
Exchequer Bonds				199	15	3
Arrears of Admission Fees (considered good)	39	18	0			
Arrears of Ann. Contributions prior to 1855 (considered good)	25	4	0			
Arrears of Annual Contributions of 1855	53	11	0			
				118	13	0
				£4669	1	9

Debts.	£	s.	d.
Balance in favour of the Society	4669	1	9
	£4669	1	9

[*N.B. The value of the Mineral Collections, Library, Furniture, stock of unsold Transactions, Proceedings, Quarterly Journal, and Library Catalogue is not here included.*]

Feb. 2, 1856. DANIEL SHARPE, *Treas.*

INCOME.

	£	s.	d.	£	s.	d.
Balance at Banker's, January 1, 1855	383	4	3			
Balance in Clerk's hands	22	16	6			
				406	0	9
Legacy (Greenough)........................				500	0	0
Composition received				31	10	0
Arrears of Admission Fees	33	12	0			
Arrears of Annual Contributions	34	13	0			
				68	5	0
Admission Fees of 1855				155	8	0
Annual Contributions of 1855				636	6	0
Dividends on 3 per cent. Consols..................				112	18	4
Dividends on Exchequer Bonds....................				6	11	3
Publications:						
Longman & Co. for Sale of Journal in 1854 .	59	18	10			
Sale of Transactions	15	4	9			
Sale of Proceedings	0	8	0			
Sale of Journal, Vol. I. to VI.	14	19	0			
Sale of Journal, Vol. VII.	5	0	6			
Sale of Journal, Vol. VIII........................	8	14	0			
Sale of Journal, Vol. IX.	16	5	6			
Sale of Journal, Vol. X...........................	89	19	0			
Sale of Journal, Vol. XI.*	160	13	2			
				371	2	9
Sale of Library Catalogue				0	17	6
Sale of Geological Map of England (Greenough)				7	10	0
				£2296	9	7

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

Feb. 2, 1856. THOS. F. GIBSON, ALFRED TYLOR, } *Auditors.*

	£	s.	d.
* Due from Messrs. Longman and Co., in addition to the above, on Journal, Vol. XI...	£57	7	6
Due from Authors for Corrections	8	11	0
Due from Fellows for Subscriptions	44	6	0
	£110	4	6

Year ending December 31st, 1855.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Invested in Consols (Legacy)				500	0	0
General Expenditure :						
Taxes	64	12	10			
Fire Insurance	3	0	0			
House Repairs	13	2	2			
Furniture Repairs	9	16	1			
New Furniture	27	13	10			
Fuel	29	10	0			
Light	36	9	8			
Miscellaneous House Expenses, including Postages	48	17	11			
Stationery	25	2	0			
Miscellaneous Printing	30	3	2			
Tea for Meetings	20	19	10			
				309	7	6
Salaries and Wages :						
Assistant Secretary and Curator	200	0	0			
Clerk	120	0	0			
Porter	87	10	0			
House Maid	33	4	0			
Occasional Attendants	13	8	6			
Collector	22	19	10			
				477	2	4
Library				80	17	3
Museum, including Assistant				40	18	6
Diagrams at Meetings				8	17	0
Miscellaneous Scientific Expenses				5	11	0
Publications :						
Transactions	9	18	2			
Transactions, Vol. VII. Pt. 4	81	2	8			
Journal, Vols. I. to VI.	4	16	0			
Journal, Vol. VII.	0	10	4			
Journal, Vol. VIII	1	7	10			
Journal, Vol. IX.	1	4	9			
Journal, Vol. X.	3	3	3			
Journal, Vol. XI.	649	1	4			
Journal, Vol. XII.	3	4	8			
				754	9	0
Balance at Banker's, Dec. 31, 1855	117	16	0			
Balance in Clerk's hands	1	11	0			
				119	7	0
				£2296	9	7

Estimates *for the Year* 1856.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions on Quarterly Journal...	44	6	0			
Due for Authors' Corrections	8	11	0			
				52	17	0
Arrears (See Valuation-sheet)				118	13	0
Ordinary Income for 1856 estimated :						
Annual Contributions (200 Fellows)				630	0	0
Admission Fees :						
Residents (10)	105	0	0			
Non-residents (10)	63	0	0			
				168	0	0
Compositions				94	10	0
Dividends on 3 per Cent. Consols, ...				128	4	4
Dividends on Exchequer Bonds				6	10	8
Sale of Transactions, Proceedings, Geological Map, Library Catalogue and Supplement.....................				70	0	0
Sale of Quarterly Journal	300	0	0			
Due by Messrs. Longman and Co. in June, for sale of Journal in 1855..................	57	7	6			
				357	7	6
				£1626	2	6

DANIEL SHARPE, Treas.

Feb. 2, 1856.

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
General Expenditure :						
Taxes	48	0	0			
Fire Insurance..................................	3	0	0			
House Repairs..................................	15	0	0			
Furniture Repairs	15	0	0			
New Furniture	20	0	0			
Fuel	40	0	0			
Light	35	0	0			
Miscellaneous House Expenses	50	0	0			
Stationery	25	0	0			
Miscellaneous Printing	25	0	0			
Tea for Meetings..............................	22	0	0			
				298	0	0
Salaries and Wages :						
Assistant Secretary...........................	200	0	0			
Clerk	120	0	0			
Porter	90	0	0			
House Maid......................................	33	4	0			
Occasional Attendants........................	12	0	0			
Collector	23	0	0			
				478	4	0
Library, New Books, Printing Supplem. Catalogue, &c.				100	0	0
Museum, including Assistant				50	0	0
Diagrams at Meetings				15	0	0
Miscellaneous Scientific Expenses				10	0	0
Publications : Quarterly Journal				500	0	0
,, Transactions, &c.				75	0	0
Balance in favour of the Society				99	18	6
				£1626	2	6

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

15TH FEBRUARY, 1856.

AWARD OF THE WOLLASTON MEDAL AND DONATION FUND.

AFTER the Reports of the Council had been read, the President, W. J. Hamilton, Esq., on delivering to Sir Roderick I. Murchison the Wollaston Medal, awarded to Sir William Edmond Logan, addressed him as follows :—

SIR RODERICK MURCHISON,—It has already been announced this day that the Council of the Geological Society have awarded the Wollaston Palladium Medal for this year to Sir William Logan for his valuable contributions to geological knowledge in his paper on the origin and structure of the coal-beds in England, and his subsequent labours in Canada in carrying out the geological survey of that country, and more particularly for the admirable geological map of Canada constructed by himself from materials of his own collecting, and exhibited at the great exposition at Paris last year. The Council hope that Sir William Logan will continue the further progress of this survey with the same energy which he has hitherto shown, and that the Canadian legislature will not be slow in providing him with the necessary means to enable him to complete an undertaking which reflects no less credit on the Government which has so liberally supported him than on himself.

In requesting you, Sir, to forward to Sir William Logan this mark of their appreciation of his exertions, I may be permitted to allude more fully to his merits and to some of the circumstances connected with his survey of the Canadian provinces. Previous to the year 1842, when Mr. Logan first commenced the geological survey of Canada, he had already distinguished himself in this country by several valuable papers communicated to this Society. In 1840* he read an interesting paper " On the character of the beds of clay lying immediately below the coal-seams of South Wales, and on the occurrence of coal-boulders in the Pennant grit of that district." In this paper Mr. Logan pointed out the great importance of this underclay varying from six inches to more than ten feet in thickness, and considered such an essential accompaniment of the coal. He also pointed out the important fact of the innumerable specimens of *Stigmaria ficoides*, by which these underclay beds are so strongly marked. He was, I believe, the first to remark that, from the fact

* Proceedings of the Geol. Soc. of London, vol. iii. p. 275.

that over the vast area of the coal field of South Wales not a seam had been discovered without an underclay abounding in Stigmaria, it was impossible to avoid the inference that there must be some essential and necessary connexion between the existence of Stigmaria and the production of the coal. He thought there were reasonable grounds for supposing that in some way or other the *Stigmaria ficoides* was the plant to which may be mainly ascribed the vast stores of fossil fuel.

In 1842 he communicated another important paper, "On the Coal-fields of Pennsylvania and Nova Scotia*," in which he described some interesting particulars connected with the extent and character of the carboniferous deposits of Pennsylvania; he also pointed out the extension to the coal-fields of America of those facts bearing on the origin of coal which I have alluded to in noticing his former paper on the coal-seams of South Wales. The presence of the underclay, or Stigmaria fire-clay as it is sometimes called, was almost universal. The second portion of this paper refers to the coal-fields of Nova Scotia, which he also examined in the autumn of 1841. Here also he observes, that under every bed of coal which he had examined, amounting to more than twelve, he had detected the Stigmaria fire-clay, and he was informed by Mr. Poole, the superintendent of the Albion Mines, that similar strata occupy the same position in the coal-field of Cape Breton.

In the same year Mr. Logan communicated another paper to this Society, in which he described the phænomena accompanying the packing of ice in the river St. Lawrence. In the same paper he has described a remarkable landslip which took place in the valley of the St. Lawrence in 1840, and has also given an account of the occurrence of marine shells on Montreal Mountain, where they are found on a sort of raised beach, 430 feet above Montreal Harbour, or about 460 feet above the Atlantic.

Since that period, with the exception of two papers on the fossil tracks in the Potsdam sandstone and on the stratigraphical relations of that rock, Mr. Logan's communications to this Society have ceased. Appointed in 1842 to superintend the geological survey of Canada his whole time and energies have ever since been devoted to that important work. We have watched his progress with interest, and now witness the result. And in congratulating him upon it we must not forget that before this period no systematic examination of the geology of Canada had been undertaken. Up to that time some partial attempts only had been made by a few enlightened individuals to form a commission with the view to examine the country, both geologically and mineralogically; but it was only in 1841 that the Chambers allotted a sum of £1200, or 30,000 francs, for the geological examination of the province, and Sir William Logan was appointed to carry out the work with Mr. Alexander Murray as an assistant. The examination having been thus commenced, it was continued under the government of Lord Metcalfe by a second vote of 40,000 francs per annum, for five

* Proceedings of the Geol. Soc. of London, vol. iii. p. 707.

years from 1845. In 1850 the grant was again renewed under the government of Lord Elgin for a similar period.

When we consider the circumstances connected with carrying out a geological investigation in a new country like Canada, where the progress of civilization has not yet cleared the ground of its primæval forests, where the geographer has not yet prepared the way for the geologist by the construction of correct and trustworthy maps, and where commerce and social intercourse have not yet prepared the means of communication, we may form some idea of the vast difficulties with which Sir William Logan has had to contend, and which he has so successfully overcome. A considerable portion of the Canadian territory has already been geologically surveyed by Sir William Logan and Mr. Murray, assisted by Mr. Richardson. It appears that up to 1854 the explorations embraced the shores of Lakes Superior and Huron, as well as the great western basin of Canada, the valley of the St. Lawrence, as far as the Gulf, together with numerous other valleys, as the Richelieu, Yamaska, Saint Francois, and Chaudière, together with a large portion of Lower Canada south of the St. Lawrence, including the district of Gaspé.

Having placed himself in communication with Mr. James Hall of New York, who is about to publish a geological map of the United States on the same scale as that of Canada, Sir William Logan has adopted the same subdivision of formations as that already employed by Mr. Hall in the palæozoic district of the United States; we shall thus have the advantage of seeing these two maps constructed on the same plan, an arrangement of great importance for the future examination of the American continent; and Sir William Logan deserves great praise for thus adopting a nomenclature already introduced, instead of endeavouring to establish a new one of his own.

I can give no better evidence of the value of this survey and of the manner in which it has been carried on by Sir William Logan than by quoting the testimony of an American writer in Silliman's Journal*. It is there stated: "No geological survey on this continent has been carried on with more thoroughness and with results of higher importance to the science than those of Canada under the direction of Mr. W. E. Logan. There is great precision in his observations and exactness in his statements. . . . . All the observations bear directly on the geology of the United States, and they have already solved several doubtful points as to the age of American rocks."

When the Canadian Government determined to send to the Paris Exhibition a series of the economic minerals of the country, Sir William Logan was charged with the arrangement of the collection, the whole of which, with scarcely an exception, had been procured by the personal exertions of the geological commission. In order to point out the geological relations of the specimens thus collected, he exhibited at the same time a map on the scale of $\frac{1}{900,000}$, on which he laid down, for the first time, all the details of his geological

* Silliman, vol. xix. N. S. p. 438.

labours; I consider this map to be one of the special grounds which entitle Sir William Logan to the medal which has this day been awarded to him. I am sure that every one who saw it in the Paris Exposition, or subsequently in this country, must have been struck with its execution, and the clear idea it conveyed of the geological structure of the country.

It only remains for me to request you to convey this token of our appreciation of his exertions to Sir William Logan and to assure him of our good wishes for his future success, and for the continued progress of the Geological Survey of Canada under his auspices.

Sir Roderick Murchison, having received the Wollaston Medal from the President, replied:—

Sir,—As Sir William Logan was, in the earlier part of his scientific career, a distinguished contributor to the British Geological Survey, and as my lamented predecessor, Sir Henry De la Beche, had formed the highest opinion of his capacity, it naturally gives me sincere pleasure to be the medium of transmitting to him this Wollaston Medal.

Although the Atlantic has subsequently separated us from our medallist during most of the period in which he has been occupied in successfully advancing geological science in his native country, Canada, it has been a source of true gratification to me to observe the very able manner in which he has elaborated the full and accurate succession of the most ancient rocks of the vast regions he has surveyed; and to see how clearly he has separated the great series of fundamental sedimentary unfossiliferous rocks, termed "Lawrentian," or "Cambrian," from those Silurian Rocks which, in common with all geologists of the United States until the present moment, he has placed in parallel with the Lower as well as the Upper Silurian of Britain and the continent of Europe.

The skilful manner in which he has followed out the course of these ancient Silurian deposits, from their undisturbed and unbroken sequence over vast tracts on the West to the sea-board or Eastern region of North America, where they have been contorted, broken up, metamorphosed, and mineralized, will doubtless be considered among the most remarkable labours of our honoured associate.

Whilst in his younger days he established, by the close and repeated observations to which you, Sir, have well adverted, that natural history constant which has enabled us to read off the true history of the greater number of coal-fields, his maps and sections illustrating the structure of the Canadas, prepared in the vast wilds of that country amidst hardships and privations unknown to European explorers, will be the imperishable records of his fame as a practical geologist.

The devotion and untiring energy with which he arranged and explained the natural productions of Canada, first at the Great British Exhibition of 1851, and recently at the grand Exposition of France, have obtained for him honours both from his own gracious Sovereign and from the Emperor of the French; and I have now only to assure you that no one of his well-merited honours will be more highly estimated by him, than the marked approbation of his brother geologists in bestowing upon him their highest distinction, the Wollaston Medal.

On delivering to the Secretary the Balance of the Proceeds of the Wollaston Fund, the President addressed him as follows:—

Mr. PRESTWICH,—I have great pleasure in placing in your hands the proceeds of the Wollaston Fund for this year, awarded by the Council of the Geological Society of London to M. Deshayes; and in requesting you to transmit them to that gentleman, I must beg you to inform him that the Council have came to this decision, not only in recognition of the great services he has already rendered to palæontology, and especially to that of the tertiary epoch by the exertions he has bestowed on the development of the molluscous Fauna of the Paris basin, but more especially with the view of assisting him in the further completion of his great work, 'Description des Coquilles Fossiles des Environs de Paris.' Those who like yourself have laboured at the investigation of the different beds of the Paris basin can best appreciate the merits of M. Deshayes. We all know that for many years he has regularly spent a considerable portion of each year in examining the different localities in the neighbourhood of Paris, for the purpose of making himself acquainted with their fossil molluscous fauna, and of verifying *in situ* the occurrence of specimens collected by others, and that each successive year has greatly added to the number of new species.

It is also well known that since the publication of that great work (from 1824 to 1836), the attention of many new labourers in the field of tertiary geology has been directed to this subject. They have not only settled satisfactorily the order of succession of the beds, but have collected their organic remains in large numbers, and these have in most cases been brought under the notice of M. Deshayes in addition to those collected by himself. Thus finding the number of new species rapidly increasing, and that his own collection contained many hitherto unpublished specimens, he resolved to publish a supplement to his original work, now become doubly necessary, since without a knowledge of these new forms the true correlation of the Paris beds with those of England, Belgium, and Germany is impossible. Such is the accumulated mass of materials, that he has now about six hundred new species to figure and describe, requiring from sixty to seventy plates, in the preparation of which considerable progress is already made. At the same time he proposes to re-examine the species described in his former work, and to class them all according to the present position of geology and conchology, thus bringing up the materials of his old work to the standard of the new one.

The Council would also wish by this award to testify their appreciation of M. Deshayes' talents as a conchologist, and of the manner in which he has made the study of recent Mollusca subservient to the elucidation of fossil species; and with reference to this subject, they cannot speak too highly of the assistance M. Deshayes has rendered to the British Museum in arranging and correcting the nomenclature of a considerable portion of the Bivalves in that collection, and by preparing a catalogue which has been already partly published. I have only now to request you to inform M. Deshayes that while the Council regret that the sum which they are enabled to place at his disposal is not of larger amount, they yet trust that he will find in it an assurance of the high estimation in which they hold his labours and his talents, and of the sincere interest they take in his future welfare and prosperity.

Mr. Prestwich replied as follows:—

Sir,—It will give me great pleasure to convey, as I am sure it will my friend M. Deshayes to receive, the mark of distinction with which the Society has to-day honoured him. I have long known and highly appreciated the deep research and extensive comparisons which M. Deshayes has brought to bear on the study of Tertiary shells, and can bear willing testimony to the kindness with which he is always ready to assist others engaged in similar or collateral inquiries.

I trust that this evidence of the sympathy with which the Society views M. Deshayes's labours will induce him to persevere in those labours, and to lay before us with as little delay as possible the further results of his extended researches into the fossil Testacea of the Paris Tertiary strata.

THE ANNIVERSARY ADDRESS OF THE PRESIDENT.

Gentlemen,—I now come in the fulfilment of my duty to that part of my task which, necessary as it is, must always be one of the most painful services which your President has to perform. I mean the recalling to your notice the most distinguished Members of the Society whom we have had the misfortune to lose during the preceding year. And I deeply regret that I have to state that our losses during the past year have been unusually great; great, not only as regards the members we have lost, but more particularly so with reference to the high position, both in the world of science as well as in this Society, held by many of those who have ceased to move among us. It is no small matter to have to record in one year the loss of such men as George Bellas Greenough and Henry De la Beche, the one remarkable for his zealous and faithful attention to the interests of this Society from the very first day of its existence, and the other for his success in founding and permanently establishing what has been justly called the first palace ever raised from the ground in Great Britain which is entirely devoted to the advancement of science.

George Bellas Greenough was born in 1778, and had consequently attained his seventy-seventh year when he died. His father, who was a proctor in the ecclesiastical courts, died when the son was but two years old, nor did his mother, who was the daughter of Mr. Greenough, an eminent surgeon-apothecary, long survive her husband, leaving her only son to the care of his grandfather, an accomplished classical scholar. To his care and instruction Mr. Greenough was wont in after years to attribute much of his success in life, and that taste for laborious study which he began to manifest at a very early period. He was sent to school at an early age, and when nine years old went to Eton. His grandfather died while George Bellas was still at school, leaving him a considerable fortune, under the guardianship of Mr. Hunt, and desiring him to add to his paternal name that of Greenough.

In 1795 he entered Pembroke College, Cambridge, and resided there for nine terms consecutively, but he never took his degree, and in 1811 he removed his name from the college books. In 1798 he proceeded to Göttingen for the purpose of prosecuting his legal studies. Here, however, it would appear that the study of natural science, under the celebrated Blumenbach, had more attractions for his inquiring mind than the Pandects and Institutes of Justinian. Having been advised to attend the lectures of this distinguished naturalist, to the attractions of which I can myself bear witness, he determined to abandon the law and to devote himself thenceforth to the pursuit of natural history and its cognate sciences. An interleaved copy of Blumenbach's 'Institutiones Physiologicæ' contains copious notes by Mr. Greenough, showing with what zeal and industry he followed his instructor's lectures. He afterwards studied mineralogy at Freiberg under Werner, and adopted his views on geology, which he continued to hold for many years. From thence he visited the Hartz Mountains and other mining districts of Germany, and, after spending some time in Germany, Italy, and Sicily, he returned to England in 1801, when he visited Cornwall and the Scilly Islands.

From that time until 1807 he was actively employed as a Member of the Royal Institution, attending lectures on chemistry, working in the laboratory, and with Chenevix, Wollaston, Davy, Babington, and others, endeavouring to promote the progress of science in all its branches. In 1806 he visited Ireland in company with Mr. R. Hutton, and although principally occupied with geological investigations, he took a deep interest in the political state of that country, and in making himself acquainted with those important social questions which were then agitating men's minds. In 1807 he was returned to parliament for the borough of Gatton, for which he continued to sit until the dissolution in 1812. But the pursuits of science were more congenial to his tastes than politics, and in the very year when he was first returned to Parliament we find him actively engaged in promoting the study of geology. In that year he succeeded in associating with himself several active and able advocates of the then infant science, the result of which was a proposal to found a new society for the furtherance of geological and mineralogical science. A printed list of geological queries was issued, and regulations for the management of a new society were discussed and arranged.

For some time before the period to which I am now alluding, a warm interest for the sciences of Mineralogy and Mining had sprung up among some of the leading men of science in England, which had led to the formation of several valuable mineralogical collections. Availing himself of this growing feeling, Mr. Greenough exerted himself to give a practical direction to the efforts of scientific men by the establishment of a new Society for the cultivation of mineralogical and geological science in a more special manner than that in which it was entertained at the Royal Society.

But Mr. Greenough could hardly have anticipated the difficulties of the task he had undertaken. During this and the two following years the opposition of Sir Joseph Banks, the President of the Royal Society, seconded by that of other influential members, threatened the existence of the new Society. They opposed the formation of a Society which they imagined would encroach on the province and impair the dignity of their own, and no means were omitted for the purpose of endeavouring to crush it. Several of the Fellows who had originally joined withdrew their names, Davy amongst the number. Mr. Greenough calmly but fearlessly resisted their efforts. He endeavoured to conciliate matters by every means in his power. He pointed out to Sir J. Banks the true objects of their intended action; with his own hands he drew up a list of the subjects which it was intended to make the objects of inquiry, and promised that any papers he desired should be freely placed at the disposal of the Royal Society. But all in vain; the hostile feeling could not be overcome. Still Mr. Greenough was unshaken, and when the Royal Society endeavoured to compromise matters by offering to make the Geological a branch of the Royal, and proposed that the papers read in the Geological Society should be subject to their control and be published in the Transactions of the Royal, Mr. Greenough and his friends who acted with him calmly but steadily stood their ground, and finally succeeded in asserting the complete independence of the Geological Society.

Nor should it be forgotten that, although much warmth was elicited in these discussions, Mr. Greenough never lost a friend. At length, all obstacles having been overcome, the Geological Society (first established in 1807) became regularly constituted in 1811, and Mr. Greenough was elected the first President, an honour justly merited by his strenuous exertions for its formation, and one which he held for a period of six years*. In the same year the first volume of our Transactions was published, and I may here mention that of the first list of Council and Officers of the Society, Mr. Leonard Horner is now the only survivor. I need not remind you that during the long lapse of intervening years Mr. Horner has ever been the steady friend of this Society. May he long be spared to us, and long continue to be the connecting link between the present generation of geologists and the first founders of the Society.

* Dr. Bostock's Address; March 1826.

From this period to the last hour of his life Mr. Greenough was actively employed in forwarding the interests of this Society, and in advancing the progress of geology and physical geography. He was unceasingly occupied in increasing his valuable collection of maps, and in entering on them and in his numerous note-books all the geological data which he could obtain either from books or from the communications of scientific travellers. But notwithstanding his vast collections and his numerous and elaborate notes on every subject connected with mineralogy, geology or physical geography, Mr. Greenough was not a great writer. No memoir from his pen, except his presidential addresses, has been published by any of the learned Societies to which he belonged.

About this period, also, Mr. Greenough was made an Honorary Member of most of the scientific societies of the United Kingdom; and, notwithstanding the war with France, he received in 1809 the diploma of Honorary Member of the Agricultural Society of Boulogne. During the next succeeding year he was actively employed in pursuing his geological explorations in various parts of Great Britain and Ireland, preparing for that great work which he was already contemplating, the Geological Map of England. In 1814 he started for Paris the very day after the Treaty of Peace was signed. Soon afterwards the state of his health, brought on probably by severe mental and bodily exertions, compelled him to take up his residence at Cheltenham; but in 1818 he was again elected President of this Society.

In 1819, after years of labour in the collection of the materials and the arrangement and construction of his work, he published his Geological Map of England and Wales, in six sheets, with an accompanying memoir, compiled from an extensive collection of maps and surveys. In order to render this work as perfect as possible, Mr. Greenough spared no efforts, and was equally willing to avail himself of the information collected by his numerous geological friends as by himself. He ever retained a grateful sense of the pecuniary assistance given him by Mr. Warburton, who had at one time contributed as much as a thousand pounds towards the work, a great portion of which, if not the whole, was subsequently repaid.

In the same year Mr. Greenough published the only work on geology which issued from the press under his own name, and when we consider the talent shown in this work, the ingenuity displayed in controverting those geological theories which he considered injurious to the science, and at the same time recollect the mass of information he had collected, and the systematic way in which it was arranged in those many MS. volumes which must be well known to all who had the good fortune to be intimately connected with him, we cannot but regret that Mr. Greenough should not have made more use of his materials, and have devoted some portion of his time to the publication of Principles of geology better adapted to the progress of the science within the last ten years than the work to which I am now alluding. Under the title of 'A Critical Examination of the First Principles of Geology,' in a series of essays, Mr. Greenough proposed to refute many of the popular theories of the day, and appears to have directed the great weight of his logical argument against the followers of the Plutonian theory.

At the same time it must be admitted that, notwithstanding the shrewdness and success with which many of the crude notions of former days are disproved in these essays, Mr. Greenough has not unfrequently brought forward statements and advanced arguments which could hardly have been expected from one who had studied his "collegium logicum" at the University of Göttingen. Take for instance that passage in allusion to the great extent of time required by the Plutonists for the performance of many operations, and which to modern geologists does not appear to be an unreasonable request :—

"Ye gods, perpetuate Time! says the Plutonist, and thinks his reasoning will be incontrovertible. But suppose the prayer granted ; suppose the Plutonist to have at command whatever time he desires ; Time graduating into Eternity ; nay Eternity itself ; what use could he make of it? What profit can a man expect from putting zeros out to interest? What increase of weight from a Fast sufficiently prolonged? If seas and rivers do not tend to produce within the period of human experience any such effect as that which we are endeavouring to account for, they will evidently produce no such effect in a million of centuries. Time may complete that which is in progress, it will never complete that which can never be begun." As a general remark too, it may be stated that this work of Mr. Greenough's was intended to refute what he considered objectionable theories, rather than to lay down what ought to be the principles of geological investigations.

An excellent review of this work will be found in the pages of the Edinburgh Review (vol. xxxiii. p. 90), where it is stated, "The work before us contains an admirable digest and collation of the most authoritative statements and opinions on a great variety of important questions, but is eminently calculated by the contradictions which it everywhere exhibits to abate the confidence of narrow observers and rash theorists, and to inculcate the necessity of that patient industry and modest scepticism by which alone the pursuits of geology can ever obtain the dignity of a science."

Excursions at home and on the Continent continued to occupy his active mind in the relaxation from those periods of hard labour which are demanded at the hands of a man of science. Mr. Greenough for some time occupied a house in Parliament Street, but in the year 1822 or 1823 the expiration of his lease compelled him to seek another residence, and he took from Government a lease of ground in the Regent's Park, and commenced building that house which he knew so well how to fill and to adorn, and where we all enjoyed his hospitality and kindness. In this employment he had an opportunity of indulging his taste for architecture, to which he had paid great attention for many years. In 1826 he took a great interest in, and was one of the most active agents in obtaining for the Geological Society, that Charter of which he was one of the first trustees; and in 1831 he was interested, with Sir R. Murchison and others, in the establishment of the British Association for the Advancement of Science, and took an active share in all the scientific institutions of the metropolis. In fact he was ever busy, ever occupied in promoting, both by his own exertions and by liberal pecuniary assistance, whatever measures were necessary for the advancement of science. Many individuals, as well as our own Society, can bear witness to Mr. Greenough's liberality. From 1833 to 1835 he was again for the third time President of this Society, and, as usual, most active in promoting its prosperity, as well as harmony and good fellowship amongst its members.

One of his most favourite pursuits, and on which his fame will mainly rest, was his skill in the construction of important physical and geological maps. In consequence of the great progress made in the investigation of English geology during the last twenty years, a second and greatly improved edition of his Geological Map of England and Wales was engraved in 1839, the copyright of which has, with Mr. Greenough's accustomed liberality, been presented to this Society. But Mr. Greenough was not only a man of science, he also possessed a remarkable taste, and a good eye and feeling for colour, and it is generally admitted that the harmony with which he has contrived to blend together the various colours by which the different geological formations are distinguished is not the least of the many merits of this Map. In 1852 he was enabled, from the vast stores of information he had accumulated, to lay before the Asiatic Society, in illustration of a memoir by himself, a series of maps of Hindostan defining all the important elements of the ten water-basins of that peninsula; and in 1854 he exhibited before the Asiatic Society and at the last meeting of the British Association at Liverpool his geological map of India on a large scale, which has since been published under the title of 'General Sketch of the Physical Features of British India.' With regard to this last production, the gigantic effort of his declining years, I cannot better do justice to the subject than by quoting to you a passage from one of the Addresses of our former President, Sir R. I. Murchison, when addressing the Royal Geographical Society as their President in 1853*, previously to the publication of this map:—

"Let me now direct your attention to the last year's labours of the veteran geographer and founder of the Geological Society of London, my valued friend Mr. Greenough. Whenever the day shall come—(and may it be far off!)—when the person occupying this chair shall be called upon to treat of the labours of this distinguished man, then will there be poured forth an enumeration of his works which will satisfy mankind that in this generation no individual among us has accumulated greater stores of geographical and geological knowledge; and that no one has made greater efforts to generalize detached data, and group them together for the benefit of our race. On this occasion it only behoves me to speak of one of

* Journal of the Royal Geographical Society, vol. xxiii. pp. cvii. and cviii.

his last efforts, or that of the illustration of Hindostan, as put forth in maps exhibited before the Royal Asiatic Society. Defining on one of these, each of the ten water-basins of the peninsula, and noting all their affluents, and the number of square miles drained by each, he read a valuable memoir to the Asiatic Society. Another work, and that to which I now particularly advert, is a grand original physical and geological Map of all India, about 7 feet long and $5\frac{3}{4}$ feet wide, which he has prepared himself, directing the insertion of every stream and hill, and sedulously consulting every authority for the geological attributes of each district between the plateaux N. of the Himalaya and Cape Comorin. On this Map the spectator sees the delineation of coal-tracts, the larger portion of which are unquestionably of tertiary age, and not like the old coal of Europe and America; the range of the diamond-deposits; the vast territories occupied by granitic and eruptive rocks; the demarcation of masses of secondary age, in which the cretaceous deposits of the age of our chalk play so subordinate a part, whilst the nummulitic formation, or oldest tertiary, has so grand a development, particularly in the north; the Silurian and other palæozoic rocks also being only known in the north-western extremity of the Punjaub and in the Himalaya mountains.

"Such a labour of love as this on the part of such a man seems to me to call not only for the special acknowledgments of all geographers and geologists, but also for the approbation of the Board of Control and Directors of the East India Company, who would do real service by publishing this great map, and thus render the name of Greenough as well known in our Eastern Empire as it is in Europe."

It is, perhaps, hardly possible to estimate the difficulties with which Mr. Greenough had to contend in preparing this map. It was commenced in 1843. Information came in but slowly, and had mostly to be sought for in the archives of the India House. Frequently when obtained its application was next to impossible from the nature and imperfection of the maps, or it was valueless from the ignorance of the observer. In 1849 Mr. Greenough almost despaired of carrying out his object, and felt tempted to give up the work which had cost him so much labour. He was, however, urged to persevere by the accomplished lady who had assisted him in his work, and who took the greatest interest in its completion*. Fresh information at length poured in, chiefly through the assistance of Col. Sykes, and in 1854 the work was completed.

After the publication of this map, with an energy almost unparalleled, Mr. Greenough, at the age of 76, started for Italy and the East with the view of making further researches, and of connecting his Eastern labours with the geology of Europe. But the complica-

* His niece, Miss Colthurst (now Mrs. Greer), had lived for many years in his house during the latter part of his life, and rendered him important services. In testimony of his regard and affection for her, Mr. Greenough bequeathed to her care all his MSS., and I am indebted to her for much of the information contained in this memoir.

tion of disease which had for years been undermining his constitution again developed itself in Italy, and compelled him to remain at Naples, where an attack of dropsy terminated his long and laborious life on the 2nd of April, 1855.

But his services to this Society did not cease with his life. By his will he has bequeathed to the Geological Society of London his valuable geological library and that portion of his collection of maps on which he had recorded his geological observations. The number of books and pamphlets comprised in this bequest considerably exceed a thousand volumes, and the maps are contained in upwards of 60 cases. Amongst these are many important works connected with our science which will greatly enhance the value of our library. He liberally accompanied this bequest by a sum of £500 to enable us to arrange the books and maps in such a manner as to render them most useful and easy of access.

Let me conclude this imperfect notice with a few additional remarks. No one who has been in the habit of attending our Evening Meetings, in the discussions at which Mr. Greenough ever took an active and important share, can have left this room without admiring the multitudinous and varied mass of information which he was enabled to bring to bear on every subject brought under our notice. And, although we are here specially called upon to do honour to his memory as a geologist, it must also be borne in mind that Mr. Greenough was a distinguished Fellow of the Royal Society, and one of the most active supporters of the Royal Geographical and Ethnological Societies. The occupations connected with these two Societies naturally brought him into direct contact and acquaintance with every corner of our globe which had been reached by the inquiries of science or by the pursuits of commerce and of civilization. At the same time, as a member of other important scientific societies, Mr. Greenough had amply availed himself of every opportunity of storing his mind and of enriching his retentive memory with a vast mass of varied information, which he was ever ready to pour forth, in private or in public, on any necessary occasion. And if at times his arguments appeared paradoxical, and he himself disposed to be sceptical with regard to newly propounded views and theories, let it never be forgotten that all was done through a sincere desire of truth. Mr. Greenough's turn of mind was eminently practical, and he was ever reluctant to believe anything that was not capable of being proved. But when once convinced of truth no one was more ready to yield to its conviction. Although long refusing to adopt the new principles of geology founded on palæontological evidence as distinguished from the mineralogical evidence of the older school, he was among the first to form a collection of fossils, and fully admitted the importance and the truth of the geological theories as deduced from the study of fossils and the investigations of palæontology.

Nor can I omit, in enumerating the merits of Mr. Greenough, to mention that to him we are mainly indebted for the great progress made recently in the science of physical geography, a branch of science singularly neglected until a very recent period, and which forms the link between geology and geography. Mr. Greenough was one of the first to recognize the necessity of an accurate delineation of the physical features of a country before we can attempt to lay down with any certainty the results of our geological investigations. It was in carrying out these views that he endeavoured to give a more scientific character to the proceedings of the Royal Geographical Society, and to enlist in its favour the suffrages of the geologist and the mineralogist, as well as those of the politician and the traveller.

And since we no longer enjoy the benefit of his presence, let us look with a higher degree of admiration and respect on that bust of him by Westmacott which we possess in these rooms, and, while thus contemplating the features of our first President and the Founder of our Society, endeavour, in our scientific exertions, to emulate his energy no less than that singleness of purpose, which was one of his greatest characteristics.

A short twelvemonth has scarcely passed away since I had occasion to announce from this Chair the award of the Wollaston Palladium Medal to the late Director-General of the Museum of Practical Geology. It is now my duty to allude to him as one of our associates whose loss we have to deplore. On that occasion I noticed some of the passages in his scientific career which had established his claim to the honour then conferred on him; at the risk of repetition I must now again allude to some of the same circumstances.

Henry Thomas De la Beche was born in 1796. After losing his father at a very early age, he resided for several years with his mother in Devonshire, then at Charmouth, and afterwards at Lyme Regis, where the cliffs teeming with the remains of former life appear to have first drawn his attention to those pursuits which he subsequently so successfully and zealously cultivated. We have thus another instance of the influence of early associations in directing the mind to those studies by which so many scientific men have afterwards distinguished themselves. The southern shores of England soon became classic ground for the geological student; and, with hammer and note-book in his hand, Henry De la Beche was one of the first to unfold the mysteries of that portion of the primæval history of our globe which was written in such indelible characters on the coasts of Dorsetshire and Devon.

Following the profession of his father he entered the Military School of Great Marlowe in 1810. Here he first exhibited those powers of the pencil and that facility of sketching the physical features of ground which so materially favoured his success in his subsequent pursuits and occupations. But his military career was short, and, notwithstanding the charms of society, to which he was by no means insensible, his active and inquiring mind eagerly sought for a more energetic and independent sphere of action than a military career could then afford, when the general peace of Europe condemned our armies to comparative inaction.

At the early age of twenty-one Mr. De la Beche entered the Geological Society in 1817. But far different was the position of the Society at that time from that which it has acquired in these palmy days. Scarcely ten years in existence it was still struggling against the attacks of two opposite parties, and was still in danger of collapsing from the rude efforts of two opposing forces. Churchmen on the one hand, with a short-sightedness which we can now scarcely credit, dreaded the effects of the unanswerable truths it put forth, while philosophers on the other hand looked down upon the young but energetic band as deserters from the parent body, setting a dangerous example to those inquiring minds who dared to believe that science required an ampler field than the apartments of the Royal Society. But time wore on, and Henry De la Beche was one of the most ardent promoters of the rising Society, which has shown that true religion has nothing to fear from the investigation of truth, and that science can best prosper by the establishment of new institutions specially devoted to the pursuit of separate branches of scientific inquiry.

From this period Mr. De la Beche was a constant frequenter of the Meetings of this Society, taking an active share in its discussions and visiting with advantage and observation different portions of the continent of Europe. He resided for some time in Switzerland and parts of France, cultivating the acquaintance of the most distinguished scientific men of those countries, and sedulously applying himself to the study of the natural phænomena so grandly exhibited in the Alps. Some of his observations on the depth and temperature of the Lake of Geneva were published in the "Bibliothèque Universelle" for 1819, and in the "Edinburgh Philosophical Journal" for 1820, together with much valuable information respecting the transport and deposit of detritus in seas and lakes. In 1824 he visited his paternal estate in Jamaica, and while attending with exemplary zeal to the management and improvement of his property he neglected no opportunity of collecting geological information, the result of which was the publication in our "Transactions" of that able memoir containing the first information we had received respecting the geological structure and formations of that island. Nor must it be forgotten that while cultivating Geology in its more attractive forms Mr. De la Beche was one of the few geologists of our country who pursued with equal zeal the study of Mineralogy. He was a first-rate mineralogist, and owed no doubt in a great measure to this circumstance much of that success which, in another sphere, distinguished his subsequent career.

Having already alluded on a former occasion to the valuable contributions to our "Transactions" from the pen of Sir Henry De la Beche, I will now only briefly recapitulate the titles of those memoirs. 1. "On the Geology of Southern Pembrokeshire." 2. "On the Lias of the Coast in the vicinity of Lyme Regis, Dorsetshire. 3. "On the Chalk and Greensand in the vicinity of Lyme Regis, Dorsetshire, and Beer, Devonshire." 4. "Remarks on the Geology of Jamaica." 5. "On the Geology of Tor and Babbacombe Bays, Devonshire." 6. "On the Geology of the Environs of Nice and the Coast thence to Ventimiglia." And 7., in conjunction with Dr. Buckland, "On the Geology of the neighbourhood of Weymouth and the adjacent parts of the Coast of Dorset." But while thus engaged in collecting and describing the facts which came under his observation, he did not neglect the more abstruse and speculative branches of the science. From his numerous observations in different regions, he arrived, by a sound and energetic system of induction, at many of those theoretical views which give a charm to his subsequent writings, and may in fact be said to have laid the foundation of the present school of geological philosophy.

But besides these numerous memoirs in the "Transactions" of our Society and others in the "Philosophical Magazine," the "Annals of Philosophy," and other scientific journals, his first distinct volume appears to have been a translation, with notes, of a selection of Geological Memoirs from the "Annales des Mines." In 1829 he published in 8vo. 'A Notice on the Excavation of Valleys,' 'Sketch of a Classification of European Rocks,' and 'Geological Notes;' and in 4to a valuable series of forty 'Sections and Views Illustrative of Geological Phænomena,' which has long been out of print.

In 1831 he published the first, and in 1832 the second edition of 'The Manual of Geology,' a work of which it is not too much to say that it not only offers to the geological student the most perfect view of the then state of geology, but that, with the exception of some slight modifications rendered necessary by the subsequent rapid progress of palæontology, it is one of the most philosophical introductions to the science ever published.

But Mr. De la Beche did not stop here. In 1834 he published a still more valuable and important work. The 'Researches in Theoretical Geology' is a work of the highest order of merit, and, indicating as it does a thorough knowledge of several branches of science, was the admiration of all his associates; it also exhibits those powers of mind and sound reasoning which enabled him soon afterwards to rise to that station which he filled with so much advantage to his country and with such credit to himself. It is impossible to read a single page of this interesting volume without being struck with the internal evidence it affords of the intimate acquaintance of the author with the various branches of physical science. Chemistry, Physics, Mineralogy, Zoology, and Mathematics are all brought forward at the proper moment and in due proportion in elucidation of the author's views; and we hardly know which is most deserving of our admiration, the clear and comprehensive form in which the various topics are brought forward, or the keen and sagacious judgment with which they are sifted and considered, and conclusions are drawn from the varied and well-described phænomena.

But a new epoch in his career was now commencing, and his own exertions were to lay the foundation of a great national institution. During his many visits to the mining districts of Cornwall he conceived the idea of a geological map of that interesting region, and carried out the bold suggestion by commencing, single-handed, at the Land's End, this undertaking, which he contemplated extending by degrees over the entire country. Backed by the support of scientific friends, the Government of the day wisely resolved that this mineral delineation should form a part of the Ordnance Survey under Colonel Colby, to which Mr. De la Beche was consequently attached.

I need not here stop to narrate all the gradual steps by which, from this small beginning, the plan of Mr. De la Beche ripened into that flourishing institution, which is now one of the chief scientific ornaments of this metropolis. With but few assistants in the first instance, and traversing many thousand miles with hammer in hand, he produced maps which have been the admiration of all who have had occasion to consult them, and laid the foundation of that geological survey of the United Kingdom, which is destined not only to enhance the value of our science, but to unfold the vast mineral riches which lie concealed beneath the surface of our country. By degrees the rapid accumulation of materials, minerals, rock specimens, and organic remains rendered necessary the establishment of a museum where they might be placed, preserved, and consulted; and then arose the idea of forming a complete Geological Museum of the British Isles, at the head of which could be placed no more worthy individual than he from whom the first idea had originated, and the appointment of Mr. De la Beche as Director of the Museum of Economic Geology was universally hailed with approbation. And when the small building in Craig's Court could no longer contain the treasures which had been collected, the voice of the nation liberally responded to the appeal of science, and then, to use the expressive words of Sir Roderick Murchison, "arose, and very much after the design of the accomplished director himself, that well-adapted edifice in Jermyn Street, which, to the imperishable credit of its author, stands forth as the first palace ever raised from the ground in Britain which is entirely devoted to the advancement of science."

These are words which, in speaking of Sir H. De la Beche, ought never to be forgotten, and I am sure I need make no apology for repeating them on this occasion. In fact I would willingly have repeated every word used by Sir R. Murchison on that memorable occasion, but I can only refer you to them. We all know the success which attended the establishment of this Institution; the School of Mines which was attached to it; the able band of scientific men, naturalists, geologists, palæontologists, chemists, and mineralogists, whom he collected around him, and who assisted him in this great national work; and finally, after the close of the Great Exhibition in 1851, to which he also devoted his attention as the chairman of a jury, the realization of his long-cherished scheme of making the Museum of Practical Geology, as it was then to be called, available for educational purposes. This was done by the establishment of courses of lectures, with the main object of teaching to the miner and the smelter those applications of science which they required, while at the same time they should be sufficiently general in their nature to suit persons not interested in mining or metallurgical pursuits.

In his inaugural discourse on the opening of the School of Mines and of Science applied to the Arts, Sir Henry De la Beche explained the history and the objects of the Institution, which had for twenty years been his constant thought, but few who heard him on that occasion could form any adequate idea of the difficulties with which he had had to contend, and which he had so successfully overcome. But during this busy period of his life, his exertions were not confined to the Museum of Practical Geology. In 1847, Sir Henry De la Beche was elected President of this Society, and I need only appeal to the recollection of those who were then Members of it, for a confirmation of the statement, that, in his discharge of his presidential duties, he fully realized the anticipations which had been held out to us.

In 1853 he published the second edition of his work, called the 'Geological Observer,' in which the materials of all his former writings are worked up into a definite shape. Originally founded on a smaller work called 'How to observe in Geology,' the object of this new publication was to afford a general view of the chief points of the science, to assist beginners, and to show how the correctness of observations may be detected, and to sketch the direction in which they may apparently be extended.

But success had scarcely crowned his efforts at the period of the close of the Great Exhibition in 1851, ere the first symptoms of that disease, which removed him from the scene of his labours, began to be developed. Before the end of that year, partial paralysis attacked him, producing at first only a slight lameness, yet gradually and slowly undermining his strength. During the three following years, the gradual progress of disease was too painfully evident to his friends. His strength was slowly wearing away, but his healthy tone of mind and keen penetration remained unimpaired. For the last few months, although his limbs refused their proper work, he was daily carried to his office, the business of which he superintended with the same energy and vivacity as before, and was actually engaged upon it only thirty-six hours before his death, which took place on the 13th of April, 1855.

That the great merits of Sir Henry De la Beche were fully appreciated both at home and abroad, the many honours conferred on him are a most convincing proof. Knighted by his Sovereign, he was also a Knight Commander of the Danish Order of Dannebrog, and of the Belgian Order of Leopold; he was a Correspondent of the Institute of France, and a Member of various Foreign Academies, and of numerous scientific bodies at home and abroad..

Thomas Weaver was born in 1773. He was long a distinguished and active Member of this Society, particularly in its earlier days. He was also one of that band of scientific men, who, with Jameson, Humboldt, and Von Buch, learnt the first rudiments of mineralogy and geology under the tuition of Werner at Freiberg, where he commenced his studies in 1790. Although he had for many years retired from the active field of science, the "Transactions" both of the Royal and of our own Society bear witness to the labours of his early life. Amongst his communications to this Society, I must particularly mention the Memoir published in the First Volume of the Second Series of our "Transactions," entitled "Geological Observations on part of Gloucestershire and Somersetshire;" and another "On the Geological Relations of the South of Ireland." He died at his residence in Pimlico on the 2nd of July, 1855.

The Right Hon. Sir H. Ellis, K.C.B., was brother to the late Charles Ellis, Esq., formerly consul at Tangiers. At an early period of his life he embraced the diplomatic profession. He accompanied the Earl of Amherst to China in 1792, and published an account of the Embassy. Having been wrecked on his return with the ambassador, they escaped to Java in an open boat, after a perilous voyage of several hundred miles. In 1814 he was appointed Minister Plenipotentiary to Persia, from whence he returned with a treaty of peace. In 1835 he again went to Persia in the same capacity, but having returned in the following year, he was soon afterwards sent on an extraordinary and secret mission to the Brazils in 1842. It was during his stay in this last country that he forwarded to this Society the interesting collection of fossil bones which were subsequently described by Professor Owen.

Amongst the distinguished statesmen who have been Members of this Society, the name of Sir William Molesworth must not be forgotten. Chiefly remarkable for his literary and political acquirements, to which, highly as we appreciate them, I have at present no occasion to allude, Sir William Molesworth, after an honourable career in the House of Commons, was, on the formation of Lord Aberdeen's administration in 1853, appointed to the office of First Commissioner of Public Works. In this capacity Sir W. Molesworth had to consider the important question of the juxtaposition of the Scientific Societies in one building. What the scheme would have ended in, had it not been for the breaking out of the war, it is difficult to say; but this I am bound to mention, that the accommodation of the Geological Society in a central position, in a building suited to its wants, and in close proximity to other scientific societies, would have found in Sir W. Molesworth, so far at least as the space or means at his disposal would have permitted, a warm and zealous advocate.

As Colonial Minister again, a post to which he subsequently succeeded, the career of Sir W. Molesworth would not have been indifferent to the Geological Society. Our investigations now extend over most of the British Colonies, in many of which geological inquiries have been set on foot, and are carried on by the Home or Colonial Governments. From many of these, in Canada, in Australia, in Ceylon, and in Africa, we have received during the past years

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much valuable information, and we consequently look with a more than common interest to the past career and qualifications of the minister who holds the seals of the Colonial Office. Unfortunately Sir William Molesworth's tenure of office was too short to enable him to carry out his long-matured plan of colonial government, which, while developing the resources of the Colonies, would at the same time, we trust, have laid open their productions in natural history, and their mineral and geological wealth.

Lewis Weston Dillwyn was another of that band of naturalists whose loss we have to deplore, and who was one of the oldest Members of this Society. Born at Ipswich in 1778, he was placed by his father in 1801 at the head of the celebrated manufactory of Cambrian Pottery at Swansea. Under the influence of Mr. Dillwyn's taste for natural history, this establishment soon became remarkable for its beautiful and no less faithful paintings of birds, butterflies, shells, and flowers. About the year 1814, this manufactory became known for the high character of its porcelain ware, under the name of Swansea China. This high degree of excellence was in a great measure owing to the introduction of a Kaolin of a superior quality, brought from the beds of decomposed granite in Cornwall, remarkable for its great abundance of felspar.

But natural history in its various branches was ever the chief pursuit of Mr. Dillwyn. In 1802 he published the first part of his work on the British Confervæ, and in 1804 he was elected a Fellow of the Royal Society. In 1805 he published, with the assistance of Mr. Dawson Turner of Yarmouth, 'The Botanist's Guide.' In 1817 he printed in two thick volumes a Descriptive Catalogue of Recent Shells, arranged according to the Linnæan method. Nor did Mr. Dillwyn confine his attention to the zoology of recent times. An enthusiastic admirer of the then rapidly developing views of geology, he communicated to the Royal Society, in the form of a letter addressed to Sir Humphry Davy, a paper on Fossil Shells, which was printed in the Philosophical Transactions; and in the same year, he presented to the University of Oxford an Index to Lister's 'Historia Conchyliorum,' which was printed at the Clarendon Press. In 1824 he addressed a second letter to Sir Humphry Davy on Fossil Shells, in which he already pointed out that the gradual approximation in form to recent shells first observed in the secondary strata, is also carried on through the tertiary formations, but that it is only in the upper crag beds that any fossil can be completely identified with a living species.

For many years Mr. Dillwyn held an influential position both as a politician and man of science in his adopted borough and county; and when, in 1848, the British Association for the Advancement of Science held its Meeting at Swansea, Mr. Dillwyn, as one of its Vice-Presidents, and as President of the Section of Zoology and Natural History, was one of the first to welcome its most distinguished members with a genuine and hearty hospitality.

Professor F. W. Johnston was born at Paisley in 1796. When he entered the University of Glasgow, he supported himself for some time by private tuition, having learnt thus early to maintain himself by those talents for which he was afterwards conspicuous. Having at a subsequent period resolved to gratify his taste for chemistry, he proceeded to Sweden for the purpose of pursuing his favourite studies under the able teaching of Berzelius. When the Durham University was founded in 1833, Mr. Johnston was appointed Reader in Chemistry and Mineralogy, an appointment which he retained until the period of his decease. In 1843 he was elected Chemist to the Agricultural Society of Scotland.

Most of his literary productions relate to the chemistry of agriculture. Amongst the most important are his lectures on Agricultural Chemistry and Geology, and the Catechism on the same science. But his last work was the most attractive. The 'Chemistry of Common Life' will be a standard work on the subjects it treats of. He was a great traveller, and his notes on North America are well deserving of notice. In his application of chemistry to geology, he was peculiarly fortunate, and those geologists who attended the Meeting of the British Association in Glasgow in 1842, must remember with delight the lucid and engaging manner in which he described the chemical change which the vegetable matter had gradually undergone during the successive processes of transmutation, from the youngest turf and brown coal, through various stages, down to the anthracitic coal of the earliest beds.

He died at Durham on the 18th of September 1855, of a rapid decline, from a neglected cold after his return from the Continent.

I regret that amongst the many Associates whom we have lost, I can only mention the names of such distinguished men as Mr. J. H. Vivian, Sir T. Frankland Lewis, Lord de Mauley, Mr. W. D. Saull, Mr. E. W. Pendarves, Mr. J. Davis Gilbert, Mr. Pusey, and Mr. G. Stephenson, many of whom were frequent attendants in these rooms; and, although not all active geologists themselves, they were fully capable of appreciating the merits of our science, and took a lively interest in the welfare of our Society.

Amongst our foreign Associates we have to regret the loss of M. Jean de Charpentier, Director of the Salt-works of Bex. He was born at Freiberg in Saxony in 1787. His father was Director-General of the Mines of Saxony, and his brother, Toussaint de Charpentier, died three years ago, Director of Mines in Prussia. From an early age he appears to have devoted his energies to the same pursuits, and became a Member of the Council of Mines in Silesia. He subsequently became Director of the Copper Mines of Baygorry, in the Pyrenees, and in 1813, when only 26 years of age, was appointed Director of the Salt-works of Bex. In this year he published his first work in the French 'Journal des Mines,' entitled "Mémoire sur le Terrain Granitique des Pyrénées." In this work, remarkable for its clear and methodical style, M. de Charpentier describes the various characteristic forms assumed by the granitic rocks of the district, as well as the distribution of the primitive rocks throughout the mountain chain.

In 1818 he read at the meeting of the Helvetic Society of Natural Sciences at Lausanne a memoir on the observations which he had made on the nature and position of the gypsum of Bex. This work, published in the following year*, led to a lively discussion between himself and Prof. Struve, then Inspector-General of the Mines and Salt-works of the Canton de Vaud. This discussion led the way to a more complete examination and knowledge of the other mineral formations of the country and their relations to each other, followed up by the discovery in 1822 of an enormous mass of rock-salt, thereby securing the permanent existence of the salt-works of Bex, the value and produce of which were greatly increased by the intelligent management of M. de Charpentier. He gradually abolished the desultory and imperfect mode of working which prevailed before his appointment, introducing a system of order and regularity in the employment of the workmen, and developing the resources of the works in a manner unknown to his predecessors. In 1823 he published his 'Essai sur la Constitution Géognostique des Pyrénées,' a work at which he had been laboriously employed during his residence in those mountains; it is accompanied by a large geological map and a view of the Pyrenees. At the same time he had prepared another important work entitled 'La Description des divers Procédés pour traiter le Minerai de Fer, confondus sous le nom de méthode à la Catalane.'

But the work which has principally served to raise the character of M. de Charpentier as a geologist and scientific observer, is his researches respecting the older and more recent glaciers. As early as 1815 the attention of M. de Charpentier and M. Venetz was directed to the glacial question, and to the possibility of glaciers having at a former period had a far greater extension down the Swiss valleys than at present. M. de Charpentier became gradually convinced of the truth of these views, and in 1835 he published in the 'Annales des Mines' his "Notice sur la cause probable du Transport des Blocs Erratiques de la Suisse," in which the glacial agency is admitted. Subsequently, the discoveries of his nephew, M. Blanchet, and the investigations of Prof. Agassiz on the scratched and polished rocks of the Jura determined M. de Charpentier to undertake a complete investigation of the whole question. The result of this inquiry was his work entitled 'Essai sur les Glaciers, et sur le Terrain Erratique du bassin du Rhône,' published in 1841.

In these and other works M. de Charpentier first called attention to the important phænomena connected with glacial action; and, although the discoveries of subsequent observers have thrown doubt on some of his conclusions, and led to modifications of others, geologists are deeply indebted to him for pointing out many important facts connected with the former extension of glaciers, for his explanation of their effects in wearing down and polishing the rocks

* See Meisner's Naturhistorischer Anzeiger, Berne.

with which they come in contact, and for his suggestive theories respecting the causes of the motion of glaciers. On this latter question, rejecting, as an insufficient explanation, the gravitation theory of De Saussure, he brought forward in conjunction with Prof. Agassiz that theory which has been called by Prof. James Forbes the dilatation theory, and which has been frequently discussed in these rooms. And although the researches of Prof. Forbes, who gives the preference to the so-called gravitation theory, have shown that some of M. de Charpentier's data are untenable, and that his theory will not account for all the phænomena connected with glacier motion, yet when we consider the internal structure of the glacier-ice and the granular form it assumes, there seems some reason to believe that an expanding force is produced by the tendency of the granules to enlargement, however it may be occasioned, as evidenced by their increasing size according to the age and duration of the ice.

In addition to these claims to our notice, I must not omit to mention that M. de Charpentier was long known as one of the first conchologists of the Continent. In 1837 he published in the Memoirs of the Helvetic Society a catalogue of the land and freshwater mollusca of Switzerland. He possessed a valuable collection of shells which has been given to the Museum of the Canton de Vaud. He was elected a Foreign Member of this Society in 1824, and died on the 12th September, 1855.

Gentlemen,—I propose in the following remarks to adhere to the plan which I adopted when I had last the honour of addressing you on a similar occasion, and I shall endeavour to lay before you a general view of the progress of our science during the past year, at the same time pointing out as well as I may be able, some of the principal features by which that progress has been marked. I conceive that such a plan will be more generally acceptable, and I am sure that it is one in which I am less likely to fail, than if I attempted to enter into a minute examination and criticism of some individual feature of geological investigation. At the same time I feel that the task before me is one of no ordinary character. It is beset with difficulties of the most opposite kind. On the one hand, if we look at the various publications of Geological Societies and Institutions both at home and abroad, the mass of matter to be examined and epitomized into an address might well appal a greater literary gourmand than myself; whilst on the other hand, however great have been the labours of geologists during the past year, I am not aware of any discovery of an unusual character, or of such an engrossing nature as necessarily to attract and rivet your attention, and to induce you to overlook the imperfections or the short-comings of this Address.

Our own proceedings and those of the Museum of Practical Geology and of the Geological Survey necessarily occupy our first attention; and having mentioned that great National Institution, you will, I trust, allow me to make one allusion in reference thereto. I have already had occasion to mention, that but a short time had intervened after we had conferred on Sir Henry De la Beche the highest mark of approbation in our power, before death deprived that institution of its talented Director. I know that the Noble Lord, in whom the appointment of a successor was vested, determined that he would recommend no one to that office whose appointment would not be satisfactory, not only to the public, but also to the members of that scientific corps which the late Director had collected round him. We all know who was appointed to that vacant office. A more popular appointment than that of Sir Roderick Murchison could not have been made, and I am confident that you will all agree with me when I say, that whoever else might have been a candidate for this office, if such there were, a better Director-General than Sir R. Murchison could not have been found. I think, too, we may fairly congratulate ourselves, that one of the most distinguished members of this Society, one who has so often and so ably filled this chair, has been chosen with the unanimous approbation of his countrymen to fill this important post. Intimately associated with Sir H. De la Beche and conversant with all his plans, Sir Roderick Murchison is admirably qualified to carry out and to complete those comprehensive views and systems of arrangement which the late Director had laid down. We may, I trust, also hope that those bonds of cordiality and alliance which have long united these two Institutions will be drawn closer together by this appointment, and that the Museum of Practical Geology will ever continue to work hand in hand with the Geological Society of London in developing the mineral resources of the country, and in carrying out the details of those branches of geological and palæontographical science in which they both delight.

The publication of the third fasciculus of the work entitled "A Synopsis of the Classification of the British Palæozoic Rocks," by the Rev. Adam Sedgwick, with "A Systematic Description of the British Palæozoic Fossils in the Geological Museum of the University of Cambridge," by Professor M'Coy, enables me at last to congratulate geologists, no less than Professor Sedgwick himself, on the completion of his long protracted labours, in the appearance of a work which adds so much to our knowledge of the Palæontology ot the ancient rocks, while it reflects the greatest credit on its accomplished author.

This fasciculus contains the Carboniferous and Permian Mollusca in the Cambridge Collection, several of which, as we are informed by Prof. Sedgwick in the introduction, are so well preserved (especially in the Series of Carboniferous Fossils from Lowick), that the internal characters of the genera could be described more accurately than was possible before on less perfect evidence.

Prof. Sedgwick explains in the Introduction the reasons why, instead of giving the synopsis alluded to in the title-page and contemplated when that title-page was struck off, he has been compelled to publish the work, with little more by way of introduction than a corrected and enlarged tabular view,—resembling that which was prefixed to the second fasciculus of the Cambridge Palæozoic fossils. Hopes, however, are held out that this synopsis will be completed without any unnecessary delay. The author then enters into a full and detailed historical statement of the reasons which have delayed the publication of the work, adding a well-merited eulogium of Prof. M'Coy's merits, and of the manner in which he has carried out the task allotted to him.

In the tabular view above alluded to, Prof. Sedgwick gives what he believes to be a true geographical nomenclature of the Oldest British Palæozoic groups. These he separates into the three following Divisions :—

I. Lower Palæozoic Division, representing the Cambrian and Silurian Series in ascending groups. To this is added a statement of the same division as developed in the Cumbrian Mountains of the north of England, giving—1, the equivalent of the Cambrian Series, and 2, the equivalent of the Silurian Series.

II. Middle Palæozoic Division, representing the Devonian Series or Old Red Sandstone, as developed—1, in Herefordshire and South Wales ; 2, in Devonshire and Cornwall ; and 3, in Scotland.

III. Upper Palæozoic Division, including the Carboniferous and Permian rocks.

It will hardly be necessary for me to observe, that in the first or lowest of these divisions, Prof. Sedgwick altogether ignores the Lower Silurian Series, and refers everything below his May Hill Sandstone to the Cambrian Series, which he again subdivides into three groups: first, the Longmynd and Bangor group called Lower Cambrian; second, the Festiniog group called Middle Cambrian; and third, the Bala group or Upper Cambrian. In the course of the long and elaborate Introduction, with its accompanying Supplement and Postscript, the author enters fully into the arguments by which he endeavours to justify this nomenclature, and which he has already brought before this Society. I deeply regret the tone in which this is done; nor can I believe that any amount of difference of opinion on scientific nomenclature, even admitting that his prior claims had been invaded by the author of 'Siluria,' could justify the use of such language as the author has employed with regard to Sir Roderick Murchison and others. But I am not called upon to discuss the question, further than to observe, that altogether to ignore the existence of the Lower Silurian System, adopted by the Ordnance Survey and by the first geologists of the continent, seems to me to be doing violence to an established nomenclature, and destroying those claims to priority which have been so generally conceded to the author of the 'Silurian System.' It must not be forgotten, that so early as 1833 Sir R. Murchison pointed out in the western parts of Shropshire and Herefordshire the existence of those formations to which the term Lower Silurian was applied in the year 1835, and that this term of Lower Silurian has since been unhesitatingly applied by the Ordnance Surveyors to the vast development of the same formations which extend through the greater portion of the regions of North Wales, while they reserve the term of Cambrian as applicable only to the lowest members of the series. It would be a strange abuse of nomenclature to attempt to change the name of a formation because the beds of which it consists are found to extend over a much larger tract of country than was originally supposed, merely because another name had been applied to the latter, when they were supposed to be different from those first described and named.

I am also of opinion that Prof. Sedgwick in the course of the whole argument has laid far too great a stress on what he calls the natural break below the May Hill Sandstone ; this break appears to be a mere local phænomenon, unknown in other parts of the formation, and not differing either in character or degree from similar breaks in other countries to which such importance has never been assigned, as *e. g.* in the Carboniferous Series of the Thüringer Wald.

There are, however, statements in this Introduction affecting the character of the Council of this Society, which, in the position I now occupy, I should not be justified in passing over in silence, however willingly I should have preferred adopting such a course; and I trust therefore that you will bear with me while I endeavour to refute the unjust charge which Prof. Sedgwick has brought against your Council *. I omit as irrelevant all notice of such vague assertions as that "there is not one Member of the Council who, so far as English evidence is concerned, has sifted the question to the bottom and examined it in all its bearings. . . . . . Some of them have dogmatized very broadly on very narrow and erroneous knowledge," &c. But when Prof. Sedgwick accuses the Society of being less truth-loving in its spirit than formerly, and states that in order to prevent the risk of mischief, the Council seem now resolved to wage war upon all discussions and canvassing of opinions on points which they *themselves wish to regard as settled,* I am bound to tell him as temperately but as decidedly as I can, that he is altogether mistaken as to the spirit by which the Council of this Society has been animated. If Prof. Sedgwick during the last three or four years had more frequently been able to come among us, and for this reason I the more regret the state of his health which has prevented it, he would have found on numerous occasions the same lively animation of discussion, and the same independence of tone and spirit which he affects to miss amongst us ; and he would have found the same zeal in the cause of truth as ever existed in former days. He would have found that the Council had no fear of running counter to the supposed interests of some scientific bodies ; that they did not wish to suppress discussion on points which they themselves wished to regard as settled. With regard to himself, he would have found a feeling of respect and veneration as due to one of the fathers of the science, and he would now perhaps recollect what he appears to have forgotten, that with reference to the suppression of any matter contained in his own papers, the Council were only acting in a spirit of self-defence, and for the interest of the readers of the Journal, when they determined, after the controversy between himself and the author of the 'Silurian System' had been carried on for some time, and the views of both on the question of disputed nomenclature had been fully and freely discussed, that they would not allow any more merely contro-

* See the Supplement to the Introduction.

versial matter to be inserted in the respective papers of either party. This measure was directed against both authors, and not, as Prof. Sedgwick seems to imagine, solely against himself. The only difference was, that one submitted to the wishes of the Council without a murmur, while the other introduced into all his papers matter of a merely controversial nature. This is the true origin of what is called an *ignorant and bitter insult*. Does Prof. Sedgwick really believe that there ever sat at the Council Board a single Member who wished to insult him? But I must in a few words explain what really happened. When the paper of 1852, alluded to in the Supplement (p. xci.), was printed, it was found that matter of a highly controversial nature, which in compliance with the resolution recently come to, ought not to have been printed, had unintentionally been inserted. Sir R. Murchison immediately claimed a right to reply, and gave notice of a paper to that effect. The Council at once saw the consequences which would ensue from such a course, and, wishing to adhere to what they believed to be a wise and prudent line of conduct, they resolved, as the least of two evils, to recal or cancel that portion of the paper which had been printed in contravention of the rule they had laid down. Surely no man should have looked upon such a proceeding as an ignorant and bitter insult.

I must also correct Prof. Sedgwick's memory when he says in the next page, that the Council refused to publish his next paper in 1853. It is true he makes no complaint. He admits that part of it was in a controversial form. But I must remind Prof. Sedgwick that it was only the conclusion, viz. the controversial portion, which the Council objected to publish; the body of the paper would have been duly printed; and when I wrote to inform him of this decision, and to request his sanction to the suppression of the latter portion, the reply which I received was to the effect that he could give no answer until he had seen the paper again, and judged of the effect of the intended omission. I directed the paper to be forwarded to him, and after waiting many months for a reply, the only intimation I received of his intention was finding it already printed in another journal. Such a proceeding was in the highest degree irregular. The paper was the property of the Society, and Prof. Sedgwick, an old President of the Society, must have known that he had no right to make such use of it without having first obtained the sanction of the Council to its withdrawal. I omit all further allusion to the matter contained in the Introduction and its Supplement. I deeply regret that I have been compelled to say so much in justification of the proceedings of your Council. I will only add, with regard to the work itself, that it is impossible to speak too highly of its arrangement, or of the scientific description of the fossils themselves, or of the beautiful plates by which it is illustrated.

At the last meeting of the British Association at Glasgow, Sir Roderick Murchison read an interesting paper "On the Relations of the Crystalline Rocks of the North Highlands to the Old Red Sandstone of that Region, and on the recent fossil discoveries of Mr. C. Peach." Availing himself of his leisure hours during the last summer in re-examining the northernmost counties of Scotland, on which twenty-eight years ago he and his companion Prof. Sedgwick had shed much light, Sir Roderick Murchison has endeavoured to determine the true relations of the crystalline rocks in the Highlands in which organic remains had been discovered by Mr. Peach, to the great deposit of the Old Red Sandstone.

After pointing out the general characters of the crystalline rocks of Sutherlandshire, and showing how they consist of regularly stratified masses of siliceous, calcareous, and schistose bands, which are very slightly affected by any slaty cleavage, he affirms that the limestones containing the fossils are really part and parcel of those ancient masses. But whilst the organic remains seem to belong to Euomphali, Lituites?, and Orthoceratites, their state of preservation is too imperfect to admit of their specific determination.

In reference, however, to their relations, he declares it to be his belief, that they are of a date certainly anterior to the Old Red Sandstones, the basement conglomerates of which wrap round the crystalline rocks, are made up in great measure of their fragments, and are seen to overlap their edges in discordant positions at several localities in the western part of Ross-shire. The flagstones and schists of Caithness, with their ichthyolites and fossil plants, are, as indicated long ago by himself and Prof. Sedgwick, in a still higher position.

Adverting to the vast dimensions and varied composition of the Old Red of the northern Highland counties, Sir R. Murchison reasserts what he put forth prominently in his work 'Siluria,' that the great tripartite group of the Old Red Sandstone, as developed in the north of Scotland, is a full and entire equivalent of the Devonian rocks of other parts of Europe.

Another interesting paper was communicated to the Geological Section of the British Association at Glasgow, by Mr. Salter, "On the recent discovery of Fossils in the Cambrian Rocks of the Longmynd." These rocks, of which the author of this paper has given a mineralogical description, were hitherto considered to be azoic, and to mark that geological period when, before the introduction of organic life, sedimentary rocks were first deposited in the ancient seas on the hardened surface of the earth. It would now appear, from Mr. Salter's discoveries, that in these most ancient beds, some small but unequivocal traces of organic life are to be found. These traces consist partly of numerous double oval impressions on the surface of the ripple-marked sandy beds. They are not above a line in length, are always placed in pairs, and parallel to one another in direction, although scattered over the stone. As they are not placed in regular series, they cannot indicate the track of a crustacean; they are supposed to offer the best analogy with the double holes of sand-burrowing worms (*Arenicola*), and have therefore been called by the author *Arenicola didyma*. Besides these, there are many distinct traces of the presence of worms in long sinuous tracks, such as are usually made by these animals.

But by far the most interesting fossils are several specimens of portions of the tail, and perhaps the head, of a new genus of Olenoid

Trilobites, closely allied to some of the forms already known in the lowest fossiliferous beds of America. To these fossils Mr. Salter has given the name of *Palæopyge Ramsayi.* Mr. Salter then proceeds to describe the other beds in the series which underlie the fossiliferous beds, consisting of shales and sandstones, in some of the lowest of which are beds of conglomerate of considerable thickness (one is 120 feet thick). These conglomerates are chiefly composed of quartz, and indicate the proximity of older and perhaps volcanic lands.

The discovery of these traces of organic life in these old rocks, however interesting in a palæontological point of view, does not justify us in looking on them as representing a new system or group. They do not indicate the existence of new or unknown forms, and can therefore only be considered as a further extension downwards of the Lower Silurian formation of Sir R. Murchison. They appear to point, however, more directly to the very commencement of organic life, which reached a considerable development in the succeeding strata, whatever may have been the lapse of time occupied in their gradual deposition. It is unfortunate that they are not in a more perfect state of preservation, since, although there can be no doubt of their organic origin, they are in far too imperfect a condition to permit any exact conclusion as to their true affinities and connexions.

An interesting communication has also been recently read at one of our Evening Meetings, from Sir R. Murchison, "On the discovery of Upper Silurian rocks and fossils near Lesmahago, in the south of Scotland, by Mr. Robert Slimon." This discovery is the more important, as, notwithstanding the extensive development of the Lower Silurian rocks in the S.W. parts of Scotland and in Ayrshire, the existence of these upper beds was previously unknown in Scotland. The descending order of the strata is well seen on the banks of the Nethaw River, Logan Water, and other tributaries of the Clyde. Here the lower carboniferous rocks, in which the coal-field of Lesmahago occurs, are underlaid by the Old Red Sandstone formation, which is well exposed between Lanark and Lesmahago. Towards its base the Old Red is here marked by a powerful band of pebbly conglomerate, while the base itself is made up of alternating red and light greenish grey flagstones and schists. These are again underlaid by dark grey, slightly micaceous, flag-like schists containing large crustaceans and other fossils. Considering the nature of the organic remains, and the evident position of the beds below the lowest Old Red, Sir R. Murchison unhesitatingly considers these Lanarkshire strata as the equivalents of the uppermost Ludlow rocks or the Tilestones of England*. Amongst the principal fossils found in this uppermost Silurian rock of Lanarkshire, is a species of *Pterygotus* not to be distinguished from the species so abundantly found in the Upper Ludlow rock of Shropshire and of Herefordshire, as well as *Lingula cornea* and *Trochus helicites.* The same deposit contains numerous crustaceans of the group of *Eurypteridæ* (Burmeister), which were described by Mr. Salter under the

* See Lyell's Manual of Elementary Geology, 5th edit. 1855, p. 420.

name of *Himantopterus*. There are five or six species of this genus, all of which are new, and one of which, judging from the head, which is alone preserved, must have been 3 feet in length.

With reference to this subject, I must also notice a paper by Mr. R. W. Banks, communicated to us by Sir R. Murchison, "On the Tilestones or Downton Sandstones in the neighbourhood of Kington, and their contents." Besides describing the geological sequence of these beds, and noticing the fossil contents by which they are principally characterized, and which are remarkable for the abundance of crustacean remains, the author exhibited some highly-finished drawings of the organic remains. These, together with his descriptive notes, indicated the existence of one or more hitherto unknown or little understood forms of crustacean life, probably of the Eurypteridæ group. Without going further into the question of other forms of organic life contained in these beds, there appears to be every reason for concluding that this Tilestone formation is, as was stated by Sir Roderick Murchison, the equivalent of the fossiliferous band which underlies the coal-field of Lesmahago. In concluding his paper, Mr. Banks says,—"From the absence of the numerous Mollusca characteristic of the Ludlow rocks, and from the presence of Crustacea that have not been found in the Ludlow beds, and especially from the abundance of the *Pterygotus*, so characteristic of the middle Old Red of Scotland, I am inclined to separate these Downton or Tilestone beds from the Upper Ludlow rocks, and class them (as Sir R. Murchison originally arranged them) as the bottom beds of the Old Red Sandstone."

Here we have a remarkable instance of that difficulty to which I alluded in my Address last year,—a difficulty which increases as our knowledge of geological formations increases. With each advancing step it becomes more difficult to draw precise limits between successive formations. The following words would almost seem to have been written in anticipation of the question under consideration:—"It has been found that between these respective limits, as at first laid down, certain fossils of the lower bed extend higher up into those above; while some of those hitherto supposed to be characteristic of the overlying formation are found extending downwards into beds of an older age." The same idea has been more fully and more clearly expressed by Sir Charles Lyell, in his last edition of the 'Manual of Elementary Geology.' He says (chap. x. p. 112), "The difficulty of assigning clear lines of separation must unavoidably increase in proportion as chasms in the past history of the globe are filled up."

Now, in the case before us, while on the one hand Sir Roderick Murchison is prepared to regard these Lesmahago flag-like schists, chiefly on the evidence of their fossil contents, as separate from the Old Red Sandstone series, and to class them with the Upper Ludlow beds, Mr. Banks, on the other hand, equally arguing on fossil evidences, proposes to remove the equivalent Tilestones or Downton Sandstones from the Upper Ludlow rocks, and to class them as the bottom beds of the Old Red Sandstone. Under such circumstances, are we not necessarily forced to the conclusion that the strata in question represent the true passage-bed from the one formation to the other? Must we not consider them as pointing out the gradual steps by which Creative power advanced from one formation to another? And, in observing how these and similar strata may, according to circumstances, be classed either with the Upper Silurian below, or with the Lower Devonian beds above, are we not warned against that partial dogmatism, which sometimes leads us to hasty generalizations founded on local phænomena, or on evidence derived from a few isolated instances?

In this case, however, it is satisfactory to find that one great source of difficulty is removed. There is no question as to the position of these beds. Found, on the one hand, at the very base of the Old Red Sandstone (if not below it), they constitute the uppermost beds of the Upper Ludlow rocks on the other; and the only question which can arise is this: whether, on the strength of palæontological evidence, it is more convenient to class them with the Silurian or Devonian formations, of which they evidently form the connecting link?

We are indebted to Mr. Sorby for another communication on a comparatively new and complicated subject; and it is only due to the author to say that he appears to have worked out his subject zealously and conscientiously. In the last volume of the Edinburgh New Philosophical Journal, he has published a paper "On the Physical Geography of the Old Red Sandstone Sea of the central district of Scotland." Mr. Sorby states that his general conclusions are, that there is a most intimate connexion between the physical geography of a sea and the currents present in it; and, since their directions and characters can be ascertained from the structures produced in the deposits formed under their influence, that the physical geography of our ancient seas may be inferred within certain limits. He then examines minutely the structure of the Old Red Sandstone rocks, their strata and stratula produced by the action of currents occasioned chiefly by the winds, or causes analogous to those which produce the great oceanic currents of the present day, and states the following as the result of his investigations:—"My conclusions are, that in the Old Red Sandstone period there extended across Scotland a branch of the sea, or strait, whose northern shore was somewhere in the line of the mica-schist rocks which extend from Aberdeen to the mouth of the Clyde; and its southern in the direction of the greywacke rocks that run across from St. Abb's Head to Wigtonshire. In this sea, at the earlier part of the period, there were considerable tidal currents; but when the upper beds were deposited, they were more or less completely absent, and there were present such as were chiefly due to the action of the wind."

Mr. Sorby has since extended his investigations to the south, and has recently communicated to us a paper "On the Physical Geography of the Tertiary Estuary of the Isle of Wight." In this paper the author has endeavoured to show, that from a knowledge of the structure of the sandy and other strata in this locality we may ascertain the direction and other peculiarities of the currents of the ancient sea which covered this area during the tertiary period, whether those currents are due to tidal action, to the winds, or to other predisposing causes; and that with this knowledge of the ancient currents, we may make out the physical geography of the coast lines of the tertiary land and sea during the same epoch. The author infers, on these grounds, that during the tertiary period there existed a wide estuary of a large river running from west to east; that the land from which the river came must have been to the north, the west, and south-west, while the estuary opened into a tidal sea towards the east; and that at the western part of the Isle of Wight area there existed a considerable shoal. The author's observations evince much close examination and ingenious deductions; but I am of opinion that we are not yet in a condition to adopt all the inferences he has drawn from the structure of the sandy deposits, or fully to understand the structure itself and the causes which may have occasioned it. The subject is one which requires much more examination and careful investigation of the various data, before we can venture to pronounce positively on the phænomena before us.

To Mr. Godwin-Austen we have been indebted during the past session for several valuable papers, in which interesting speculations are combined with much careful observation. One of these papers refers to a subject of such vast economical importance, should the anticipated results of the author be in any degree confirmed, that I should but ill perform my duties on this occasion were I not to allude more particularly to the paper "On the probable extension of the Coal-Measures beneath the South-Eastern parts of England." Startling as the proposition may at first appear to many, that coal may possibly be found under the chalk districts of the south-eastern parts of England, much of this surprise will disappear when we consider in how close proximity to the chalk of the Boulonnais the Coal formations between St. Omer and Calais occur. Mr. Godwin-Austen has directed much of his attention to the study of the palæozoic rocks south of the Channel, and it is from his observations respecting the relative position of the Carboniferous beds of the north of France, between Boulogne and Calais, and the Cretaceous beds which form the south-eastern prolongation of the axis of elevation of the Wealden districts in the S.E. of England, that he has been led to the conclusions which form the subject of this communication.

The author stated, after describing the physical and geographical position of the various coal formations existing between the valley of the Ruhr and the district of St. Omer and Calais, where coal has been met with in boring for water, that the views he entertains respecting the extension of the Coal-measures in the south-eastern parts of England depend on the correct restoration of the boundaries of land and water areas in the palæozoic periods. He remarked that among the earliest rocks, as evidences of former terrestrial conditions, it is not until we ascend as high as the upper palæozoic deposits that we meet with evidences of definite hydrographical areas, and that many terrestrial surfaces of the carboniferous period have remained such ever since. The author then pointed out, that in palæozoic times there existed a main north and south ridge traversing what is now Western Europe, and extending from Scandinavia to North Africa. To the westward of this old range there was another tract, also running north and south, which was even then bounded to the west by the Atlantic valley, and is now traceable in the northern and western portions of the British Isles. From very early times there was an increase of land from this western or Atlantic tract towards the present European area by the successive elevation of the palæozoic sea-beds; and it was shown that this took place along east and west lines, one of which became the axis of an elevation which is distinctly traceable through a long series of geological changes. In proof of these statements, the author alluded to the evidence derived from the geological conditions and formations of England and France, and particularly with reference to the east and west ridge above alluded to: the author remarked that he regarded the absence in France of the Upper Silurian system as having been caused by an east and west barrier cutting off communication with the Upper Silurian zoological group of Shropshire and Scandinavia, and constituting a division between two hydrographical areas, in the northern of which the true Upper Silurian fauna had its development, and in the other what the author considers as its southern equivalent, viz. the Rhenane and Devonian group; and he showed that there was evidence of this barrier in the shingle-beds of the Lower Silurian formation both in Northern France and in Cornwall, which point to a neighbouring east and west coast-line,—in the half arch of cleavage of the chlorite schists of the Prawle, proving the existence of an elevated east and west range of old rocks, now locally destroyed and replaced by the English Channel,—and in the occurrence of an elevatory axis ranging east and west along the southern shores of Devonshire.

The author then proceeded to consider the relation of the coal-beds to this old east and west ridge, which he had traced from the valley of the Ruhr by Aix-la-Chapelle through the Ardennes and the South of Belgium by Liège, Namur, and Valenciennes, accompanied by the palæozoic formations lying on its northern flank, the contour of the old coast-line being more or less clearly marked by the lithological conditions of the conglomerates, grits, sandstones, &c. of the littoral or the deep-sea deposits. The further continuation of this ridge to the westward is proved by the chalk axis of elevation through Artois (passing to the N.W. at a considerable angle to the eastern part of the ridge), and by the denudation of the Boulonnais and of the Weald of Kent and Sussex. At the same time, further to the west, at Frome in Somerset, the identical series exposed in the Boulonnais emerges again in similar unconformable relations, and Devon and Cornwall supply evidence of the western extremity of this old ridge, which united the two great north and south ranges of land, and formed an extensive gulf-like configuration of this Western European area in Palæozoic times. It was along the inner (southern and western) borders of this somewhat semicircular indentation (open apparently to the north) that the great coal-formation had its origin. In other words, the Rhenish and Belgian coal-fields, together with the midland and northern Coal-measures of England, are the remains of a succession of fringing bands of dense vegetation occupying a continuous tract of coast-line. At this period the central gneissic plateau of France was a terrestrial area with lakes and rivers, and supported a rich coal-producing vegetation, the remains of which are preserved in the original depressions in which they were accumulated. The author then pointed out other extensions of ancient land in various parts of Europe, and described the different physical conditions with which they were connected. He showed that the Boulonnais coal belonged to the Mountain Limestone series below the geological horizon of the Franco-Belgian coal. This latter probably underlies the oolitic rocks in the neighbourhood of the Marquise district.

The author concluded his statement by deducing the following inferences:—1st. that the physical configuration of Western Europe at the period of the upper or true Coal-measure period indicates the probable continuity of a band of coal-growth from the midland and south-west of England to the south of Belgium; 2nd. that there may also exist a lower stage of coal-deposits, extending somewhat west of the Boulonnais and of equal value; 3rd. that the influence of the old axis of flexure on the distribution of the oolitic and cretaceous groups, favours the presumption that there is no great thickness of overlying strata interposed between the Coal-measure series and the present surface; 4th. that the upper Coal-measures may be regarded as occupying a line on the north of the Weald denudation, or conforming generally to the direction of the Valley of the Thames, whilst the lower series may occur on a line coincident with the chalk escarpment of that denudation.

However startling these views may at first sight appear to those who expect to find all the intervening strata between the Carboniferous and Cretaceous series, regularly deposited, it has nevertheless appeared to many practical men as not at all exceeding the bounds of probability; and when we recollect how many instances occur of different strata being deficient in various localities, or so thinning out as not to offer any practical difficulty to the solution of the question, the apparent *primâ facie* improbability is greatly diminished. Moreover, when we reflect on the vast practical results which would accompany such a discovery as that of coal in the south-eastern district of England, the truth of which might be tested by judicious borings on a comparatively small scale, we can hardly refrain from expressing a desire that such an experiment should be made. The existence of granite masses stated to have been found in or below the chalk formations of Kent, if indeed they are not transported boulders, would appear to indicate that the crystalline basis of the stratified rocks is, in some places at least, not at so great a distance from the surface as might otherwise have been expected, had all the different stratified formations been deposited in their normal or typical condition, and of the same thickness as they occur in other parts of

England. But whether the suggestion be acted on or not in the present day, we are greatly indebted to Mr. Godwin-Austen for bringing forward the subject, and for bringing his knowledge of the palæozoic rocks of the Boulonnais to bear on the geology of the neighbouring Wealden.

Professor Ramsay read at one of our Evening Meetings an interesting paper "On the occurrence of Angular, Subangular, Polished, and Striated Fragments and Boulders in the Permian Breccia of Shropshire, Worcestershire, &c." This formation, remarkable on account of the imbedded fragments being angular, instead of being rounded as in the usual conglomeratic beds of the Permian and New Red Sandstone formation, had long ago attracted the attention of different geological observers, and various causes had been assigned to account for this discrepancy in the appearance of its contents. The object of Prof. Ramsay, after carefully examining all the localities where these breccias occur in Staffordshire and Worcestershire, and every opening exposed whether by nature or in quarries, is to point out the probable existence of glaciers and icebergs in the Permian epoch. And although it may be premature to consider this statement as correct, or to adopt all the conclusions of Prof. Ramsay, it must be admitted that there is something peculiar in this breccia formation; and there seems no reason for questioning the conclusion which Prof. Ramsay has arrived at from an extensive examination of these scratched and angular boulders, viz. that they have been derived from a considerable distance, and that they have been transported by the agency of water. Nor am I prepared to admit that all the arguments by which it has been attempted to refute the theory of Prof. Ramsay are altogether conclusive. Some of these objections he has noticed in his paper, and more or less satisfactorily answered. We know too little of central heat as yet, or in what proportion, if at all, it has diminished by radiation since the Carboniferous and Permian epochs, to found any safe conclusion on such an argument; still less, even admitting such a supposition as the existence of central heat, do we know the causes from whence it proceeded. It was long considered as a geological axiom, that our earth was before its first consolidation a mass of liquid or viscous igneous matter. But the truth of this so-called axiom has now been seriously called in question, and many geologists are disposed to admit the equal, if not greater, probability of the soft or liquid state of the primitive earth being due to aqueous rather than igneous causes.

But to return to Prof. Ramsay: surely they who would wish to invalidate his arguments on the general ground of the improbability of the existence of glaciers and icebergs during a period when a tropical vegetation is supposed to have flourished in the neighbouring districts, must have forgotten the eloquent description given by Mr. Darwin of the glaciers of South America, when he states*, that "glaciers here descend to the sea within less than two degrees and a half from arborescent grasses, and (looking to the westward in the same hemisphere) less than two from orchideous parasites, and within

* Researches in Geology and Natural History, p. 285.

a single degree of tree-ferns!" The same distinguished writer alludes further on (p. 291), to the importance of the circumstance of a luxuriant vegetation with a tropical character encroaching so largely on the temperate zones, under the same kind of climate that allows of a limit of perpetual snow of little altitude, and consequent descent of glaciers into the sea. In South America glaciers descend into the sea in lat 46° 30′. The occurrence also of those denizens of the tropics, the humming-birds, at an elevation of 10,000 feet above the sea, and along the western coast of South America from the tropics to the forests of Tierra del Fuego, as described by the same author, is another important fact bearing on this argument which cannot altogether be overlooked.

These considerations seem to show, that, even admitting the tropical character of the Permian flora and fauna, which however Prof. Ramsay hardly does, there is no improbability of their juxtaposition with glaciers in lat. 51°, at a period too when we are unacquainted with the relative distribution of land and sea. It appears to me, however, that the strongest argument against Prof. Ramsay's theory, is to be derived from his own account of the breccia-bed itself. Without giving the exact thickness of this bed in any locality, the vast extent of country over which it is distributed, amounting according to the author's own calculation to an area of 500 square miles, and distributed moreover with great regularity, militates strongly against the glacial theory. In ordinary cases we find the glacial detritus either collected in vast irregular heaps or monticules at the termination of the glacier, or distributed in long parallel lines or ridges, of many miles in length, along the edges of the glacier, marking the limit of its action, and accurately defining its extent. I am not aware that the transported matter of glaciers is ever found spread out with the regularity of a real subaqueous formation, as has been the case with these Permian breccia-beds; and even admitting some of these breccia-beds to have been transported by the agency of icebergs floating across the waters and transporting the detritus from a neighbouring shore, the great extent of the beds in question would almost equally preclude the probability of such a solution of this remarkable deposit. Vast *débacles* occasioned by the sudden burstings of the barriers of an extensive inland lake, or violent disturbances of the ocean by the elevation of mountain chains or the sea-bottom, many instances of which must have occurred in various periods during the palæozoic age, appear to me a more simple and satisfactory mode of accounting for the different phænomena described by Prof. Ramsay. During the violent commotion caused by such an agency, the huge masses of rock, accompanied by a sea of mud, would be hurled against each other, and the sharp angles of the disrupted masses might easily impress on the sides of transported boulders those striæ and scratches which have given rise to the theory of their being due to glacial action or to icebergs. The subject, however, is an interesting one, and we may hope that the further progress of the Geological Survey will throw additional light on the causes of the phænomena described by the author of this paper.

Mr. E. Hull has given us an interesting paper "On the Physical Geography and the Drift Phænomena of the Cotteswold Hills," in which he has endeavoured to account for the formation of the valleys and intervening headlands in the Gloucester plain, by showing that the valleys occur in the direction of slight anticlinal lines and the headlands in the direction of synclinal lines having a mean north and south strike. The preservation of Bredon Hill is attributed by the author to a fault traversing the southern side of the hill from east to west. In the second portion of his paper, Mr. Hull points out the existence of several distinct pleistocene deposits, found at intervals over this district. Of these the most ancient is the northern drift, then the estuarine, and last the warp-drift; of the first no traces are to be found on the Cotteswold Hills, which were above the sea at the period of its deposition; but the sands and gravels of which it is composed, derived from the waste of the new red sandstone and carboniferous limestone, are plentifully strewed over the vales of Gloucester and Moreton. The occurrence of boulders of millstone-grit near the southern extremity of the Moreton Valley, is supposed by the author to indicate the southern extension of icebergs brought down by the northern current. The estuarine drift, composed of oolitic detritus and restratified northern drift, was found in the Valleys of the Evenlode, Moreton, Cheltenham, and Stroud, containing the remains of now extinct Mammalia. The warp-drift was found at the height of 600 or 700 feet, equal to that which the northern drift attains, while the estuarine drift is not found at a higher elevation than 300 feet above the sea. Traces of an ancient sea-beach were also found by the author at the base of the inferior oolite escarpment. It was also stated in conclusion, that in order to explain all the phænomena of the drifts and denudations of the country, at least three elevations and two submersions of greater or less amount must be supposed to have taken place.

Some interesting discussions on the Newer Tertiary Deposits of the Sussex Coast have also occupied our attention at the Evening Meetings. Mr. Godwin-Austen and Mr. Martin of Pulborough have each contributed some additions to our knowledge on this subject. Mr. Godwin-Austen fully described several of these beds, which he considers as the glacial deposits of the district. They consist of gravels of different kind, overlaid by brick-earth somewhat variable in its characters. At Selsea, where the glacial deposits are 25 feet thick, the underlying eocene clay is seen at low water perforated by a large variety of *Pholas crispata*?, and overlaid by a deposit containing *Lutraria rugosa*, *Pullastra aurea*, *Tapes decussata*, and *Pecten polymorphus*, contemporaneous with the *Pholades*. This deposit, clayey in places, contains a great variety of pebbles and boulders of granitic, slaty, and old fossiliferous rocks, such as are now found in the Cotentin and Channel Islands. The occurrence of these granitic and slaty blocks in the yellow clay was the principal subject of the paper. The author pointed out the difficulties that lie in the way of supposing that they were derived from the coast of Cornwall or direct from the shores of Brittany or the Channel Islands, and considered that his former observations on the bed of the English Channel had prepared the way for the hypothesis he now advanced, viz. the former existence of a land barrier composed of crystalline and palæozoic rocks, crossing from Brittany to the south-east of England, and forming a gulf or bay open to the west. Into this bay the marine fauna represented by the *Pholades* and their associates extended from the westward, and in the hollow of the bay at a somewhat later period, coast-ice brought the boulders from along the old shore-line, which is now represented by a sunken peak in mid-channel lying south-east from the Isle of Wight, and by a shoal of granitic detritus. The author also alluded to the alterations of level which had subsequently taken place, and the partial destruction of some and formation of other deposits by frequent oscillations. That these huge boulders of crystalline and other older rocks, some of which are more than 20 feet in circumference, have been transported by ice, seems probable enough, but there appears to me a physical difficulty in the way of Mr. Godwin-Austen's theory, that they were stranded in the hollow of this supposed bay. Icebergs or coast-ice charged with such boulders are uniformly moved by currents; and, if this bay were closed up to the eastward, it is difficult to imagine how any current would so set directly into the bay as to strand the floating icebergs in the bight. The same current which brought them in, supposing a current to have set into the bay, would, by sweeping round the coast, have again carried them out to sea; at the same time, the occurrence of these boulders in the drift-beds is of great interest; but, without a more careful comparison of the crystalline rocks on the opposite coast and in the Channel Islands, it would be difficult to decide from whence they may have been brought. It seems probable, however, that the parent rocks will be found in the Channel Islands, or the numerous reefs by which those islands are surrounded.

Mr. Martin, in his paper on some geological features of the country between the South Downs and the Sussex Coast, refers the boulder-drift of Mr. Godwin-Austen to another zone of Wealden drift in addition to those which he had already described as mantling round the nucleus of the Weald, the corresponding parts of which zone he thinks are to be found in the Valley of the Thames. This zone he considers as the remains of the boulder-deposit spread over the tertiary districts of this and the adjoining parts of the North of Europe, before their continuity was disturbed by the upheaval of the great anticlinal axis of the South of England. Mr. Martin regards the country under review as a sectional part of this great anticlinal, and thinks that it must not be considered apart from the wide geological area to which it belongs, and that its phænomena of arrangement and drift belong to the epoch of that upheaval, thus showing the effect of powerful diluvial currents set in motion and assisted at the same time by the dislocations known to abound in this part of our island, and without the aid of which the author considers we can arrive at no satisfactory conclusion respecting the drifts and other phænomena of the denudations and other surface-changes here exhibited.

Amongst the interesting discoveries of fossil remains during the past year, I may mention that of the first example of the subgenus *Bubalus* yet recognized as fossil in Great Britain. It consists of the cranial part of the skull with the horn-cores nearly perfect. Prof. Owen, after a careful examination and comparison with recent crania, stated, that, as far as the materials at his command enabled him to judge, the differences between the fossil and recent Musk Buffalo are not of specific value; he considered that the *Bubalus moschatus* of the Arctic region, with its now restricted range, is the slightly modified descendant of the contemporary of the Mammoth and the Tichorine Rhinoceros, which with them enjoyed a much wider range both in latitude and longitude, over lands that now form three divisions or continents of the northern hemisphere.

Mr. Prestwich has added a communication respecting the gravel near Maidenhead in which these remains were found. A mass of ochreous gravel occupies the Valley of the Thames from Maidenhead to the sea. It consists principally of subangular chalk-flint. The author considers the date of its deposition to be posterior to that of the boulder-clay of Norfolk and Suffolk, and also posterior to the gravel which caps the chalk-plateau traversed by the Valley at Maidenhead. The low-level gravel rests at Maidenhead on chalk-rubble, and the skull of the Musk Buffalo was found, with fragments of other bones, low down in the gravel, where it begins to be mingled with the chalk-rubble.

A communication has also been read to us by Mr. Prestwich on the boring sunk through the chalk at Kentish Town. This boring has pierced the following succession of beds:—London Clay, 236 feet; Woolwich and Reading Series, 61½ feet; Thanet Sands, 27 feet; Middle Chalk, 244½ feet; Lower Chalk, 227½ feet; Chalk Marl, 172 feet; Upper Greensand, 59 feet; Gault, 85 feet; and then 176½ feet of a series of red clays with intercalated sandstones and grits, the total thickness being 1290 feet, and as yet no water had been obtained. It was naturally expected that the sands of the Lower Greensand formation would be found immediately to succeed the Gault. Instead of them, however, red sandy clays have presented themselves, and the important question arises, What are these beds? Are they a local variation of the Gault? Or have the Lower Greensands here assumed a new character? Or have the workmen suddenly got into a new formation? The very few fossils met with in these clays, if indeed they can be depended upon as really coming out of this formation, are in favour of their being Middle Cretaceous, and above the horizon of the Lower Greensand. But the occasional occurrence in the clay of large rolled fragments of syenite, porphyry, basalt, hornstone, and Old Red Sandstone, and its general mineral features, appear to indicate a littoral character for these deposits, and to point to the possible neighbourhood of a ridge of older rocks which have modified the conditions under which the lower cretaceous beds were formed in this area. This question becomes one of great interest in connexion with Mr. Godwin-Austen's theory of the possible occurrence of the carboniferous rocks immediately or nearly under the Chalk of the south-east of England. The further consideration of this important question was referred to a Committee, who will, I trust, be able to report on it at some early future Meeting of this Society. In the mean time it is to be hoped that parties will be found with sufficient enterprise and energy to prosecute the search, until either the water-bearing strata shall have been reached, or the nature of this somewhat anomalous formation shall have been ascertained.

The question of the chemical composition of granite has been carefully studied of late years by Prof. Haughton, and numerous papers on the subject from his pen and that of Prof. Galbraith, have appeared in many of the scientific publications in London, in Dublin, and in Edinburgh. His inquiries have hitherto been almost, if not entirely, confined to the granites of Ireland; and some of the results of his investigations and analyses have been recently brought under our notice in a paper entitled "Experimental Researches on the Granites of Ireland." The first part of the paper described the granites of the south-east of Ireland, which are reducible to three types depending on their chemical and mineralogical composition. The granite of the first type, which Prof. Haughton proposed to call "potash-granite," is found in the main granitic chain of Wicklow and Wexford, and at Carnsore in the south-east of Ireland. The granite of the second type, which is a "soda-granite," occurs at Rathdown and Oulast, and is distinguished from the former by a diminution of silica and an increase of lime and soda. The third granite is peculiar, and is found only at Croghan Kinshela, near the gold mines of Wicklow. It consists of quartz, albite, and chlorite, while the potash-granites of the main chain consist of quartz, orthoclase, and margarodite (mica). The three granitic districts of the north-east of Ireland are then described. They are known as the Mourne, Carlingford, and Newry districts. The granite of Mourne consists of quartz, orthoclase, albite, and a green mica, probably similar to margarodite. The Carlingford granite is a "potash-granite," in which hornblende replaces mica. At the junction of this granite with the carboniferous limestone, a remarkable change takes place in the granite on penetrating the limestone in dykes. From being originally a compound of quartz, orthoclase, and hornblende, it is converted by the addition of lime into a compound of quartz, hornblende, and anorthite, which last mineral was noticed for the first time as entering into the composition of British rocks. The Newry granites belong to the "soda-granite" type, and resemble in many respects the secondary granite of the Wicklow and Wexford districts.

I am not aware that any practical results have yet been obtained from these analyses, and the knowledge of these elementary distinctions in the composition of the granites. Perhaps, as the investigations are extended to the granites of other countries, where their conditions may be different, we shall obtain some information as to the different ages of these differently combined rocks. At all events, we are under great obligations to Prof. Haughton for having undertaken these investigations, already partly carried out by M. Delesse.

I have much pleasure in stating, that the progress of the Geological Survey of the Empire has been most satisfactory during the past year. Under the able superintendence of Prof. Ramsay, no less than 610 square miles in Sussex and Hampshire have been for the first time accurately surveyed, and as the surveyors gradually creep on towards the metropolis, we may confidently look to a further elucidation of those important questions connected with the supply of water to the metropolis, &c., which have already been so ably treated of by Mr. Prestwich and others in their memoirs on the water-bearing strata of London.

A similar extent of surface has also been surveyed in North Wilts, Northampton, Oxford, Warwick, Gloucester, and Berkshire. A large extent of work in the south and middle of England, already previously surveyed, has been inspected and prepared for publication. In the extension of the Survey into Scotland some progress has been made in laying down on the six-inch scale maps the outline and structure of the coal districts around Edinburgh, more particularly of Haddingtonshire and Fifeshire. Nor has the Survey of Ireland under Mr. Jukes been less actively carried on; good progress is making in delineating the rugged, broken, and almost inaccessible coasts of Cork and Kerry. The map on the one-inch scale has also been partly issued by the Ordnance.

Considering these active operations, and the able staff employed in carrying out the difficult and sometimes intricate details connected therewith, it is to be hoped that the Government will not lose sight of the importance of the Institution of which the Geological Survey forms such an important feature, nor of the desirableness of preserving its independent action. The Museum of Practical Geology and the School of Mines is rapidly becoming one of the most important scientific establishments of this metropolis; and when we find the Director-General in constant and direct communication with the different Departments of Government, who are desirous of obtaining from him information which a few years ago they knew not where to apply for,—when the Admiralty require information respecting the wear and tear of our coasts, and the consequent impediments to navigation,—when the Foreign Secretary desires to obtain reports on coal and other minerals from the seat of war,—when the Colonial Minister applies for proper Mineral Surveyors to explore the West India Islands and other Colonies,—or when the Home Government calls for reports on and analyses of our British ores, and particularly of iron, and when we find that the Institution has now brought together for the first time in this country accurate returns of the produce of coal and other minerals, we may form some idea of the importance of this establishment, and may, I think, boldly express the hope that no unnecessary trammels will be interposed to interfere with its energies, or to prevent its direct communication with that department of Government under which it is placed.

With regard to the publications of the Institution, it is a great satisfaction to me to announce that the geological description of the Isle of Wight by the late distinguished palæontologist Edward Forbes is about to appear as one of the Memoirs of the Survey. It will, I doubt not, sustain his well-earned reputation: the task of editing and preparing this work for publication has been undertaken by Mr. Godwin-Austen, whose knowledge of the ground, which he had often visited in company with his lamented friend, renders him most competent to carry out this labour of love.

In addition to this work, a most instructive and valuable Decade on the Echinoderms of the Oolitic rocks, compiled by Mr. Salter and Mr. Woodward from the fragmentary notes of Edward Forbes, is also about to appear*.

It was with much regret that I was compelled last year to announce that the volume of the Palæontographical Society for 1854 had not then made its appearance, but I ventured to state from what I knew of its forthcoming contents, that it would be found fully to maintain the high reputation acquired by its predecessors. The volume has since made its appearance, and I appeal to all who have witnessed its goodly size and still more goodly contents, whether my anticipations have not been fully realized. There is another special merit in this volume which will not be lost sight of, viz. that it contains the completing parts of several important works, which will enable members to arrange them in a more convenient manner for reference and use than that in which they are now placed. In addition to the Permian Fossils by Prof. King, completed in a former volume, we have now the following works completed: 'The Fossil Cirripedia of Great Britain,' by Mr. Darwin, in two parts; the first volume of 'The Fossil Brachiopoda of Great Britain,' by Mr. Davidson; 'The Mollusca of the Great Oolite,' by Messrs. Morris and Lycett; and 'The Fossil Corals of Great Britain,' by Messrs. Milne-Edwards and Jules Haime. Besides these, this volume contains the second part of the 'Fossil Reptilia of the Wealden Formations,' by Prof. Owen; the second part of 'The Fossil Remains of Mollusca found in the Chalk of England,' by Mr. Sharpe; and the third part of 'The Eocene Mollusca of England,' by Mr. F. Edwards.

In his Address from this chair in 1854, Prof. E. Forbes pointed out the great importance to the geological student of the publication of the interesting monographs of this Society; I therefore trust that it will not be inopportune to give a slight account of the contents of this volume.

Mr. Davidson's portion of this volume completes his essay on the Brachiopoda of the Cretaceous formations. It also contains the completion of the genus *Terebratula*, the number of species of which is extended to thirty-three, although the two last are given, apparently without sufficient explanation, as *Waldheimia*, the names in the text and in the list of plates not corresponding. This is

* The decade has been published while these sheets are passing through the press, but I will not trespass on the manor of my successor in the chair by alluding any further to its great merits.

followed by the genera *Rhynchonella* with fourteen species ; *Argiope*, one ; *Crania*, one. To this the author has added a table illustrating the geological distribution of all the British Cretaceous Brachiopoda, the total number of which is forty-nine. In his supplementary observations on the stratigraphical distribution of the species, Mr. Davidson remarks on M. d'Archiac having stated in his 'Histoire des Progrès de la Géologie,' that the British cretaceous strata contain fifty-two species of Brachiopoda ; he observes that his own list of forty-nine greatly exceeds in reality the number of true species recorded in M. d'Archiac's table, inasmuch as at least twenty-two or twenty-four of M. d'Archiac's names are only synonyms, whereas his list contains a number of species new to England and not mentioned in any other publication. Still he admits the possibility of error, and observes that possibly the number of hitherto observed species in the British cretaceous strata may not exceed forty-five, and adds that the correctness of this number must also depend upon the correctness of the age of certain other beds, particularly the Farringdon gravel, a question into which he enters at some length. It is impossible to praise too highly the execution of the seven plates by which this portion of Mr. Davidson's work is illustrated. In the Appendix, and the supplementary additions to the Appendix, the author has introduced certain corrections and addenda, with an additional plate, bringing down our knowledge of the subject to the last moment of publication.

The next essay to be noticed is the second part of Prof. Owen's Monograph on the Fossil Reptilia of the Wealden Formations, containing the order *Dinosauria* and genus *Iguanodon*. The paper is illustrated by nineteen plates, some of very large size, representing different portions of osseous remains of the Iguanodon, many of which are drawn to the natural size. The text descriptive of these illustrations is a favourable specimen of Prof. Owen's well-known power of comparing and elucidating the osteology of the fossil Vertebrata. I would particularly call attention to the lucid manner in which he has pointed out the real analogies and nature of that curious specimen so long considered, on the authority of Dr. Mantell, to be the bony core of the frontal horn of the Iguanodon. Prof. Owen shows, on grounds which appear to be incontrovertible, that this fossil relic is in fact one of the phalangeal bones, and he sums up the evidence he brings forward to show that it belonged to the end of one of the toes instead of to the head of some great Wealden Saurian, by pointing out the characters which separate the gigantic Iguanodon from the little modern Iguana, which has an osseous conical horn or process on the middle of its forehead.

This is followed by the Monograph by Prof. Morris and Mr. Lycett on the Mollusca from the Great Oolite. The specimens are derived chiefly from Minchinhampton and the coast of Yorkshire, and this third part contains the completion of the Bivalves. It is accompanied by seven plates representing the species described, of which I need only say that their execution is worthy of the place they occupy in the volumes of the Palæontographical Society.

Messrs. Milne-Edwards and Jules Haime have contributed a valuable addition to this volume by the completion of their Monograph on the British Fossil Corals. This fifth part of their work contains the Corals from the Silurian formation, the value of which, in a geological point of view, is apparent from their extraordinary abundance and relative importance during the period when the Silurian deposits were formed. As the authors observe, the variety of species is here as considerable as in most of the coralliferous rocks of a more recent date, and what adds to the importance of the study of Silurian corals, is the good state of preservation in which they are generally found; and so abundant are the fossil corals found at Dudley and other localities, that at the present day more than half the species discovered in the Silurian deposits of the West as well as of the East Hemisphere have been found in England, chiefly owing to the exertions of Sir R. Murchison and his followers. The authors then observe that the British Silurian fossils were originally described and figured by Mr. Lonsdale, who referred most of them to the species previously described by Goldfuss from the Devonian deposits of the Eifel; but they add that this supposed identity does not exist in any of the well-characterized species. After comparing the specimens figured by Mr. Lonsdale in Sir R. Murchison's work with those figured by Goldfuss and now in the Poppelsdorf Museum at Bonn, they have ascertained that almost all are specifically different, a conclusion at which M. d'Orbigny had also arrived, and which is further confirmed by the researches of Prof. Sedgwick and Mr. M'Coy.

They add that the British Silurian Corals differ but little from those of Gothland, and very much resemble those from Bohemia, while they are generally distinct from those of the Silurian deposits of North America. The total number of species discovered in the various Silurian deposits amounts to 129, all of which, with the exception of eight, belong to the authors' divisions of *Zoantharia tabulata* and *Z. rugosa*. Of these, seventy-six have been found in England, and about half of these have not been met with elsewhere. Sixty-eight of these British fossils belong to the families of Favositidæ and Cyathophyllidæ, and the only species not belonging to the above-mentioned higher divisions are four Fungidæ. It may also be noticed, that most of them belong to the Upper Silurian deposits. It only remains to mention that sixteen plates accompany this portion of the Monograph, making altogether seventy-two plates of British Fossil Corals.

Mr. Darwin has contributed to this volume a monograph on the Fossil Balanidæ and Verrucidæ of Great Britain, which, with the Lepadidæ already published, complete his work on the British Thoracic Cirripedes. Mr. Darwin observes in his Introduction, that as yet only sixteen species in these two families have been found fossil in Great Britain, and that of these sixteen, nine are still living forms. It is probably owing to the extreme difficulty of identifying the species in these Cirripede families that their study has been hitherto so much neglected, as has been noticed by Mr. Darwin, and this is particularly the case with the Balanidæ or Sessile Cirripedes. Their form depends greatly on their position and grouping. The surface of attachment has a great effect on the form of the shell; for, as the shells are added to at their bases, every portion has at one time been in close contact with the supporting surface. Mr. Darwin observes, that in consequence of the great variability of those features which are generally considered as characteristic, he has been compelled for the identification of species to have recourse to characters which require the closest examination. Moreover, he considers that without an examination of the opercular valves, it is seldom that the Sessile Cirripedes can be satisfactorily determined in a fossil condition. The Balanidæ do not appear to range lower down in the geological series than the Eocene period, when both in Europe and in America they were represented by few species; although they abounded during the Miocene and Pliocene periods. But owing to the difficulty of identifying species the number of nominal species is far too great. Mr. Darwin believes that, if properly examined, it would be found that the whole number of species of Balani in the several tertiary formations, from the Eocene to the Glacial, throughout Europe would not exceed twenty.

Mr. Sharpe's contribution to this volume is a portion of the continuation of his valuable monograph on the Fossil Remains of Mollusca found in the Chalk of England. This portion is still confined to the Cephalopoda, and contains the description of thirteen species of Ammonites illustrated by six plates.

The last and, to many geologists, perhaps the most interesting contribution to this volume is the third part of Mr. F. Edwards's monograph of the Eocene Mollusca, or descriptions of shells from the older Tertiaries of England. In the two former parts Mr. Edwards had described the Cephalopoda and the Pulmonata, or free air-breathing Mollusca. This third part contains an account of the *Prosobranchiata*, one of the two divisions into which M. Milne-Edwards has subdivided the water-breathing Gasteropoda, the other being the *Opisthobranchiata*. With reference to the dental apparatus of the Gasteropoda, to which much attention has recently been paid by many distinguished naturalists for the true identification of genera, Mr. Edwards justly observes, that however valuable it may prove to malacologists, it can only be indirectly available to the palæontologist. The genera described in this part are *Cypræa* eight species; *Ovula* one, problematical; *Marginella* seven species; *Voluta* thirty-one, seven of which have been added by the author himself. With regard to one of these, *V. maga*, possibly the *V. magorum*, Sow., and figured imperfectly by Brocchi as a subapennine species, Mr. Edwards observes that Prof. Beyrich has described a Volute from Westeregeln, *V. decora*, Beyr., so closely resembling this species that it is difficult to distinguish them. Should they on actual comparison or further discoveries prove to belong to the same species, Mr. Edwards observes that the name given by Prof. Beyrich must supersede that given by himself. These genera are illustrated by eight plates by Mr. J. de C. Sowerby. The next Part will commence with the genus *Mitra*, and we are informed by the notices given out by the officers of the Palæontographical Society, that the forthcoming volume for 1855 will contain the fourth Part of the Eocene Mollusca with ten plates. There is, therefore, a reasonable expectation that this work, which has long been anxiously looked for by the students of Tertiary Geology, will now rapidly advance towards completion.

It is impossible for me even to allude to all the valuable papers on British Geology which have appeared in the numerous metropolitan and provincial journals during the past year, many of which are of great importance and deserving careful study.

Foreign Geology.

France.—The volumes of the Bulletin of the Geological Society of France bear ample testimony to the active exertions of our neighbours in the cause of geological inquiry. I regret that neither time nor space will permit me to do full justice to the many able memoirs they contain. I must refer you to the volumes themselves for information, merely premising that the structure of the great Alpine formations, and the geology of the principal secondary formations seem chiefly to have attracted the attention of the French geologists.

Amongst the principal memoirs contained in the Bulletin, I may, however, mention the following:—A Notice on the Age of the lower and middle beds of the Coralline Group (Coral rag) in the department of the Yonne, by M. G. Cotteau. With a complete list of Fossils found in the Coral rag and Oxford Clay.

M. Jules Baudouin laid before the Society a geological map of the district of Chatillon sur Seine, laid down between 1840 and 1855 on the topographical survey of the Dépôt géneral de la Guerre, accompanied by full details of the different formations which occur in that locality.

M. Omboni read a communication on the sedimentary formations of Lombardy, and on the structure of the southern flanks of the Alps, from the Tyrol to the vicinity of the Lago Maggiore. A geological map and section accompany the memoir. M. Omboni has proved the existence in this region of several of the secondary formations of Europe, and particularly of the Muschel-kalk of Werner.

The following formations are described:—1. Recent deposits; 2. Erratic formations; 3. Tertiary; 4. Cretaceous deposits; 5. Jurassic; 6. St. Casciano groups; 7. Triassic; 8. Permian; 9. Carboniferous; 10. Crystalline formations.

The Marquis de Pareto has communicated a notice on the nummulitic formation at the foot of the Apennines.

M. Pomel communicated a geological account of the country of the Beni Bou Said, near the frontier of Morocco.

But I must more particularly allude to an interesting series of papers and discussions respecting the age of the Anthraxiferous formations of the Alps.

M. Scipion Gras* read a long communication on the geological constitution of these beds, and the differences which distinguish them from the Jurassic formation. In the course of this memoir, M. Gras gives his reasons for placing these anthraxiferous beds amongst the transition or palæozoic rocks. He quotes the Verrucano of Tuscany, which they greatly resemble, to support his views, and on the strength of the resemblance between them, as observed by many geologists, and from the fact of true carboniferous fossils having been found in the Verrucano, he places the anthraxiferous beds of the Alps in the same carboniferous horizon.

Some correspondence on this subject subsequently took place between M. Sismonda and M. Elie de Beaumont, with especial references to the age of the Verrucano at Jano in Tuscany. The question of the age of these anthraxiferous beds of the Alps is one which has occupied the attention of every geologist who has visited the country, and a long list of writers and of memoirs is given in the Bulletin, all having reference to this much-discussed question. The last communication on the subject is from M. A. Sismonda, who, in a letter addressed to M. Elie de Beaumont, gives an account of the fossils from the Col des Encombres (Savoy) and the Col de la Madgelaine in the valley of the Stura (Piedmont). They occur on the route leading from Saint Michel-en-Maurienne to the Tarentaise, and confirm the opinion of M. Elie de Beaumont, that the anthraxiferous formation of the Central Alps cannot be referred to a more remote period than that of the Lias. The fossils occur principally at the junction of the dark schistose crystalline limestone with the calcareous beds called *Calcaire de Villette*. The writer concludes that the anthraxiferous beds of the Alps are newer than those of Jano in Tuscany, the latter being below the *Verrucano,* which he identifies with the infra-liassic conglomerate of Valorsine and Ugine, whereas in the Alps the anthraxiferous beds are above the conglomerate. Moreover, the Jano fossils are decidedly palæozoic. The only resemblance between the two formations consists in their flora. But geologists now know that the flora of a formation is not so sure an identification of age as the fauna. It would be an interesting investigation to inquire into the cause of this difference. Possibly vegetable life was not so easily destroyed by the changes in the conditions of life and by the convulsions of the ancient world, as the more delicately organized individuals of animal life, and the flora of one period was thus more frequently preserved and carried on into succeeding epochs.

Now it is generally admitted, that the anthraxiferous beds containing vegetable impressions, supposed to indicate carboniferous species, alternate with Jurassic beds containing Belemnites, &c.; and some geologists have endeavoured to explain this anomaly by local inversion or contortion; the most recent investigations, however, would seem to controvert this view, for the beds are perfectly parallel, and there appears to have been no contortion or folding over of

* Vol. xii. p. 255.

them: the result is, that some authors refer the whole formation, including the Jurassic forms, to the Carboniferous epoch, whilst others refer the whole, including the vegetable remains, to the Jurassic period, accordingly as they attach a greater or less importance to the evidence of Plants or of Mollusca.

MM. Scipion Gras, Chamousset, Ewald, and Michelin refer the whole to the coal-measures, whilst MM. Elie de Beaumont, Ad. Brongniart, De la Beche, De Montalembert, Bertrand-Geslin, Sismonda, Dufrenoy, De Collegno, and Roget (1855) consider the whole as belonging to the Jurassic period. The weight of evidence appears to be in favour of referring the whole formation to the Jurassic rather than to the Carboniferous period.

M. Barrande has also published in the Bulletin* a memoir on the organic filling-up of the siphuncle in some of the Palæozoic Cephalopoda. This phænomenon was first incidentally noticed by the author in the Orthoceratites of the family *Vaginati*. Further researches showed that these were not the only creatures possessing the faculty of secreting an organic substance, for the purpose of successively closing up the space of the siphuncle. An examination of all the ancient Cephalopoda, and particularly the Nautilides, led the author to the discovery that the gradual closing up of the siphuncles takes place, not only in the other groups of the genus Orthoceras, but also in the allied genera of Cyrtoceras, Phragmoceras, and Gomphoceras, &c., and, generally speaking, in all the Nautilides with a large siphuncle; whilst no certain trace of it could be found in those with a narrow siphuncle. The importance of this discovery, both in a zoological as well as in a palæontological point of view, has induced the author to publish the result of his investigations. After describing the different modes in which this closing up of the siphuncles takes place in different groups of Cephalopoda, with particular reference, however, to the various families of Orthoceras, the author concludes with some general observations respecting the object of this phænomenon, and observes, that the study of it leads to results which confirm former opinions respecting the vertical distribution of the Cephalopoda in the Palæozoic formations, and will hereafter further tend to establish a correct geological chronology of these old sedimentary deposits.

M. Jules Haime has communicated to the Academy of Sciences an account of the Geology of the Island of Majorca. The oldest beds he has described belong to the upper and middle groups of the Liassic formation. They contain many characteristic fossils, as *Belemnites umbilicatus, Ammonites Jamesoni, Mactromya liasina, Pholadomya decora, Lima pectinoides, Pecten, Rhynchonella tetrahedra*, &c. He also found Oxford clay with *Ammonites plicatilis* and *A. athleta, Belemnites hastata*, and *Terebratula diphya*. The Neocomian formation has also a great development in this island, with its characteristic fossils. Above this are beds of the Cretaceous epoch, overlaid by others containing Nummulites. This again is overlaid

* Vol. xii. p. 441.

by a freshwater lacustrine deposit, consisting of compact bituminous limestones and marly limestones, interstratified with beds of rich lignite or brown-coal. These beds, M. Haime thinks, may be identified with those of the gypsum of Provence. The fossils appeared to be *Melania laurœa, Planorbis obtusus, Limnœa pyramidalis,* and two new species, *Clausilia Beaumonti* and *Achatina Bouvyi.* Other tertiary beds occur, belonging to the middle tertiaries and of the age of the Sub-apennine marls. The quaternary beds are found on the sea-shore, and their fossils all belong to species now living in the Mediterranean. They occur on the south, east, and north sides of the island, but those on the south side differ from those found to the north.

The fossil evidence thus confirms the views formerly entertained by M. Elie de Beaumont, on the authority of information derived from M. Cambessèdes. These beds, with their imbedded fossils, are still more fully described in the Bulletin de la Soc. Géol. de France, vol. xii. p. 234.

M. Louis Bellardi has published a complete Classified List, or *Catalogue Raisonné,* of the Nummulitic fossils of the district of Nice, in which he has been assisted by Prof. Sismonda for the Echinoderms, by M. d'Archiac for the Foraminifera, and by M. Jules Haime for the Corals. M. Bellardi omits all geological description, referring to M. Sismonda's published work on the subject, and to the intended publication of Prof. Perez. His object has been to describe the whole nummulitic fauna of the environs of Nice, for the purpose of facilitating a comparison between it and the nummulitic formations of other countries. He omits all reference to the age of the nummulitic beds, which he considers already settled by the labours of previous geologists, but he is of opinion that the simple comparison of the fauna of this region with that of the Paris basin proves that it belongs unquestionably to the Eocene period, in accordance with the opinions of MM. Deshayes, Sismonda, and others. The list of fossils contains 372 species belonging to the following classes:—Cephalopoda, 5; Gasteropoda, 115; Acephala, 177; Annelida, 4; Echinodermata, 22; Foraminifera, 17; Polypifera, or Corals, 29; Bryozoa, 2: of which 112 species are found in the Eocenes of the Paris basin, 54 in the London basin, and 48 in Belgium.

M. d'Archiac has published in the Journal l'Institut the outlines of an Essay on the Geology of the mountainous district of the Corbières, communicated to the Philomathic Society in July 1855. The district in question is situated near the Mediterranean, to the south of Carcassone. The general features of the country had been already correctly laid down by M. Dufrénoy and others, but M. d'Archiac observes that he considered it would be useful to rearrange, by means of fresh observations, the facts already known,—to endeavour to classify them in a more methodical manner than had yet been done, by adding certain orographical considerations hitherto neglected, which help to explain more satisfactorily the geological details,—and, finally, to determine several palæontological horizons, the details of which were still imperfect.

The following table will give some idea of the geological series of the Corbière formations as established by M. d'Archiac:—

System.	Formation.	Group.	Etage.
Recent.			
Quaternary.			
Tertiary	Middle ?	Molasse.	
	Lower	Nummulitic	1. 2. 3.
		of Alet.	1. 2. 3.
Secondary	Cretaceous	Upper 1. 2.	1. 2. 3. 4.
		Lower: 3. Wanting.	
		Lower: 4. Neocomian	1. Wanting. 2. 3.
	Jurassic	Lias	Upper.
Transition (Intermédiaire.)	Carboniferous (Coal).		
	Devonian ?		
Primary	Granite.		

Igneous rocks (diorites, amygdaloids and spilites, basalts, wackes, &c.).
Metamorphic or uncertain (dolomite, cargnieule, gypsum, salt ?).

The present paper only embraces the Cretaceous formation; M. d'Archiac reserves for a future opportunity the Jurassic and underlying formations.

M. Constant Prévost has announced to the Académie des Sciences* the interesting discovery in the conglomerate-bed, between the pisolitic limestone and the plastic clay, near Meudon, of the tibia of a fossil bird of gigantic size. This conglomerate had, according to M. Elie de Beaumont, already produced numerous bones and teeth of Mammifers and Reptiles. But this discovery of a Bird was pronounced by M. Valenciennes to be one of the most interesting osteological discoveries made in the Paris basin since the days of Cuvier. The bird belonged to the family of Natatores, and must have been nearly two or three times the size of a swan. It has been called *Gastornis parisiensis*, Héb. M. Hébert subsequently announced the discovery of a femur of the *Gastornis parisiensis*, found in the same bed as that containing the tibia, and within 10 feet of it.

With reference to the paper by MM. Hébert and Renevier on the Nummulitic formations in Switzerland alluded to in my address last year, I may mention that M. Renevier has since published in the "Bulletin de la Société Vaudoise des Sciences Naturelles," a more correct and detailed account of his subsequent investigations of this formation, although he considers that the term Nummulitic is no longer appropriately applicable to the Tertiary strata of the Vaudoise Alps. M. Renevier had originally divided this formation into two beds, viz. the Cerithium and the Nummulitic, of which the Cerithium bed was the more recent. Subsequently, however, he received infor-

* Comptes Rendus, tome xl.

mation that Nummulites were also found overlying the Cerithia. He consequently made a fresh examination of the beds of La Cordaz. This, he considers, has led to a clear and definite result, sufficiently explaining the difference of opinion which had prevailed respecting the relative position of the two formations. The result is as follows :—The bed with large *Naticæ* at La Cordaz, which is the same as the Cerithium-bed of the Diableretz, is intercalated between two nummulitic beds, of which the upper and most recent is by far the thickest. This idea had already been entertained by M. Studer, who had truly anticipated that this bed is only a local appearance, for in many places it is altogether wanting, and the thick bed of nummulitic limestone lies directly on the Gault. With regard to its age, M. Renevier only repeats what he and M. Hébert had already stated; viz. that the Cerithium-bed contains a mixture in nearly equal proportions of the fossils of the Sable de Beauchamp and the Fontainebleau sand. It is therefore probable that this nummulitic formation of the Vaudoise Alps forms a connecting link between the eocene and miocene formations, and thus corresponds in age with the gypsum of Montmartre and the palæotherian fauna of Maurmont.

M. Renevier adds a list of the fossils from those nummulitic beds, containing 70 species; observing that there are from 15 to 20 more, of which the remains are too imperfect to be determined.

M. Ange Sismonda has communicated a letter to M. Elie de Beaumont on the Nummulitic rocks (Bull. Soc. Géol. France, vol. xii. p. 807), in which he gives the results of his brother's palæontological researches on these beds. The nummulitic formation is divisible into two great zones. The lowest has many characteristic species, with a few of those also found in the eocene formation, as the beds of the Corbières, Biaritz, and Nice. The upper zone may be divided according to its fossils into two subdivisions; the lowest of these has also some species peculiar to it, mixed with a proportionately greater number of eocene species. To this belong the beds of Saint Bonnet and Faudon in France, Pernant and Entrevernes in Savoy, Cordaz and the Diableretz in Switzerland, Ronca, Castel-Gomberto and Montecchio-Maggiore in the Vicentin. The upper bed of the second zone contains a much smaller number of species exclusively nummulitic, with a few species peculiar to it, and a certain number of miocene species. To this belong the beds with Nummulites of Acqui, Dego, Carcare, and other places in the valley of the Bormida. Of these two great nummulitic zones M. Sismonda considers the lowest to be anterior to the elevation of the Pyrenees; this is the "Mediterranean nummulitic formation" of M. Elie de Beaumont, whilst that of Acqui is subsequent to this great elevation, and corresponds with the period of M. E. de Beaumont's nummulitic formation of the "Soissonais."

We are indebted to Mr. Daniel Sharpe for an interesting communication on some of the more recent phænomena exhibited in the alpine valleys. Having, during the past summer, again visited the Alps with the view of carrying out those observations which he had so successfully commenced last year, Mr. Sharpe's attention was directed to the numerous phænomena visible in most of the alpine

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valleys and on the mountain-sides, which appeared to indicate the action of the sea at a comparatively recent period. The object of his paper, "On the last elevation of the Alps, with notices of the height at which the sea has left traces of its action on their sides," is to describe the phænomena themselves, and to explain the probable causes by which they have been produced. Mr. Sharpe endeavours to show, that after the alpine region had assumed its present form, and the existing valleys had been excavated, the whole country was submerged below the level of the sea, and stood 9000 feet lower than at present; and that it then rose out of the sea by a succession of unequal steps, separated by long intervals of time, during which the waves produced impressions on the mountain-sides, which are still visible. The effects thus produced are described under three heads. 1st.—The erosion of the mountain-sides in certain regular and definite lines, above which they rise into rugged peaks in striking contrast with the smoother forms below. This physical feature had already been observed by Hugi and others, although attributed to a different agency. Mr. Sharpe shows that throughout Switzerland these lines of erosion occur at three distinct levels, viz. 4500, 7500, and 9000 English feet above the sea; he points out their occurrence in different valleys having no regular communication with each other, and argues that no action but that of water could have produced a uniformity of level over such an extensive area, and that a long period of time was necessary to form such deep indentations on the mountain-sides.

2nd.—The sudden increase of steepness which occurs at the head of every alpine valley is assumed to be due to the excavating action of water standing for a long time at that height. A table was given of the elevation above the sea of the heads of between forty and fifty valleys, at various altitudes; this shows a remarkable correspondence of level between the excavation of the valleys and the lines of erosion at 4500 and 7500 feet, but the ice and snow in the upper valleys prevent all observations with regard to the highest line at 9000 feet.

3rd.—Mr. Sharpe considers the terraces of alluvium in the valleys, in accordance with the opinion of Mr. Darwin, Mr. Yates, and others, to have been formed by detritus carried down into water standing at the level of the head of the terrace. The elevation of many of these terraces is given, and a remarkable correspondence is shown to have existed between the height above the sea of terraces in valleys which have no connection with each other, and of terraces in some valleys with the heads of other valleys.

All these effects might have been produced by a sea surrounding the Alps, but cannot be explained by any other means; and, the level of this sea being assumed to have been constant, the Alps must have been rising out of the waters while these operations were going on. The period of this, their last elevation, is described by Mr. Sharpe to have been after the Tertiary epoch, and a great part of the vast accumulations of sand, gravel, and rounded blocks which are seen in the valleys of the Alps, and covering the lowlands of Switzerland are considered to have been formed by the waves beating against the mountains during their elevation.

Finally, with reference to the question of the angular erratic blocks on the sides of the Jura and in other districts, the author observes that, by showing that the levels at which these blocks are found were below the sea for a long period at the epoch of their removal, he gets rid of the only serious difficulty opposed to the views of those who have supposed them to have been transported by floating ice.

Objections have been raised against some of Mr. Sharpe's views on the ground of no marine remains having been found in the numerous terraces which represent the ancient beaches or sea-bottoms. Much of the force of this objection disappears when we consider the nature of the deposit or detritus which forms these terraces. They consist almost invariably of coarse sand, gravel, and rounded boulders, the movement of which would have prevented the preservation of the delicate shells which the marine waters may have contained. Moreover, the objection is merely a negative one, and when we consider the remarkable fact of the terraces of alluvium occurring at the same height on the opposite sides of the alpine chain, as described by Mr. Sharpe, it appears impossible to doubt their having been occasioned by the agency of water which enveloped both sides of the mountains at the same time and at the same level, and it appears equally certain that this body of water must have been an oceanic body. At all events the existence of such a sea filling up the great Swiss valleys affords a more simple mode of accounting for the occurrence of the angular erratic blocks on the Jura, by supposing them to have been floated across from the central chain on icebergs, than the theory by which they are supposed to have been carried across on glaciers filling up the whole intervening space. It is a similar fact to that of the occurrence of enormous fragments of granite on the island of Chiloe, which Mr. Darwin supposes may have been carried from the main land across the intervening arm of the sea by the same agency.

Views of a nature somewhat different from those of Mr. Sharpe have been advocated by M. A. Morlot in a paper published in the Edinburgh New Philosophical Journal*, "On the past Tertiary and Quaternary Formations of Switzerland." The author of this paper alludes to the numerous terraces that occur at different heights in all the valleys of Switzerland, but he attributes the origin of the diluvial formation or drift of which they consist to the action of the existing system of rivers, when their beds were at a higher level, in consequence of the continent standing lower by several hundred feet. But he adds, if the continent were to be uniformly upheaved once more, the rivers would scoop out a deeper channel in their modern deposits which would then project in the shape of terraces, as is the case with the diluvial drift. Without stopping to examine this apparent contradiction of rivers forming the diluvial deposit and then scooping it out, I will mention that the main object of the author's paper is to point out the existence of two glacial periods

* Vol. ii. 1855, p. 14.

separated by an intermediate diluvial period, during which the glaciers, which had not only covered up a great portion of Switzerland, but the vast lowlands of Northern Europe, disappeared even in the principal valleys of the Alps to a height of at least 3000 or 4000 feet above the present level of the sea. And this diluvial period after a long duration was again succeeded by a second glacial period, during which the alpine valleys were again taken possession of by the glaciers, though to a much more limited extent, the great glacier of the Rhone not extending beyond Geneva, and standing at Vevay full 2500 feet lower than the first glacier. The principal proof of this statement the author finds in a section discovered by himself in the neighbourhood of Clarens, where the superincumbent diluvium, 7 or 9 feet thick, forming part of a terrace 100 feet above the lake, rests upon the glacial deposit at least 40 feet thick, consisting of compact blue clay containing worn and scratched alpine boulders, thus showing the existence of the first glacial period before the diluvial drift was deposited, while evidence of the second glacial period is found in the abundant deposits left on the diluvial terraces.

The subject is one of great interest, but at the same time of considerable difficulty, nor is it quite clear how the author makes out that the deposits of the second glacial period have been left on the diluvial terraces which overlie the first glacial deposits, when he endeavours to show that the second glacier stood so much lower than the first.

Prof. F. J. Pictet has published during the past year the third number of his work called 'Matériaux pour la Paléontologie Suisse,' or Collection of Monographs of the fossils of the Jura and of the Alps. It contains, 1st, the Eocene vertebrated animals of the Canton de Vaud, and 2ndly, the fossils of the Aptian system, giving in the first instance the bivalves and univalves. We may congratulate ourselves on the progress of a work which, by uniting together all the fossil remains of Switzerland, with good descriptions and accurate engravings, will be of great assistance in promoting the study of Palæontology.

Germany.—It was stated in my address last year that Sir R. Murchison and Mr. Morris had communicated to the Geological Section of the British Association at Liverpool a short notice of their observations on the palæozoic rocks of the North of Germany, viz. in the Hartz and Thüringerwald; and that a full account of them would shortly be laid before this Society. This pledge has been fully redeemed, and we have had laid before us from these gentlemen a most interesting and valuable communication "On the Palæozoic and their associated rocks of the Thüringerwald and the Hartz." Although I then gave a slight sketch of some of their observations, I cannot now omit giving a short summary of the recapitulation with which the authors have concluded this important paper.

They have shown that of the two districts described, the Thüringerwald alone exhibits any of the oldest sedimentary rocks, the strata containing the lowest Silurian fossils being there underlaid, as in Great Britain and Bohemia, by vast masses of slate and sandstone, in which no forms of a more composite structure than Fucoids have yet been detected. These bottom rocks and the superposed Lower Silurians of that tract were, it appears, elevated into dry land, and placed during a long period out of the reach of sedimentary influence, since none of those strata of the unequivocal Upper Silurian of Bohemia, or the Lower and Middle Devonian, which are so much developed in the Hartz, are to be seen in the Thüringerwald.

Towards the close, however, of the Devonian era, both tracts were again covered by a sea in which animals lived differing from all those which preceded them, whilst the recesses of that ocean, whether in this region or in the Rhenish provinces, were spread over by volcanic dejections which were interlaminated with ordinary submarine beds. These were followed by other accumulations of mud and sand, in which thin courses of coal were formed out of the transported stems, branches, and leaves of land-plants.

After these lower carboniferous beds had been accumulated, a great upheaval took place over all those parts of Germany and France where such strata occur, raising them up with those which had preceded them. The next sediments formed on the edges of all that preceded them are the feeble equivalents of our upper coal-fields, and these were succeeded by the rothe-todte-liegende or lower red sandstone. And here the authors observe that our country offers no example of that great break between the lower and upper divisions of the carboniferous group which is so very dominant a physical feature throughout Germany and France.

It was after the deposition of the lower red sandstone that one of the most striking of the physical revolutions of this portion of the crust of the earth took place in the change of the geographical direction of the masses of rock, from their normal alinement of N.E. and S.W. to one trending from N.W. to S.E., the turbulence of the period being decisively marked by great outbursts of porphyry and the extravasation of vast sheets of porphyritic lava.

The authors then observe that it is evident from the disturbed condition of the secondary strata between the Thüringerwald and the Hartz, as well as from similar appearances to the north of the Hartz, that each of these older masses was for a long period an area of upheaval and oscillation, by which the interjacent formations were thrown into the plicated forms which they still exhibit. The authors further infer that there are in the Thüringerwald proofs of ancient movements of which no trace is to be found in the Hartz, thus affording evidence of the truly *local* character of such disruptions.

It is also observed, that, while each of these tracts presents some marked analogies with the Silurian basin of Bohemia, each differs more from that tract than they do from each other. In their great fundamental rocks of greenish and talcose grauwacke, the South Thüringerwald and the district of Prague agree, as well as in the chief mass of the Lower Silurian rocks, though the fossils of the primordial zone of Bohemia have not been found in the Thüringerwald, and all the Lower Silurian is wanting in the Hartz; and the rich Upper Silurian limestones of Bohemia have no true representatives in Thuringia. Again, whilst the Hartz contains all the members of the Devonian rocks, with a copious development of the Lower Carboniferous, and whilst the Thüringerwald possesses neither the Central nor Lower Devonian bands, none of these formations have yet been found in Bohemia, where the Silurian rocks are at once and abruptly followed by the upper coal-beds.

We thus see at what different epochs the breaks occur in the older rocks of Germany and France, and in the palæozoic series of Great Britain. But the authors observe that, notwithstanding all these differences, whether consisting of such local dismemberments or varied lithological conditions, the four natural palæozoic groups of Russia, Scandinavia, Germany, and France have been perfectly assimilated to their congeners in Britain; so that, despite of great breaks in each natural division of these regions, the classification by means of Silurian, Devonian, Carboniferous, and Permian remains is everywhere maintained.

I would direct the careful attention of those geologists who may be disposed to connect the great and general mutations of life with disruptions and disturbances similar to those here alluded to, to the concluding observations of this paper. The authors state that, in Germany no physical dismemberment has been observed which separates the upper palæozoic strata, accumulated at the close of the Permian epoch, from the lowest mesozoic strata, formed during the earliest period of the Trias, the summit of the one being everywhere conformable to the base of the other; and yet the change of life which took place at that period of quiet physical transition was absolute and complete.

It does not however necessarily follow (and I am not certain whether the authors mean to infer it or not), that these Upper or Triassic beds immediately followed the deposition of the Permian. For, although no disturbances or change of inclination of the strata may have taken place, an indefinite period of time may have elapsed between the deposition of the two formations; that such was the case is indeed rendered probable by the great change of organic life observed between these two formations. But no evidence of such a lapse of time would be forthcoming if the lower bed had maintained its horizontality during the intervening period.

We have not yet received the completion of the text of the Drs. Sandberger's work on the 'Fossils of the Rhenish Devonian System in Nassau,' but I understand that we may soon expect it. In the mean time, Dr. G. Sandberger has forwarded to me a catalogue of the principal fossils figured in it, and which may serve as characteristic types of the formation. To this he has added a table of contents, from which it appears that the following organic remains are to be described in the work:—

	Genera.	Species.	Newly described.
Pisces	2	2	
Crustacea	11	19	6
Annulata	2	8	5

	Genera.	Species.	Newly described.
Mollusca :—			
1. Cephalopoda	9	78	47
2. Gasteropoda	18	80	40
3. Pteropoda	4	13	7
4. Pelecypoda	23	53	27
5. Brachiopoda	18	54	11
6. Bryozoa	5	7	5
Echinodermata	15	18	10
Polypi	10	15	1
Amorphozoa	1	1	1
Plantæ :—			
P. cellulares	5	5	
P. vasculares	7	11	
Total	130	364	160

—thus affording an immense addition to our knowledge of the palæontology of this formation. This is followed by a geological description of the different beds which constitute the formation, and a tabular view of the distribution and development of the Rhenish or Devonian system, and its principal members throughout the world.

M. Barrande has published, in the 'Transactions of the Bohemian Society of Science,' an interesting account of the parallelism between the Silurian deposits of Bohemia and Scandinavia, in which he points out, first, with regard to stratigraphical conditions, the thinness of the Silurian beds in Scandinavia, as compared with their vast extent and development in Bohemia. According to M. Angelin and Sir R. Murchison, the beds of Scandinavia are not above 1000 feet in thickness, whereas those of Bohemia are probably fifteen times as thick. It also appears that the sedimentary deposits of the two countries were formed under very different local influences, both with regard to the nature of the elementary substances constituting the rocks themselves, as well as with respect to the vertical arrangement of these substances. Moreover, the palæozoic beds of Scandinavia have almost universally preserved their original horizontality, while the analogous deposits of Bohemia have been much elevated and disturbed even before the commencement of the carboniferous period.

With regard to the palæontological relations between the two countries, Scandinavia has not yet afforded nearly so many species as the smaller basin of Bohemia. The different classes of animals also offer remarkable contrasts between the two countries, one species being more abundant in one country, and another preponderating in the other. The great development of Crustacea is a remarkable feature of the Silurian fauna of both countries, and particularly of Scandinavia, where no less than 350 species of Trilobites have been registered by M. Angelin, while those of Bohemia only amount to 275. In general, however, there is a great resemblance in the *facies* of the fauna of the two countries, with the sole exception of the fish, one species of which has been found in Bohemia, but none in Scandinavia. In neither country have any remains of land or freshwater Mollusca been discovered, or even traces of land vegetation.

After giving a detailed comparison of the nomenclatures followed in the description of the fossils, and of the local beds and their peculiar fossils, as well as of the general fauna itself in the two countries, the author sums up with certain general conclusions, in which he observes that it would be difficult to find two countries, offering at the same time such striking contrasts in the details and such harmony on the whole, as Bohemia and Scandinavia. Some of these contrasts are very remarkable. Out of 2500 or 3000 species found in the two countries, there are scarcely any identically the same. Thus, out of 350 Trilobites in Scandinavia and 275 in Bohemia, there are only six forms common to the two countries.

After pointing out other contrasts and analogies, the author states that these observations have led to the refutation of two opinions hitherto almost universally accepted. The one is that the earliest created beings belonged to a class of organic life holding a very low position in point of organization. This is disproved by the high degree of development of the Trilobites, which evidently represent the earliest living creation on the globe. The other is the generally received opinion of the almost universal diffusion of the same fauna, in the older beds, over all the seas of the ancient world. The comparison of the faunas of Scandinavia and Bohemia shows that organic life in the oldest periods was subject to the same limited and exclusive laws of distribution and settlement as are observed in the present day. This is particularly the case with the Crustaceans. The Brachiopoda alone appear to have had a more universal extension in the Silurian epochs.

Prof. Girard of Halle has published an interesting volume on the Geology of the North German Plain, particularly between the Elbe and the Vistula, accompanied by a geological map of the country between Magdeburg and the Oder. This district comprises those localities in which the Tertiary formations of North Germany are being now so successfully worked out by Prof. Beyrich and others, and we therefore hail with pleasure any additional information on the subject. The author is Professor of Mineralogy at Halle, and, except in so far as general remarks are concerned, does not appear to have given much attention to the palæontology of the country. The work is divided into three parts, the first of which is a geographical and orographical description of the country, containing an account of its principal physical features — hills, valleys, and river-courses. There are curious speculations regarding the former course of the Vistula through the lowlands to the west of its present line, and the possibility of the Oder having also been similarly affected. After describing the different ranges of hills, which partly intersect and partly bound the district in question, the author concludes the first portion of his work in the following words :—“ To recapitulate the foregoing sketch of the East German lowlands, it represents, as we have already stated, a triangle, the southern side of which is formed by certain ridges of hills equally extended and but slightly separated, whilst the north side consists of a chain of hills broken up by numerous gorges ; between these hills a flat extent of country stretches away, which towards the east assumes the character of a marshy plain, and towards the west that of a much interrupted undulating table-land. The waters of the Polish and German mountains flow into this low plain from the south and from the east, first pressing themselves along its southern barriers until they find an opportunity of breaking through them, and reaching the intermediate lowlands, and then either following the general inclination to the north-west, or finding a shorter outlet into the sea between the northern ridges."

The second part gives a systematic view of all the geological formations which occur in the district; especially those existing along the southern or northern boundaries, although occasionally a few insulated outliers are met with, as the island of Heligoland, the rocks of Lüneburg, &c. No crystalline rocks have been found. The oldest formation is that of the Trias, the Bunter Sandstein of which forms the whole of the island of Heligoland, whilst at a distance of upwards of a hundred miles to the south-east, the similar rocks of Lüneburg are found in the direct continuation of the line of strike. The rocky reefs on the east side of the island of Heligoland show the regular series of overlying formations, all dipping to the north-east or east-north-east, consisting of Muschelkalk, Middle Jura, Hils-clay or Gault, and above it the White chalk. The following formations are then fully described by the author. 1. Trias formations. 2. Jurassic. 3. Chalk. 4. Tertiary. The insulated occurrence of some of these formations at great distances from each other over this vast tract of country is very remarkable. They point to the former existence of islands, and of reefs in the tertiary seas, by which they were partially worn down and covered up. The occurrence of the Coral-rag or Upper Jura on the banks of the Vistula, and at a great depth, discovered in boring for salt, is pointed out as singular, being the only instance of this particular member of the Jurassic formation having been found in this part of the continent, inasmuch as the Jurassic rocks to the eastward, in Courland, Lithuania, and Russia, are described by Murchison, De Verneuil, and Keyserling as belonging to the Lower and Middle Jura formations.

The consideration of the Cretaceous formations follows next. The author points out the important differences which existed between the physical character of the two cretaceous seas, the one of which occupied the Mediterranean basin and the South of France, the other extending from England and the North of France between Germany and Scandinavia into Russia; but I do not understand on what grounds the author assumes that this northern cretaceous sea (p. 54) had no communication with the Western and Southern Ocean. What barrier existed to the west or north-west to shut off its communication with the Atlantic?

Of the Tertiary formations, the Brown-coal deposits are considered by the author as the oldest, and he adopts Von Buch's opinion that there is only one brown-coal formation in Europe. Yet he admits that there are certain brown-coal formations, which, both from the positions in which they are found and from their organic contents, must have been caused by totally different agencies. He considers the brown-coal generally as a marine deposit, and to have been occasioned by the heaping together of drift-wood on the sandy bottoms of the ancient seas, and does not admit that any great change of level took place between the cretaceous and tertiary deposits. Next in importance is the Septaria-clay, with its numerous fossils, overlaid by diluvial deposits; these the author divides into northern and southern formations.

The third portion of the work is occupied with the geological description of particular districts.

Prof. Girard has also published during the past year another work entitled 'Geological Wanderings.' It consists of a series of letters written in the preceding year, in which he has described some of the chief geological features of parts of Switzerland, particularly the Valais and neighbouring districts; the Vivarais and its older rocks, basalts, and volcanoes; and finally, the Velay and Le Puy, in which many of the phænomena connected with the igneous and plutonic rocks of that interesting district are described and analysed. One of the author's chief objects in the Velay was to inquire into the extent and origin of the basalts, and he found there, as in the Vivarais, that these rocks were much older than the volcanos, and that they were entirely independent of them; he also found that the volcanic mountains of the Velay consisted solely of scoriaceous outbursts, and that no lava-stream had flowed from them; in this respect confirming the observations of former travellers.

Dr. Guido Sandberger of Wiesbaden has recently published in the 'Journal of the Nassau Society for Natural History,' an account of the first discovery of a species of *Clymenia* in the Cypridina-slates of the Devonian system, near Weilburg in Nassau. For many years Dr. Sandberger and his brother had in vain sought throughout this formation, and particularly in the limestone-masses contained in the Cypridina-slates, for the genus. This discovery is the more interesting, as it confirms the identity of this deposit with the Cypridina-slates of other districts.

One species only has as yet been found in Nassau, and that is new; the name of *Clymenia subnautilina* has been given to it. The genus *Clymenia* was originally proposed by Count Münster, and we are already indebted to Dr. G. Sandberger for a notice in the 'Bulletin de la Société Impériale des Naturalistes de Moscou' of 1853, giving an account of the nature and characteristics of *Clymenia* and the allied form of *Goniatites*. Some interesting remarks on the analogies between these two genera, by Dr. Sandberger, will also be found in his memoir on the "Organization of Goniatites," in the 'Journal of the Nassau Society for Natural History,' 1851. In the notice under consideration, the author alludes to the measurement of the thickness of the whorls of this species of *Clymenia* by means of the Leptometer, an instrument invented by himself for the purpose of measuring thin bodies, which could not be got at by any ordinary ruler or compasses. He observes in a recent communication that he has given it this name (from λεπτὸς, *thin*), on account of its being adapted to measure the thickness, slope, and taperness of all possible minute and thin flat bodies, whether concave, convex, or flat, or any combination of these forms, as well as the dimensions of irregularly formed bodies. It is also applicable to the measurement of crystals and minute objects of natural history, and to other purposes connected with the arts and industrial pursuits. Even the thickness of a sheet of paper may be ascertained by means of it. Dr. Sandberger has presented one of these instruments to this Society, to which I have already had occasion to direct your attention, and for which our best thanks are due to him.

During the past year Prof. Beyrich has published, in the 'Journal of the German Geological Society,' the third part of his work on the shells of the tertiary formation of the North of Germany. The genera described in this part are *Tritonium*=*Triton*, Lam., 7 species; *Murex*, 14 species; *Tiphys*, 4 species; *Spirilla*, 1 species; *Leiostoma*, 1 species; *Pyrula*, 6 species. It is impossible to overrate the importance of this work, and when we consider the attentive care which Prof. Beyrich has brought to bear on the task he has imposed on himself, we are justified in looking forward to its completion as the inauguration of a new epoch in our knowledge of the North German Tertiaries and of their relations to those of Belgium, France, and England. I have fully alluded to this question on a former occasion; I will therefore now merely recal to your attention the objects which Prof. Beyrich had in view in undertaking this work. When he first began to direct his attention to this subject, he soon perceived the insufficiency and incorrectness of all the previously existing catalogues or lists of names of the molluscous fauna of the tertiary beds of North Germany, and how ill-adapted they were to enable the geologist to establish a correct comparison between it and the fossils of other countries. They were generally unaccompained by illustrations. This evil had been already acknowledged by the Imperial Geological Institute of Vienna, who had charged Dr. Hörnes with the preparation of a separate work on the fossil shells of the tertiary basin of Vienna, in which not only the names, but full descriptions and accurate drawings of all the species should be given. What Dr. Hörnes had undertaken for the Vienna basin, Prof. Beyrich proposes to accomplish for the North of Germany.

"It is my intention," observes Prof. Beyrich in the first part of this work, "to extend my observations to all the tertiary formations which have been discovered from the frontiers of Belgium and of Holland, eastward through Germany as far as the Oder. All these formations belong undoubtedly to one series of deposits closely connected with each other, and of which the faunas are so intimately allied by numerous gradations, that the removal of any single member from the series would destroy the continuity of the whole. In order to have a clear insight into the relative connexions of deposits which occur at such various and distant points, we must bring together for comparison the fossils from the neighbourhood of Düsseldorf, Osnabrück, and Bünde, those of Hildesheim and Cassel, those of Lüneburg and the island of Sylt, as well as those from the neighbourhood of Magdeburg, and from the Marches of Brandenburg. We must also examine the tertiary shells which have been transported into new positions in the diluvial deposits, in order to obtain a perfect view of the molluscous fauna of the tertiary seas of the North of Germany."

It is well known that Prof. Beyrich and others have looked upon these German Tertiaries as Lower Miocene rather than Upper Eocene. He has founded this opinion on the fact that the oldest Tertiary formation in this part of Germany, which he calls the Magdeburg Sands, agrees most with that of Lethen in Belgium, which belongs to the lower portion of the Système Tongrien, and immediately overlies the Système Lackenien, the uppermost of Dumont's five systems, which, taken together, are the equivalents of the Paris Eocene formations up to the sand of Beauchamp, and of those of England up to the Barton clay. In the last part of his work now under consideration, Prof. Beyrich explains the reasons which have induced him to adopt a new term to denote this particular formation instead of that of Lower Miocene which he has hitherto used.

He observes, "Since I determined in the introduction of this work, contrary to the views of Lyell, to call the North German equivalents of Dumont's Tongrian and Rupelian system Lower Miocene rather than Upper Eocene, the contents of the separate faunas, which all belong to the same system, have been greatly increased by the communications which I have received from all directions. The independent separation of these faunas, both from the Eocene below, as well as from the Miocene above, with which they are only connected at their respective limits by a greater number of common species, has been thoroughly established at every successive step of the inquiry. I have, therefore, thought it desirable to recognize this peculiar Tertiary group as a separate independent formation, by giving it a new and specific name. For this purpose I proposed, in a former Memoir on the position of the Hessian Tertiary formations, the name of Oligocene, a word in evident etymological connexion with the universally adopted terminology of Lyell, and also expressing an idea between Eocene and Miocene."

This proposal of Prof. Beyrich is, perhaps, under the circumstances, the best that could be adopted. It is an additional proof of what has been already advanced in these rooms respecting the impossibility of fixing precise limits between different formations, and of the probability that as our knowledge increases we shall be compelled by degrees to abandon all those breaks and subdivisions which were formerly looked upon as the legitimate boundaries between successive geological periods. It is a term which may be appropriately applied to the formation of the Mayence basin, for which I have also advocated the term of Lower Miocene instead of Upper Eocene, inasmuch as it recognizes that formation as marking the commencement of a new series of deposits, in accordance with the facts themselves, rather than the conclusion of an old series; and at the same time it meets the views of those who were unwilling to recognize a Miocene *facies* in the fossils of that region.

In the course of last summer I communicated to the Society a short notice from Prof. Beyrich, in which he observed, with reference to my observations on the brown-coal of North Germany, that no German geologists had ever stated that the Septaria-clay had been found *under* the brown-coal, and that I was consequently in error in assuming the existence of two distinct brown-coal formations, the one above and the other below the Septaria-clay formation of Berlin, Magdeburg, &c., as I had asserted in my Address from this chair last year. In making this communication, I observed that this correction of what I had supposed to be the order of stratification in North Germany would be attended with important results, as we could in this case no longer recognize that connected system of superposition of strata which I believed had been made out between the Westeregeln beds near Magdeburg (*Tongrien inférieur* of Dumont), and the more recent Miocene formations of the Vienna basin. I also stated that I trusted that the exertions of the many able German geologists now engaged in the investigation of the Tertiary formations of Germany, would soon enable us to ascertain more correctly the true connexions between the tertiaries of North Germany and the younger deposits of the Vienna basin.

I have consequently been much interested in finding in the last volume of the Journal of the German Geological Society* a communication from Dr. Koch to Prof. Beyrich, in which he states that in the course of a geological examination of the districts of Carentz and Conow in the neighbourhood of Dömitz, he had discovered a Septaria-clay formation. A subsequent visit, after the clay beds had been further opened out, procured him some interesting and characteristic fossils, proving it to belong to the true Septaria-clay. Amongst these were *Nucula Deshayesiana*, Nyst, *Lucina unicarinata*, Nyst, or *L. obtusa*, Beyr., *Pleurotoma subdenticulata*, Münst. Goldf., with a cast of a *Nucula* resembling *N. Chastelii*, Nyst, besides many well-preserved species of *Foraminifera*. The position of these beds led Dr. Koch to the conclusion that they *underlie* the brown-coal formation, which is extensively developed in that district. Should the further inquiries which Dr. Koch intended to make at a subsequent period confirm this statement, it will show that, contrary to the hitherto-received opinion of the German geologists, there really does exist a brown-coal formation superior to the Septaria-clay, and it may possibly turn out after all, as there is as yet no positive evidence against it according to Prof. Beyrich's own remarks, that the brown-coal formation of Brandenberg really does occupy the position I had originally assigned to it. At all events, there is still a wide field open for future investigation and discoveries in the Tertiary formations of North Germany.

With regard to Southern Germany, however, there is no doubt of the existence of brown-coal of a much younger date. I find in the *Neues Jahrbuch* of Leonhard and Bronn for 1855, p. 206, a statement that Prof. M. P. Lipold describes the brown-coal of Wildsfluth in Upper Austria, in the district of the Inn, as belonging, according to the vegetable remains it contains, to the upper division of the Tertiary formation, and that it must therefore be considered as

* Zeitschrift der deutschen geol. Gesellschaft, vol. vii. part i. p. 11.

belonging to the newest brown-coal. In the account of the mining-industry of Austria, recently published, there is a place called Wildshut on the Salza, entirely agreeing with this description, where a seam of coal, 9 feet thick, is worked. This is probably the same place as that alluded to by Lipold, of which I have not been able to find any further notice.

I must refer you to the Journal of the German Geological Society for other valuable papers on various points connected with the progress of geology during the present year. You will find in one of the last numbers, received only a few days ago, an important communication from Dr. Bornemann of Mühlhausen, on the Microscopic Fauna of the Septaria-clay of Hermsdorf near Berlin. The author has increased the number of species of *Foraminifera*, from this locality alone, from 62 given by Prof. Reuss, to 117; of the 55 new species, 47 are absolutely new, and they mark a decided difference between the Tertiary formations of the North of Germany, and those of the Vienna basin. The number of species of *Entomostraca* has also been increased from 2 to 15.

The remarkable mass of igneous rocks called the Kaiserstuhl, in the valley of the Rhine, between Strasburg and Basle, must be well known to all geologists who have visited that part of Germany. It is known to all German mineralogists as the best locality for many interesting and scarce minerals. Prof. Sandberger informs me that metamorphosed Tertiary formations containing fossil plants, such as *Daphnogene polymorpha*, have been found in it, wedged in amongst the basalts; these tertiary beds must therefore have been broken up by the igneous outbursts. The bed which overlies the pisolitic iron-ore (Bohnerz) of Kandern contains the same plants, and is in fact undistinguishable from the leaf-bearing sandstone of the Mayence basin. I may here also mention, that most of the fossils of the Alzey fauna have been found near Kreuznach, in the barytic sandstone of the Hardt. Hitherto only a few of the Mayence basin fossils had been found in that locality. And finally he informs me that the land and freshwater shells of Wiesbaden have been found near Gratz, but unfortunately not yet in contact with the marine beds of the Vienna basin.

I have now to call your attention to two valuable papers by Prof. Ludwig of Mannheim, well known for his geological investigations respecting the southern slopes of the Taunus, and his intimate acquaintance with the geology of the Wetterau. They are published in the last yearly Report of the Wetterau Society for Natural History at Hanau. The first is on the connexion between the Tertiary formations in Lower Hesse, Upper Hesse, in the Wetterau, and on the Rhine. Recognizing the marine sands of Alzey as the oldest of these formations, Prof. Ludwig points out the different localities at which the various formations occur, and the relative positions of the marine, brackish, and fresh-water deposits; and to all who take an interest in the tertiary geology of Northern Germany this memoir will be of the greatest use. Looking, however, to the physical structure of the country, he does not consider, notwithstanding the close approach of the fossils of the Alzey marine beds to those of Hesse-Cassel and Magdeburg, and others, that there was any direct communication between the two seas. The Gulf of Alzey he considers to have been probably in immediate connexion with the Mediterranean or Southern Ocean; he suggests that the molasse of Switzerland may have formed a portion of the same formation, and that its waters did not extend northwards of the Taunus and the Hundsrück. The marine beds of Cassel, on the other hand, belonged to the southern prolongation of a northern ocean. Considering the large number of fossils in these Alzey beds, which have been identified with those of the North of Germany and of Belgium, I think this complete separation is somewhat doubtful.

The following table appended to the memoir will show how Prof. Ludwig arranges chronologically the different tertiary formations of Germany:—

A. Pliocene.
   Basalt clay; brown-coals of Dorheim and Annerod.

B. Miocene.
1. Système Bolderien of Belgium. The dark sandy clays of Winterswick in Holland; near Bockholt in Westphalia; from Celle near Güstitz, north of Perleberg in Preignitz. Wanting in Hesse and on the Rhine.
2. Steinberg shell-sand, marine sand of Crefeld, Osnabrück, Bünde, Hildesheim, Alfeld, Luithorst, Guntersen, from Reinhardswald, Hesse Cassel, and Wilhelmshöhe.
3. Système rupelien supérieur. Clays of Boom, septaria-clay of Celle, Hohenwarth near Magdeburg. Görzig near Köthen, Hermsdorf, Freienwalde, Bukow, Joachimsthal, Stettin, Oberkaufungen Neustadt, Eckardroth.

   Brackish and freshwater formations of the same age. Leaf-sandstone partly, Littorinella-limestone, blue clay, the most recent brown-coal formation of the Vogelsberg.
4. Système rupelien inférieur. Marine. Pectunculus-bed of Bergen in Belgium, Alzey sands. Sandstone with *Ostrea longirostris* of Bad Sulz, marine molasse of Switzerland.

   Brackish and freshwater formations. *Cyrena*-marl, *Cerithium*-beds with brown-coal and impressions of leaves (leaf-bearing sandstone in part) from the Rhine-Wetterau basin; clays with *Cerithium*, *Littorinella*, and *Melania*; brown-coals of Lower Hesse as far as the neighbourhood of Marburg.

The second paper contains a list of all the tertiary fossils found in the Wetterau arranged stratigraphically, and describes the relations of the different formations in which they occur. This paper is also one of great merit, and, in recommending it to the notice of tertiary geologists, I will only observe that I cannot find any satisfactory reason for considering the *Cyrena*-marls and *Cerithium*-beds to be of the same age as the marine sands of Alzey. There can be no doubt that near Weinheim and Alzey, the blue clays with *Cerithium* and *Cyrena* overlie the marine sands of Alzey, and I do not understand why Prof. Ludwig should assume a different chronology with respect to the beds of the Wetterau where the marine sands do not occur.

The Imperial Geological Institute of Vienna has, on the occasion of the Universal Exhibition at Paris, published an interesting volume respecting the mines and mineral wealth of the Austrian empire, entitled, "Geological View of the Mining Industry of the Austrian Monarchy," prepared and arranged by Herr v. Hauer and Herr Foetterle. It is well arranged under the different heads of metals, iron (special), salt, coal, &c. This is preceded by a geological sketch of the Empire divided into four great groups or districts. These are—1. Bohemo-Moravo-Silesian district; 2. Alpine district; 3. Carpathian district; 4. Tertiary and alluvial plains. All the geological formations occurring in each are systematically arranged and their geographical boundaries pointed out, with a sketch of the principal physical features of each formation. It is impossible to estimate too highly the importance of the work as a book of reference for the geological formations of the different portions of the Austrian Empire.

We are greatly indebted to Count Marschall of Vienna for having undertaken to supply us with MS. notes of the proceedings of the Imperial Geological Institute of Vienna, by which we have been put in possession of their proceedings long before the printed notices could otherwise have reached us. In one of his recent communications to Mr. Jones, who is the channel through whom this correspondence is carried on, we have an abstract of Director Haidinger's address at the commencement of the present session. From this we learn that the Geological Survey of Austria is progressing rapidly and satisfactorily. Since the death of M. Czjzek, the survey of Bohemia has been entrusted to Dr. Hochstetter, who, in the distribution of the different districts, has reserved to himself the N.E. portion as well as the communication with the Saxon geologists, especially with Prof. Cotta, with the view of connecting his map of the frontier district with the surveys already executed by order of the Saxon government. The districts south of the river Drave are already so far surveyed that the Institute has now sufficient materials in hand to enable them to construct the geological map of the whole of the Duchy of Carinthia, together with portions of Carniola, Goritzia, and the Venetian territory. The Chevalier von Hauer has carefully examined the country across the Alps, from Passau on the Danube to Duino on the shores of the Adriatic, in order to exhibit to the meeting of German naturalists, which was to have been held at Vienna in September last, a complete section of the whole geological structure of the Alpine chain. This meeting, as has been already mentioned, was postponed to the present year, in consequence of the prevailing epidemic. The environs of Tured on the shores of Lake Balaton, in Hungary, have been surveyed by the Chevalier Zepharovich, and considerable progress has also been made in the geological survey of portions of Styria.

The Chevalier v. Hauer and M. Foetterle, ably assisted by Dr. Hörnes, have completed the rearrangement of the most characteristic collection hitherto made of the fossils of the secondary deposits of the Alps and the Carpathians, and of the nummulitic and other upper tertiary beds. These latter connect the whole of this new series with the beautiful collection already exhibited of the fossils from the tertiary basin of Vienna. The secondary strata represented in this series are, in ascending order, the grauwacke beds, the Werfen and Hallstadt strata, the Dachstein limestones, the Kössen, Gresten, Adneth, and Hierlatz strata (to most of which I had occasion to allude in my former address), the jurassic, neocomian, Gosau, and upper cretaceous formations. The ninth part of Dr. Hörnes's valuable work on the 'Fossil Mollusca of the Vienna Tertiary Basin,' containing the genera *Cerithium, Turritella, Phasianella, Turbo, Monodonta, Adeorbis, Xenophora,* and *Trochus,* with five plates, has just been published. Having on a former occasion alluded to the importance of this work, the true value of which had been already recognized by my predecessor, I will now only observe that when completed this work will be indispensable to the student of tertiary geology.

Dr. Hörnes has also communicated to the Imperial Academy of Science at Vienna some interesting particulars respecting the peculiar geological position of the Hallstadt beds which occupy a fixed calcareous zone along the whole line of the Alps, from Hörnstein to the Tyrol, and which have so long been an enigma to geologists. The discovery of numerous organic remains, and their careful examination have shown that this formation contains a very remarkable fauna, peculiar to itself, exclusively Alpine, and of which no one species can be identified with non-alpine forms, although several show a great resemblance to forms which in other parts of Europe are characteristic of palæozoic and jurassic formations. This is the more remarkable, as both in the beds above and in those below, forms occur which are identical with non-alpine forms,—*e.g.* Herr v. Hauer has found in the grauwacke beds of Dienten, five species found in other parts of Europe, and M. Süss also points out several non-alpine forms as occurring in the overlying Kössen beds. Another peculiarity of this Hallstadt fauna is that the most typical species show a great resemblance partly to palæozoic and partly to jurassic forms: thus the genera *Holopella, Loxonema,* and *Porcellia* are related to the former; whilst the species of *Phasianella, Turbo, Neritopsis, Pleurotomaria, Cirrus,* and *Lima* have a jurassic type.

Thus it appears that, while in a palæontological point of view these beds cannot be satisfactorily identified with any non-alpine formations, stratigraphical investigations have recently shown that they should be considered as the equivalents of the upper trias beds of the rest of Europe. These remarks appear to confirm the opinion already given by Prof. Merian.

In further reference to this subject, the following additions to the palæontology of this district have been published in the ninth volume of the Memoirs of the Mathematical and Natural History Class of the Imperial Academy of Sciences at Vienna:—"On the Brachiopoda of the Hallstadt beds," by Edward Süss, with two plates; "On the Gasteropoda and Acephala of the Hallstadt beds," with two plates, by Dr. Hörnes; "Supplement to the knowledge of the Cephalopod fauna of the Hallstadt beds," by Franz von Hauer, with five plates. Respecting the discovery of these fossils by Dr. Fischer of Munich, Herr v. Hauer observes, that the results obtained by Hörnes and Süss in their respective investigations entirely agree with those which he had obtained from the study of the Cephalopoda. Not one of the species in all these different classes had hitherto been found beyond the Alps. They are principally entirely new forms, and only a very few of them were known from the Saint Cascian beds. There are no less than twelve new species of Ammonites, the whole number previously known from the Hallstadt beds being twenty-five.

This result appears the less extraordinary since the true geological position of the Hallstadt beds has been more exactly determined. They form, according to von Hauer, an upper member of the triassic series which has never yet been found except in the Alps, and which must be considered as about contemporary with the Keuper, so poor in marine remains, and which is altogether without Cephalopods. The character of the fauna of the Hallstadt beds also corresponds well with this age. It fills up the gap which appeared to exist between the fauna of the palæozoic and that of the secondary formations, a gap which was in a great measure owing to the scarcity of organic remains in the trias formations beyond the Alps. It includes forms of the palæozoic type, as *e. g.* numerous Orthoceratites, Ammonites, with smooth sides and lobes, completely evolved Nautilus, &c., combined with Ammonites of the families of the Ceratites, Arietes, and Heterophylla, and Nautilus of the Jurassic type. Dr. Hörnes makes the same observation respecting the remarkable combination of palæozoic and jurassic forms with reference to the Gasteropoda and Acephala found in these Hallstadt beds.

The same volume also contains an account of the Chelonian remains from the Austrian tertiary deposits by Dr. Karl Peters. The specimens described belong to the genera *Trionyx, Emys,* and *Chelydra*, and Dr. Peters states that in the description of them he has in general followed the views of the author of the 'Monograph on the Fossil Reptilia of the London Clay.' These Chelonian remains are all derived from the Neogene deposits of Austria; but Dr. Peters observes, that since he had completed his memoir he has received from the brown-coal of Siverich a fragment of a new species of *Trionyx,* the first species of tortoise yet found in the eocene formations of Austria. It comes from the same coal-beds as those in which the *Anthracotherium dalmatinum* of Herm. v. Meyer was found, and which belong to the nummulitic series. Herr. v. Hauer has communicated to the same Academy a notice of some fossils found in the Dolomite of Monte Salvatore, near Lugano, which confirm the impression that this Dolomite and the underlying Verrucano belong to the Trias formation. We owe the discovery of these fossils to the Abbe Giuseppe Stabile of Lugano, and his brother. Many of them are true Muschelkalk fossils, and point, as Herr v. Hauer observes, to the great analogy between these beds and those of the Trias formation of the northern Alps, and more particularly identify them with the Hallstadt and Guttenstein beds.

I will only further mention that Dr. Frederic Rolle has communicated a paper on the Echinoids of the Upper Jura beds from Nikolsburg in Moravia, with a description of the new species found in that locality, and refers to the previous works of MM. Ferstl, Hörnes, Süss, and Foetterle, who had already partially examined the geology and palæontology of that district.

The occurrence of a fragment of carbonized wood in the rock-salt of Wieliczka, a specimen of which had been forwarded by Prof. Zeuschner to Prof. Hausmann of Göttingen, has been the subject of much discussion at Vienna. The fragment which still exhibits the structure of wood has generally a lignite appearance, although Prof. Hausmann is rather disposed to compare it with certain species of anthracite from the Meissner in Hesse, and also considers that it has been exposed to and altered by the action of heat. This, it has been observed at Vienna, would reopen the question, how far rock-salt is to be considered as the result of an eruptive process. I do not see it in this light. For even admitting that the wood has been acted on by heat, it does not necessarily follow that that action must have taken place after it was imbedded in the rock-salt. But the carbonization of fossil wood is not necessarily the result of heat. Nor does it appear that there is any ground for reverting to a theory now supposed to be exploded that rock-salt is an igneous product.

It is also highly satisfactory to observe, that considerable progress is being made in working out the geology of the more distant provinces of the Austrian Empire.

In the 'Comptes Rendus' for September last (p. 386) is a notice by M. François Lanza on the geological formations of Dalmatia. Omitting all reference to the tertiary beds, of which the fossiliferous beds of the eocene period are the most important, M. Lanza confines his attention for the present to the cretaceous formation. The series of white chalk (*la craie blanche*) contains numerous species of the family *Rudistes*, many of which are new. Of these, several species of *Radiolites* and *Hippurites* appear to be the most important. Some of them are of large size. M. Lanza found in the cretaceous limestone of Verpolia, near Sibenico, a gigantic *Hippurite* of which he possesses a fragment 80 centimetres in length, with a diameter of 10 centimetres. The author has never found any species of *Inoceramus* in this Hippurite limestone, although he found several new species in the supracretaceous beds of yellow marly sands, associated with Nummulites. He also found a calcareous schist with Ichthyolites in the Jurassic formation. Through the labours of the Vienna geologists we may now hope that the interesting details of the geology of Dalmatia, apparently rich in fossils, will soon be satisfactorily worked out.

In the Report of the Proceedings of the Imperial Institute of Geology for March 1855, Prof. Lipold has communicated additional information respecting the cretaceous and eocene formations in the N.E. portion of Carinthia*. Dr. Hörnes has lately made out fifteen fossil species, which belong to the lowest members of the eocene formation, and have the greatest resemblance with the fossils found in the Val

* Neues Jahrbuch für Mineralogie, 1855, p. 586.

di Ronca. The lowest beds consist of unfossiliferous clays, over which are fossiliferous marls and marly limestone, with seams of coal; these are succeeded by yellow and white sands, above which again are sandy and calcareous beds, abounding with Nummulites, which form the upper member of the deposit. Echinoderms also abound in the nummulitic limestone of Piemberg. These beds rest on the north side of the trough, on argillaceous mica-slate, and on the south side on the cretaceous formations. These latter, however, are more extensively developed in the north-eastern portion of Carinthia, and the occurrence of Hippurites (*Rudistæ*) leaves no doubt of their belonging to the chalk; here they consist of marls, sandstones, and limestones, the latter being the most predominant. In these the author also found several species of corals and undetermined bivalves. The author concludes by describing the other localities in which these cretaceous beds occur in Carinthia.

Norway.—In the last number of the Edinburgh New Philosophical Journal, Mr. David Forbes has published an interesting paper on the Silurian and Metamorphic Rocks of Norway, the result of investigations partly undertaken at the request of Sir R. Murchison. This communication must be considered only as an introduction to the subject, as from the natural difficulties of the country considerable time will be required to enable him to produce any detailed account of the rocks, especially as regards their fossil contents. Mr. Forbes describes the peculiar appearance of the foliation of the metamorphic rocks on the western side of Langesund Fjord as in striking contrast with the Silurian beds constituting the promontory of Langesund, which have a general dip of 12° to the eastward. The appearance was so striking, that it at once annihilated all idea of its having resulted from any alteration of the original lines of stratification. The occurrence of miles of such vertically foliated rocks, differing even as they do in mineral composition, seemed to Mr. Forbes incompatible with the idea of supposing them to represent originally horizontal strata tilted into a vertical position. He is disposed to think, that, having been originally deposited as a moderately thick and nearly horizontal bed of sandstone, conformable to the Silurian strata now seen overlying them at one extremity of the section, the foliated arrangement is due to their having been affected by the intrusion of granite veins and other agencies, thus producing a series of cracks and joints, possessing comparative regularity when viewed on a large scale. After describing the principal geological features and the organic remains of the district he visited, Mr. Forbes, in concluding his remarks, again returns to the question of the vertical foliation, and, repudiating the idea of stratification having produced it, refers to an opinion formerly pronounced by himself, that the particles of matter in rocks may rearrange themselves at a comparatively low temperature, and he believes that this theory will give the best explanation of the phænomenon, and that there will thus be no difficulty in accounting for the vertical structure of these rocks. Setting aside, then, the direction of the lines of foliation as due to other causes, and keeping in view the character of the rock masses of the whole, Mr. Forbes thinks that certain dotted undulating lines which he has drawn through the vertical foliations will represent the old lines of stratification, and present only a series of undulatory beds due to upheaval or subsidence, and that he will thus be able to analyse large tracts of gneissic formation hitherto considered irresolvable.

When we consider the numerous cases where this vertical, or almost vertical, foliation occurs in crystalline and metamorphic rocks, the explanation here given becomes of great importance. At the same time it should be observed, that unless some indication of the ancient stratification is still visible, either in lines of colour or in some change of mineral appearance, it does appear to be rather a bold assumption to imagine a series of lines of stratification of which no evidence exists, merely on the authority of a somewhat parallel system in the Silurian deposits, which at one extremity of the section overlie these metamorphic beds.

M. Theodor Kjerulf, to whose labours in the field of the palæozoic geology of Christiania I alluded last year, has lately communicated to Sir R. Murchison some additional information on the subject, obtained during the past summer. M. Kjerulf separates the beds of the Silurian basin of Christiania into three divisions or groups, of which the lowest two are decidedly Lower Silurian, and the greater part of the upper group decidedly Upper Silurian. The limit between these two groups consists of bands of limestone and marl, containing *Pentamerus* in great abundance, and this bed forms a perfect geological horizon throughout the whole district. He has called these groups, in ascending order, Oslo Group, Oscarskal Group, and Malmö Group. The total thickness of these formations is said to be 1930 Norwegian feet (1980 English), of which 400 belong to the Oslo, 700 to the Oscarskal, and 830 to the Malmö group. He mentions the different localities where these groups are chiefly developed, and describes the contortion of the Oslo group as a great system of waves spread over the original bottom rock of the Christiania basin or valley. This bottom rock is gneiss, mica-schist, &c. The Malmö group is principally developed in the island of that name; and as the nomenclature of the groups adopted by the author is in a great measure geographical, the true boundary between Upper and Lower Silurian is placed *in* that group, and near the bottom. It is difficult to understand the reasons which have induced the author to adopt this somewhat arbitrary system of subdivision, which, to say the least, introduces some confusion into his classification. It would seem more natural to have retained the lowest bed of this group (9 & 9 *b* of the Author's Section) in the underlying group of Oscarskal.

The connexion between the Malmö beds and the Lower Silurian formations was for a long time obscure; but the thick beds of calcareous sandstone (No. 8), with *Tentaculites annulatus*, *Chætetes* (*petropolitanus*?), and an *Orthis* cleared up the difficulty, and enabled the author to fix the thickness of the whole formation more accurately than had hitherto been done. The Lower Silurian beds are somewhat less thick than was at first supposed; while, on the other hand, the Upper Silurian formation is considerably thicker than was before stated. The author gives the following table as the general result:—

	Feet.		
Oslo group and Oscarskal group	1100	Lower Silurian.	Llandeilo and Caradoc.
Bed No. 9	370		
Malmö group (without No. 9) .	460	Upper Silurian.	Wenlock and Lower Ludlow.
	1930		

The author then describes the metamorphic gneiss of Bugten and Akershus, and particularly the geological features on the promontory of Bugten, where the beds which by their fossils have been identified with No. 9 dip partly under the gneiss and partly overlie it; and the result to which M. Kjerulf here comes is, that the gneiss partly overlies the Lower Malmö schists, and that the lower divisions are altogether wanting: "we must therefore assume," adds the author, "that both a portion of the Lower Malmö schist, as well as probably the whole of the older Silurian formations which are here wanting, have been altered by metamorphic action into gneiss." M. Kjerulf promises to send, by another opportunity, lists of the fossils of each of the different subdivisions. The communication is accompanied by a series of admirable sections, prepared by M. Kjerulf, to explain the relative positions and geographical extent of the different groups referred to by him.

Russia.—A letter from M. Abich, published in a recent number of the 'Bulletin de la Soc. Géol. de France*,' contains some interesting details of Russian geology. He mentions that the recent explorations of the officers of the *Corps des Mines*, who have examined the regions south of the Ural, and in the neighbourhood of the Sea of Aral, show that an extensive eocene deposit, with a molluscous fauna rich both in genera and species, occurs on the eastern and southern shores of that lake. They are mostly identical with those of the Paris basin, and in an admirable state of preservation. These eocene beds overlie nummulitic limestones, resembling those in the Mediterranean basin, and beneath them is the chalk. The inferior cretaceous and jurassic formations crop out on the steep banks of the Aral. The gault and neocomian beds contain the same fossils as to the north of the Caucasus. The eocene formations of these Aralo-Caspian regions are again covered by the middle tertiary formation, which forms the upper portion of the Ust Urt, the absolute elevation of which is greater than the maximum of the mean level of the more recent deposits called *Aralo-Caspian* in the whole space of the Aralo-Caspian table-land. The soil of the whole of this region belongs to the middle tertiary formation, and is characterized by the same fossils as occur in Volhynia, Podolia, and Bessarabia. The existence of this vast eocene basin, which extends far beyond the sea of Aral, will greatly add to our data for the knowledge of the geological structure of the

* Vol. xii. p. 115.

steppes which stretch from the foot of the Caucasus into the interior of Central Asia. M. Abich reports that M. Helmersen is preparing a memoir on the formations surrounding the Sea of Aral.

Italy.—A notice on the Geological Map of Sardinia, by General A. de la Marmora, also occurs in the twelfth volume of the 'Bulletin,' in which the gallant General describes with great care the principal plates of the atlas of his geological description of that island. Some of the plates are finished, the others are in progress. The geological map of the island is on the same scale as that of France by MM. Elie de Beaumont and Dufrénoy, and the author has employed almost the same colours for the different formations. Thirteen straight lines on the map represent the sections through the principal features. These form a separate plate. Two others represent the principal eruptive phænomena. Some of the basaltic appearances, and the most recent volcanic outbursts, are analogous to those of Auvergne.

A new labourer in the field of Italian geology has appeared in the person of Crescenzo Montagna, captain of the Royal Corps of Artillery of Naples, who has recently published in that city a work on the coal of Agnana. This locality for Italian coal is, I believe, new. Agnana is situated near Geraci, in the southern part of Calabria. The object of Capt. Montagna's work is, in the first place, to point out the various sedimentary formations which occur in the district he describes, and then to determine the geological age to be ascribed to the coal in question. The work itself is interesting and unpretending; and, considering the difficulty of obtaining information, or seeing the works of other geologists in other fields, in a country so circumstanced, both physically and politically, as the kingdom of Naples, it evinces both energy and perseverance on the part of the author. At the same time this very circumstance has occasionally led him to enter on the consideration of questions already decided, and permanently established by all geological authorities.

It is clear from the fossils found by the author, that the upper beds, which form gently undulating hills rising from the sea-side, and which contain *Cassidaria echinophora,* belong to the Sub-apennine formation. Other tertiary formations succeed in descending order; below these are calcareous beds, containing two, if not more, species of *Nerinæa,* and clearly indicating the existence of cretaceous beds. The coal-beds underlie this formation, which reposes on argillaceous schists, in which organic remains are scarce and uncertain. The fragmentary relics are considered by the author as representing forms belonging to the mountain limestone, but the evidence is as yet incomplete.

The following, in descending order, is the sequence of formations observed and described by the author:—

I. TERTIARY.
1. Subapennine. Hills at the foot of Liderno.
2. Falunian. Timpa di Tenda,—shell-beds of Geraci and Salvi.
3. Paris and London-clay basin. White marls, Calcaire grossier, gypsum.

II. SECONDARY. A. Cretaceous:—
1. Cenomanian (d'Orb.).
2. Aptian.
3. Neocomian.
B. Jurassic:—
1. Kimmeridge clay. Scolaro, and coal-beds.
2. Coral rag? Limestone of Mutolo.
3. Oxfordian. Iron ores.
III. PALÆOZOIC. Argillaceous schists.
IV. AZOIC. Rocks of Monte Barone.

In the tenth volume (p. 211) of the "Nuovi Annali delle Scienze Naturali" is an account, by M. Scarabelli, of the geology of the province of Ravenna, accompanied by a geological map of the district. The author describes it as a supplement to his former work on the geology of the province of Bologna. He refers the different formations to the following subdivisions—Eocene, Miocene, Pliocene, Quaternary, and Modern. The oldest or eocene is comparatively unimportant. The miocene consists chiefly of a sandy micaceous molasse, with few fossils, as *Carcharodon crassidens*, *Car. angustidens*, *Buccinum*, *Tellina*, and *Artemis*. This is overlaid by a band of gypsum or selenite, which forms a lofty and conspicuous crest through the country nearly parallel to the high road from Bologna to Forli. The several thick beds of this deposit give altogether a thickness of about one hundred metres. Its general strike is N.W. to S.E. with a dip to the N.E. Resting on this gypsum formation are the blue fossiliferous marls which the author refers to the pliocene epoch. These marls in their upper portion become gradually more arenaceous, and, by degrees, almost conglomeratic, with a gentle inclination to the plain to the N.E. Marine remains are very abundant, and the author considers that they show an intermixture of true miocenic and pliocenic forms. He adds a list of the fossils hitherto found, from which it appears that there are 30 species of Bivalves and 133 of Gasteropoda. This disproportion, however, can hardly be correct, particularly when we consider the marly or muddy nature of the ground, so peculiarly the habitat of the lamellibranchiated bivalves. It is probably owing to the greater difficulty of obtaining the bivalve shells in a perfect condition. The author observes that fish bones have also been found. The most interesting feature however is, that in the upper strata, and where the marls begin to pass into yellow sands, bones of Hippopotamus and Rhinoceros begin to make their appearance, and these, combined with littoral marine species of shells, are also accompanied by freshwater shells; showing thereby that the bones were carried into an estuary, where the marine products were mixed up with terrestrial and fluviatile remains. In proof of this there has been recently found in the sandy marl near the River Pratella, in a bed containing *Cardium edule*, *Mactra triangula*, *Balanus*, and *Paludina*, a collection of thirteen or fifteen coprolitic bodies containing traces of vegetable structure, and which therefore appear to have belonged to some great herbivorous animal. This gradual change of the blue marls into sandy beds probably indicates the period of the gradual rising of the country and the increasing shallowness of the water near the coast, when the arenaceous particles brought down by the rivers were deposited near the coast line, whilst the lighter argillaceous sediment was carried to a greater distance; it may perhaps be laid down as a general geological axiom that a change from argillaceous into arenaceous deposits is an indication of the gradual elevation of a sea-bottom at no great distance from the coast.

The author then proceeds to describe the beds of the quaternary period, which form a littoral band fringing the marine deposits which they overlie unconformably, containing the remains of Elephants, Rhinoceros, Equus, Cervus, and other large ruminants which have been collected near Imola, where was the delta formed by the ancient course of the river Santerno.

An account of the formation of the modern period, which consists of the plain of Ravenna, is reserved for a subsequent communication.

Connected with the tertiary remains of the Mediterranean basin, I would not willingly omit a reference to Dr. Wright's paper, on Fossil Echinoderms from the island of Malta, published in the 15th volume of the "Annals and Magazine of Natural History." These fossils and the details of their stratigraphical arrangement were principally procured by Lord Ducie, to whom Dr. Wright was indebted for much valuable information. The strata are divided into five groups, each with its characteristic fossils. These are in descending order: 1. Coralline limestone; 2. Yellow sand; 3. Clay; 4. Calcareous sandstone; 5. Hard cherty limestone. It is hardly necessary to add that they all belong to the miocene epoch.

Spain.—Let me now direct your attention for a short period to that peninsula which was for so many years the seat of our military exploits; here we shall find that the germ of geological science observed some years ago, and detected in the works of Spanish engineers in the Mining Review of that country, appears now to be actively taking root, and to hold out the expectation that before many years shall have elapsed, we may hope to see the geology of Spain, hitherto chiefly explored by foreigners, thoroughly worked out by the new school of Spanish geologists. We are indebted to our old acquaintance and friend M. de Verneuil for a short but interesting notice on the progress of geology in Spain during the last few years, and principally during the year 1854. From this and other sources I shall endeavour briefly to lay before you some of the principal results of this new field of energy in geological research.

The first impetus to this new movement was given by the foundation of a school of mines at Madrid about twenty years ago. In 1847 an academy of sciences was created, and shortly afterwards a commission was appointed by the Spanish government to construct a geographical and geological map of the Province of Madrid. It is to M. Casciano de Prado, Vice-President of this Commission, that we are principally indebted for the more important geological discoveries recently made in that country. With the aid of MM.

Ezquerra del Bayo and Paillete, he drew attention to the palæontology of Spain. M. Ezquerra first noticed the existence of fossil bones in the miocene formation of Madrid, and the latter, having discovered in the Asturias and the kingdom of Leon devonian fossils in a very perfect state of preservation, enabled MM. de Verneuil and d'Archiac to write two memoirs on the palæontology of those districts. Subsequently M. de Verneuil, in his work "Sur la Constitution Géologique de plusieurs Provinces d'Espagne," published some lists of fossils found in the secondary rocks. But a great gap still existed between the palæozoic and jurassic formations. Slight indications of the trias had been observed by several geologists, but it was only in 1853 and 1854 that M. de Verneuil and his companions in this field were fortunate enough to discover the characteristic fossils of the muschel-kalk, viz. *Ceratites* resembling *C. nodosus, Nautilus bidorsatus, Myophoria lævigata,* and *M. curvirostris.* These interesting species were obtained from Hombrados to the east of Molina de Aragon, from the neighbourhood of Mora and of Tivisa, not far from the mouth of the Ebro.

But to return to the recent operations of M. Casciano de Prado: convinced that the geology of a province cannot be understood if confined to political boundaries, this enterprising geologist extended his investigation into all the provinces bordering those of which the geological examination had been confided to him: thus we are indebted to him for the first geological map of the provinces of Madrid and Segovia, in which the geographical features, thanks to the map of M. Coello, are laid down with unusual care and exactitude. During the past year M. Casciano de Prado was further instructed to make a detailed topographical map of the different deposits of coal in the province of Palencia. The examination of other carboniferous basins on the southern flank of the Cantabrian chain was confined to other persons, of whose labours M. de Verneuil has not been able to give us an account.

Notwithstanding the political disturbances, M. de Prado continued his labours during the whole summer. He discovered three granitic outbursts or islands in the Cantabrian chain. The Devonian and Carboniferous formations are so arranged that the former expands from east to west, at the expense of the latter. Thus in the province of Leon few Carboniferous fossils are found, but many Devonian; whilst, on the contrary, in the province of Palencia, the Carboniferous fossils are more abundant than the Devonian. M. de Prado has greatly added to the carboniferous fauna of Spain, for he says that he has found more than one hundred species in the province of Palencia alone. The results of his labours are such that he has now been enabled to prepare a geological map of the four important provinces of Madrid, Segovia, Palencia, and Valladolid.

M. de Verneuil also calls our attention to an admirable geological account of the kingdom of Valencia, by M. F. de Botella, published in the Mining Review* of Spain. It is accompanied by a geological map, the basis of which was laid down by M. de Verneuil himself, when

* Revista Minera, vol. v. pp. 562 & 675.

travelling two years before with M. de Botella. The Spanish government has on this occasion shown a most praiseworthy interest in the progress of geological knowledge by confiding to M. de Botella the task which he desired of constructing, during the next three years, a detailed geological map of this same kingdom of Valencia, consisting of the three provinces of which the capitals are Alicante, Valencia, and Castellon de la Plana. Among other interesting statements contained in this notice are the barometrical measurements of various heights of mountain chains made by M. de Verneuil and published in the Bulletin de la Soc. Géol. de France, vol. xi. p. 661; and after alluding to different memoirs recently published on Spanish geology in various scientific periodicals in Germany, France, and elsewhere, the author states that the result of his own travels in Spain, during the last six years, will appear on a small scale in the Geological Map of Europe, about to be published by Sir R. Murchison and Mr. Nicol in England, and by M. Dumont in Belgium.

I can only briefly refer you to the 'Bulletin de la Soc. Géol.'* for another interesting notice on Spanish geology by M. Casciano de Prado, called, "On the Geology of Almaden and a part of the Sierra Morena, and the Mountains of Toledo." The country is described as one of great difficulty in consequence of the many and violent convulsions to which it has been exposed in all geological periods, and it is also intersected by many mountain chains. The lower Silurian beds are greatly developed in the central portion of the country, in Estremadura and the province of Toledo, and are overlaid by the Devonian. Characteristic fossils are abundant in some places, as *Calymene Tristani*, *Orthis testudinaria*, &c.

Asia Minor.—The importance of a sufficient supply of coal to enable them to carry on their naval and military operations in the Turkish waters has been so much felt by our government, that, the supplies from Heraclea not appearing sufficient, they despatched Mr. Henry Poole, from this country, for the purpose of examining some beds or seams of coal, the existence of which, near the Gulf of Nicomedia, had been pointed out by the British Consul at Brusa. Considering the physical geography of the country and the position of the coal-beds of Heraclea with regard to the palæozoic rocks of Constantinople, and the cretaceous formations which occupy so large an area in Asia Minor, I felt tolerably confident that the result of Mr. Poole's examination of the country would in this respect be perfectly satisfactory. It appears, however, from the communications which have been made to us by the Foreign Office and by Sir R. Murchison, that Mr. Poole has not succeeded in finding any real coal; he describes the route he followed in his investigations, and observes that in the different points to which his attention was directed he found nothing but lignite of a very inferior quality. When we recollect, however, that coal has been discovered by M. de Tchihatcheff in the eastern parts of Asia Minor, in the Taurus, and in the neighbourhood of Erzeroum†, I do not feel disposed altogether

* Vol. xii. p. 182.

† Bull. de la Soc. Géol. de France, vol. xi. p. 402, &c.

to give up the expectation that real coal may be found in the district between Heraclea and the Gulf of Nicomedia.

In my address last year I alluded to the communication made by M. Tchihatcheff to the Geological Society of France respecting the geology of Asia Minor. Those remarks referred chiefly to the southern parts of that peninsula. I now learn that he has also made some interesting discoveries in tertiary geology along the northern shore. An eocene deposit was unexpectedly discovered in the neighbourhood of Samsoun, on the Black Sea, mixed up with melaphyr rocks. Near the village of Kadikieui, amongst the hills and ravines, were found in great numbers shells of almost all the species which are now living in the Black Sea, as *Tellina*, *Venus*, *Cardium*, *Pecten*, a variety of *Ostrea edulis*, and *Rotella lanceolata*. The only extinct species found were a *Natica* and *Turritella subangulata*, Brocchi. The surface of the trap-rocks on which these shells are distributed appears to be occasionally covered with a very thin coating of a dark marly limestone. In these thin bands, *Nummulites Ramondi*, Defr., *N. irregularis*, Desh., with *Alveolinæ* and *Operculinæ*, and innumerable fragments of comminuted shells, are found. From the occurrence of this nummulitic formation in the neighbourhood of Samsoun, and the existence of the recent shells, M. Tchihatcheff deduces the following conclusions:—

The melaphyrs and traps which play such an important part along the whole of this northern shore of Asia Minor must have burst forth before the Nummulitic period; and at a very recent period these trap-rocks and the whole coast must have been submerged, and the waters of the Black Sea not only covered the plain where Samsoun now stands, but beat against the hills on which the village of Kadikieui, now two leagues distant from the sea, is placed.

I am acquainted with several localities in Asia Minor where the recent forms alluded to by M. Tchihatcheff may be found at various elevations along the coast of the Black Sea; but I was not aware of eocene forms having yet been found there. They are however abundant in the interior, and I have myself found the nummulitic formations nearly in the meridian of Samsoun, or S.W. from it, and about 100 miles to the south; and in other parts of Asia Minor they are abundantly met with.

Egypt.—Mr. Leonard Horner has published in the volume of the Philosophical Transactions for 1855, an account of recent researches near Cairo, undertaken with the view of throwing light upon the geological history of the alluvial land of Egypt. The following is an outline of Mr. Horner's argument on this subject. One of the most difficult problems in geology is to ascertain, even approximatively only, the time which has elapsed during the period of the formation of any particular series of strata, even when the inquiry is confined to the most recent of the tertiary deposits. In considering the means by which this difficulty might be overcome, it occurred to Mr. Horner that, if there were a country in which a certain alteration in the level of the land had taken place within historical time, and where the entire change under consideration presented throughout a tolerable uniformity of character, we should be justified in holding that the portion of change that had taken place within the historical period would afford a measure of the time occupied in the production of the antecedent part of the same change. Egypt appears to Mr. Horner to be the only land of all parts of the world as yet known to us that offers an instance of a great geological change that has been in progress throughout the whole of the historical period down to the present day, and which we have reasonable grounds for believing had been going on with the same uniformity for ages prior to the period when our reckoning of historical time begins. This is owing to the annual inundation of the Nile, and the sediment that falls from its waters on the surface of the land it overflows. The historical monuments of Egypt are the oldest in the world, and afford the most accurate records of the earliest period of the human race in which any trace of civilization has been discovered, combined with records scarcely less accurate of geological changes contemporaneous with history, and having such a degree of uniformity as to warrant us in carrying back the dates of changes of a like nature beyond that of the earliest historical documents.

With these views Mr. Horner determined to endeavour to investigate the formation of the alluvial land in the valley of the Nile in Upper and Lower Egypt, comparing the depth of sediment which has accumulated to a considerable height above the base of the oldest works of art near the Nile with the sediment deposited below the base of these same monuments on the rock forming the bottom of the channel. If, he observes, the depth of sediment above the base of these works of art be divided by the number of centuries that have elapsed since the date of their erection, we may obtain a measure of the secular increase of the sediment; requiring, however, a correction for causes that might make a difference in the rate of increase between earlier and later periods.

Having thus fully stated his object, Mr. Horner commences his inquiry with an account of the physical geography and geological structure of Egypt, an account of the inundations of the Nile, and of the solid matter conveyed by the Nile to form its sedimentary deposits, and then proceeds to describe the recent researches undertaken at his suggestion. These embrace an account of the excavations at Heliopolis, descriptions and analyses of the soils, descriptions of the several pits and shafts sunk, and a synopsis of the soils passed through in the excavations. But these excavations are not yet completed, and Mr. Horner defers all inferences as to the secular increase of the alluvial deposits until he shall have had an opportunity of describing the later and more extensive researches and excavations.

Trusting that Mr. Horner may be successful in arriving at a satisfactory result from this spirited and difficult undertaking, I will only observe, that we must not be too sanguine that these inquiries can lead to any sound or certain conclusions on the subject. The greater velocity of the water in the ante-historical period, in consequence of the greater inclination of the valley before it was filled up by the present sediment, can never be fully ascertained, or its effects calculated, although its general effect must have been to prevent any accumulation of deposit in the same ratio as afterwards, and from this cause alone the rate of filling up must have been a perpetually varying one.

You are aware that the Messrs. Schlagintweit, whose observations on the elevation and physical structure of the Alps are so well known, have proceeded to India for the purpose of making similar physical and meteorological observations on the mighty chain of the Himalaya and its lateral ranges. On their journey from Cairo to Suez they made some interesting geological observations. Mr. A. Schlagintweit writes as follows to his friend and patron A. von Humboldt:—"The greater portion of the sand of the desert appears to have been derived from the easily disintegrating tertiary formations which exist in large masses along the edge of the desert. The desert is decidedly a marine formation. We had the good fortune, a little to the south of Station No. 12, to discover a series of well-preserved sea-beach terraces, about 200 feet above the present level of the sea, containing numerous marine Mollusca, as *Ostrea*, *Cardium*, and *Cypræa*, with *Cidaris*, which cannot be specifically distinguished from the corresponding species which I obtained at Suez from the Red Sea." These remarks are interesting, as pointing to the greater extension of the Red Sea northwards at a former period, and almost proving the connexion within recent geological periods between the Red Sea and the Mediterranean.

India.—From India and our Eastern colonies and possessions we have not received many communications during the past year. But I must not omit to mention that the Rev. Mr. Hislop has forwarded to us a paper on the connexion of the Umret coal-beds with the plant-beds of Nagpur, and of both of these with those of Burdwan. It will be recollected that some time ago Messrs. Hislop and Hunter sent to this country a valuable collection of fossil plants from the sandstones of Nagpur, and it may be observed, that it is in consequence of the identification of the Nagpur flora with that of the coal-fields of Umret that Mr. Hislop has been able to fix the position of the coal-formation of India. In a former communication on the Jurassic formation of the Nagpur territory, Mr. Hislop described it as consisting of four members in the following descending order:—

1. Thick-bedded coarse ferruginous sandstone, with a few stems of trees.
2. Laminated sandstone, rich in vegetable remains.
3. Clay-shales of various colours, with traces of reptiles and worms.
4. Limestone, generally crystalline.

On that occasion Mr. Hislop stated that he considered the Indian coal-measures as the equivalent of No. 3. Subsequent discoveries have led him to the conclusion that their true position is amongst the beds immediately below the ferruginous sandstone No. 1.

The arrangement of the strata of what Mr. Hislop calls the Indian freshwater Oolitic formation is consequently somewhat modified in this paper. The author gives the following series in descending order :—

1. Upper sandstone series (Panna or Punna sandstone of Dr. Carter).
2. Laminated series. Kattra shales of Dr. Carter.
   a. Arenaceous, carbonaceous, or bituminous, 300 feet thick in Nagpur, 2000 in Bengal.
   b. Argillaceous shales, green, red, blue, and white, with tracks of reptiles and worms.
   c. Limestone, compact or crystalline.
3. Lower sandstone series. Tara sandstone of Dr. Carter; not developed in Nagpur.

I may add, that, as the Indian Government have just sanctioned the construction of a branch railway to Nagpur from the Bombay main line, we may look forward, at no very distant period, to some valuable information on this subject. The resident engineer of the line, who is a member of this Society, has promised to collect all the information in his power on the geology of Western India.

In another district the railway operations have already borne fruit. I find in the Journal of the Geological Society of Dublin, amongst other papers of great interest, an account of a hasty examination of the Nerbudda Valley in Central India by Mr. Arthur Jacob. The coal-formations and iron-deposits have been long known to exist in this part of India, and Mr. Jacob's object in visiting them was to ascertain the feasibility of establishing an iron-manufacture in that district. In doing this he has done good geological services. The coal occurs in sandstone beds, and is sometimes much inclined, in places dipping almost vertically. The iron also occurs in veins and nodules of red hæmatite, in the sandstone which is probably Oolitic, but sometimes also in the basalt. With regard to the age of the Bengal coal-fields, it appears from the reports lately sent home by Mr. Oldham that they too must be considered as belonging to the Mesozoic rather than to the Palæozoic period.

America.—I must not omit to direct your attention to the sketch of the geology of Canada by Messrs. Logan and Hunt, printed at Paris for the purpose of explaining the geological map and the collection of minerals sent by the Canadian Government to the Universal Exposition of Paris. It is accompanied by an admirable reduction of the map in question.

From this notice it appears that below the Lower Silurian system which contains the lowest fossiliferous beds, there are found two unconformable Azoic systems; the lowest of them is the Laurentian System, consisting of highly crystalline sedimentary beds, and probably corresponding with the gneiss of Finland and Scandinavia. They are chiefly gneissoid or hornblendic schists, with some felspathic porphyries and quartzites, associated with crystalline limestones, which appear to have been in a state of fusion, and to have undergone great pressure, having been forced into the fissures of the neighbouring siliceous beds. Besides these stratified beds, granites, syenites, and intrusive diorites are also met with. The second Azoic system occurs on the banks of Lakes Huron and Superior, and consists of a series of schists, grits, limestones, and conglomerates, interstratified with thick beds of diorite, and rest unconformably on the Laurentian System. Mr. Logan gives it the name of Cambrian or Huronian System. It abounds with metalliferous veins, which have hitherto been but little worked.

On the islands to the north of Lake Huron is a series of fossiliferous beds, resting horizontally on the inclined strata of the Huronian System. Further south they rest directly on the rocks of the Laurentian System. They correspond with Murchison's Lower Silurian, and are overlaid by the Upper Silurian, Devonian, and Carboniferous systems. These groups occupy the whole of the Canadian portion of the great basin bounded on the north by the Laurentian and Huronian formations.

Mr. Logan has pointed out that this basin is separated into two portions by an anticlinal axis, which, following the valley of the Hudson and Lake Champlain, enters Canada near the Bay of Misiscoui, and running thence N.E., reaches the St. Lawrence near Deschambault, ten leagues west of Quebec. The rocks of these two basins present a very remarkable difference, both in their physical and chemical aspect. The formations of the western basin are almost horizontal, and perfectly conformable, whilst in that to the east there is a want of conformity between the Upper and Lower Silurian, and between the Devonian and Carboniferous systems. The various strata of the eastern basin are, moreover, much twisted and contorted, and have in some places undergone great chemical and mineralogical metamorphism. A glance at the map at once points out this important difference. The conclusion is irresistibly forced upon us, that, while on the western side the different systems succeeded one another gradually and conformably, violent convulsions, occurring at certain epochs, on the eastern side, interfered with the tranquil succession of the deposits; and we see that, although these breaks occurred between the Upper and Lower Silurian periods, and between the Devonian and Carboniferous systems, they were still only local phænomena; and that, however they may have affected the condition of life in the neighbouring seas, they produced no effect on the regular succession of deposits even in their immediate vicinity. It would be difficult to find anywhere a better example of the necessity of not attaching too great an importance to those breaks which occur in other regions, and which, after all, may have only a local significance.

Mr. Logan then proceeds to describe the different features of these two basins, the western and the eastern, adding an account of the metamorphic rocks, and of the post-tertiary and alluvial deposits.

The volume of Mr. J. W. Dawson, entitled 'Acadian Geology,' being an account of the geological structure and mineral resources of Nova Scotia and portions of the neighbouring provinces of British America, must also be noticed. The author has endeavoured to combine two great desiderata; while striving to make his work sufficiently elementary and practical for his readers in the Colonies, he has not forgotten that it should be at the same time sufficiently accurate and original to do some service to general geology. Commencing with the most recent formations, the author successively describes the different formations of the Colony, giving, as to the most important feature, a more than equal share of attention to the description of the Carboniferous System. It is a very remarkable feature, that in the geology of Nova Scotia no formations occur between the drift and the New Red Sandstone. The middle and lower Tertiaries, the Cretaceous and Oolitic Systems, with their subordinate groups, are all wanting in this Colony, as in New Brunswick, Canada, and the Northern United States. The work is accompanied by a good geological map, and many illustrations on wood.

The recent Arctic expeditions have also added considerably to our knowledge of the geology of these extreme northern regions. A paper read by Sir Edward Belcher in the Geological Section at the recent meeting of the British Association at Glasgow, indicates the presence of Ichthyosaurian bones in the most northern part of the Arctic land. Mr. Salter, in a paper read on the same occasion, showed the connexion of this fact with the presence of Ammonites and other Lias shells on the north-western edges of Melville Island, as already described by the Rev. Prof. S. Haughton.

They are succeeded southwards in both cases by Carboniferous limestones with several species identical with those of Great Britain, thus giving us a marine equivalent for the coal-beds so long known in that island. A trace of a Devonian formation then follows with some characteristic fossils, *Productus* and *Atrypa reticularis*, and thence the whole surface of the Polar lands as far south as Hudson's Bay appears to be occupied by a grand plateau of Upper Silurian rocks extending to the granitic ridge of the so-called Laurentian chain.

Mr. Salter also called attention to a similar basin in Spitzbergen where Permian rocks have been recognized by De Koninck, succeeded southwards, in Bear Island, by strata of the Carboniferous age, the fossils of which were described long ago by von Buch.

An interesting account of the carboniferous fossils obtained by Sir Edward Belcher and the officers under his command, prepared by Mr. Salter, and of the Saurian bones by Prof. Owen, will be found in the appendix to Sir E. Belcher's work entitled 'The last of the Arctic Voyages.'

We are indebted to Mr. Isbister for a valuable compilation of all the information hitherto obtained respecting the geology of the Hudson Bay Territories, and of portions of the Arctic and north-western regions of America. This information has been partly derived from his own observations, partly from those of the many geologists and travellers who have explored, and of the naturalists who have examined the organic remains of this portion of the American continent. Mr. Isbister justly considers that, in the absence of any general view of the geological structure of this extensive but interesting region, even the most cursory classification of its formations might be useful to those employed in developing the structure of the crust of the earth. The author of the paper also adds a list of the various works relating to the geology of the northern part of North America, and which he has himself consulted. We have every reason to hope that this geological hiatus will now, to a great extent, be filled up by the exertions of the distinguished geologist to whom the Wollaston Palladium Medal has been this day awarded.

I greatly regret that time and space will not allow me to do full justice to the exertions of the geologists of the United States of America in the pursuit of geological investigation. At the same time I must mention some circumstances connected with the progress of geology in that country.

And in the first place, let me call your attention to the magnificent—I had almost said royal—publication, of Dr. Isaac Lea of Philadelphia, of the fossil footmarks in the red sandstone of Pottsville. Having already published these fossil footprints in the Proceedings and Transactions of the American Philosophical Society, the author found that the reduced plate containing the six imprints of fossils was too small to convey a correct idea of this interesting specimen. He consequently determined to reproduce it of the natural size, in order that a better representation of it, and a more correct and diffused knowledge of this, perhaps the oldest air-breathing animal on record, might be laid before geologists. The letter-press explanatory of this large engraving, and by which it is accompanied, is reprinted almost *verbatim* from the tenth volume of the Transactions of the American Philosophical Society.

In the last number we have received of the Journal of the Academy of Natural Sciences of Philadelphia will be found two interesting memoirs on the discovery of palæozoic fossils in the United States by Messrs. J. C. Norwood and Henry Pratten, of the Illinois Geological Survey. The first is a notice of *Producti* found in the western states and territories, with descriptions of twelve new species. These species have been found partly in the Mountain-limestone so extensively developed in the western and southern states, and partly in the marine limestone and calcareous clays of the Coal-measures. Indeed many of the species here described are found exclusively in this latter formation. The new species, which are exemplified by beautiful and accurate drawings by Mr. H. A. Ullfers, are *Productus Altonensis, Phillipsii, Rogersii, clavus, splendens, Wabashensis, elegans, muricatus* (not of De Koninck or Phillips), *Portlockianus, Prattenianus, Hildrethianus,* and *alternatus.*

The second is a notice of the genus *Chonetes* as found in the western states and territories, with descriptions of eleven new species. M. de Koninck, in his monograph of the genus published in 1847, enumerated twenty-three species, including those found in the United States, as the total number then known; Mr. Dale Owen has since added one more, and the addition now made makes the present number known thirty-five. Of these, seventeen occur in the western states of America, and ten in New York. Of the new species six or seven were found in limestone of the Devonian period, the remainder in the Mountain-limestone and the Coal-measures. The new species are *Chonetes Smithii, Fischeri, Littoni, Flemingii, Verneuiliana, mesoloba, Maclurea, Tuomyi, Martini, Koninckiana,* and *Logani.*

It is, I think, to be regretted that the authors of these papers have taken their specific names from those of individuals, instead of adopting the practice now prevalent amongst so many geologists of the continent of taking some characteristic feature of the fossil as the basis of their nomenclature. I fear, however, that the American geologists are not alone to blame in this respect: the practice is almost equally prevalent amongst British naturalists, but is one which should be discouraged.

The first two numbers of a work by Mr. M. Tuomey and Mr. F. S. Holmes on the fossils of South Carolina have reached us within the last few months. They promise to be a valuable addition to our knowledge of the palæontology of that state. Commencing with the pliocene fossils, these numbers contain a description of the Polyparia and Echinodermata found in that district, as well as the commencement of the description of the Bryozoa of the same region. The plates which accompany the work are admirably executed.

Two interesting reports by Dr. John Trask have been published by the Senate of the State of California on the Geology of the Coast Mountains and part of the Sierra Nevada. These ranges appear to consist principally of granite, syenite, mica-schist, gneiss, porphyries, and older greenstone, penetrated by innumerable dykes of basalt, greenstone, &c., and overlaid by sedimentary sandstones which are also frequently much disturbed by the intrusion of the later igneous rocks. Veins of quartz of various dimensions are also of frequent occurrence. Tertiary rocks with the remains of gigantic vertebrate animals and of marine shells also occur on the summits and sides of the hills constituting the Coast Mountains, as well as at a distance from the shore. They occur over a considerable area, so as to leave no doubt of the former submergence of the entire district. Although generally referred to the miocene epoch, they appear to belong to different periods; and the terraced outlines of the different groups indicate the successive steps by which the country has been elevated to its present position. Some of the bivalves are of enormous size. *Gryphææ* weighing twenty pounds have been found near Luis Obispo at a distance of fifteen miles from the coast.

These reports also contain much interesting information respecting the gold mines, their present mode of working, and their future prospects.

I would also here particularly call your attention to the eloquent and admirable address of Prof. Dana, read at the last meeting of the American Association for the Advancement of Science, held during the past year at Providence, Rhode Island. It contains a clear and interesting sketch of the typical features of American geology from the oldest palæozoic formations to the most recent tertiaries, and will be read with interest as it deserves to be studied with attention.

M. Marcou has also published in the 'Bibliothèque Universelle de Genève' for last year a notice on the Occurrence of Gold in California. After describing the different localities and formations in which the gold is found, M. Marcou concludes by observing that he has arrived at the same conclusion as Sir R. Murchison respecting the gold of the Ural, viz. that its deposit took place between the conclusion of the miocene formation and the post-pliocene or quaternary period. With this difference, however, that in California the eruptive rocks in which the gold has been formed, and which are its true matrix, do not belong, as in the Ural, to the Silurian system, but to the miocene or pliocene period. They certainly are more recent than the eocene, the beds of which they have disturbed and dislocated. Moreover in California the veins of auriferous quartz were formed at the same time as the eruptive rocks in which they occur, and not subsequently to them as in Russia.

Professor Henry D. Rogers has recently published, in Edinburgh, a Geological Map of the United States and British North America. This Map forms a portion of Keith Johnston's Physical Atlas, and has been engraved by him for that work. It professes to be constructed from the most recent documents and unpublished materials. It is therefore with the greater surprise that I find that Prof. Rogers, contrary to the opinion of the majority of his countrymen, and of the officers of the Geological Survey of Canada, has entirely ignored the existence of the Lower Silurian group, and has referred the rocks which the American geologists designate as such to the Cambrian system. I need only refer you to the able and eloquent address of Prof. Dana, already alluded to, for a confirmation of the statement that the division of Upper and Lower Silurian is fully recognized by American geologists. In alluding, near the close of his address, to the disturbances which appear to have marked on the American continent the separations between various epochs, Prof. Dana observes—"The question of the existence of a distinct *Cambrian system* is decided adversely by American records. The mollusca in all their grand divisions appear in the Lower as well as in the Upper Silurian, and the whole is equally and alike the Molluscan or Silurian age. The term Cambrian, therefore, if used for fossiliferous strata, must be made subordinate to Silurian."

In another portion of this eloquent address, Prof. Dana says, in reviewing the succession of epochs in American geological history, that after the close of the Azoic age, in a period of extensive metamorphic action and disturbance, the Silurian or Molluscan age next opened, and continued, under various aspects and numerous subdivisions, until the commencement of the Devonian age or *age of fishes*. Here then we have a great natural-history character by which to designate the Silurian age, viz. from the first commencement of molluscan life down to the period when the first vertebrate animals appeared in the form of fishes. The Silurian or Molluscan age is, however, distinctly divided by Prof. Dana into the Upper and Lower Silurian, each of which is again subdivided into several periods.

For other evidence of the opinion of American geologists on this point, I will only refer you to an able review of Murchison's 'Siluria,' in 'Silliman's Journal*.'

The Geological Surveys of the different States in America appear to be making satisfactory progress. The Annual Report on the Geological Survey of the State of Wisconsin by Dr. James Percival, who commenced his labours in August 1854, has recently been published. In it the rock strata of the lead region are described; Dr. Percival appears to be inclined to the view that the lead occurs in veins, instead of deposits or beds. This view has not hitherto been generally admitted.

The first Annual Report of the Geological Survey of the State of New Jersey, for 1854, has also been lately published at New Brunswick. Mr. Cook, the assistant geologist, recognizes in the cretaceous strata, three distinct beds of greensand marl, alternating with strata of sand. The lower marl bed is 30 feet thick, and contains *Exogyra costata, Gryphæa convexa, Ostrea falcata, Terebratula Sayii, Belemnites Americanus*, &c. The second contains *Gryphæa convexa* and *Terebratula Harlani* in great numbers. In the third bed fossils are rare.

A paper on the changes which take place in the structure and composition of mineral veins near the surface, with particular reference to the East Tennessee Copper Mines, by J. D. Whitney, is published in Silliman's American Journal, vol. xx. p. 53.

South America.—I have heard with great regret of the death of Dr. Voltz, a distinguished German naturalist and geologist, who was travelling in South America. He was exploring Surinam and died at Paramaribo. His most interesting discovery was that of several quaternary deposits at different heights above each other, containing the shells of Mollusca now found living on that coast. Prof. F. Sandberger, who has seen the collections he has sent home, mentions as instances of these Mollusca found at various elevations, *Marginella cærulescens, Purpura cataracta, Ranella granulata*, and *Venus Dombyi*, all of which are now found on the same coast.

It is not improbable that they belong to the same formation as that described by Col. Henneken in St. Domingo, many of the fossils of which were described by Mr. Moore in a former volume of our Journal. These latter, however, were referred to the tertiary period.

Colonies of Great Britain.—From our colonies in the southern hemisphere, we have, during the past year, received much valuable information respecting the geological structure of those regions. Natal, and other districts of Southern Africa, Australia, and New Zealand have each contributed to this accession of our knowledge, and I regret that the space allotted to an annual address will not permit me to do more than briefly to allude to them, referring you for further and more detailed information to the recent numbers of our Quarterly Journal. From the district south of Natal we have had a notice of some cretaceous rocks by Capt. Garden, who succeeded in collecting an interesting suite of fossils from the cliffs and walls of caves near the river Umtafuna. These fossils have been

* Vol. xix. N. S. 1855, p. 373.

described and mostly figured in our Journal by Mr. W. H. Baily, who observes that they bear a close affinity to the collection of fossils from Southern India, so ably described by Prof. E. Forbes. Dr. P. C. Sutherland has also given us some important information respecting the geology of Natal, in a series of letters addressed to Sir R. Murchison. Beds of sandstone and shale occur alternating with trap-rocks ; in the former, several seams of coal have been found of no very good quality, and which, from the appearances of the vegetable remains in the shale, appear to belong to the Oolitic rather than to the true Carboniferous formation. These facts are interesting as they corroborate Mr. Bain's observations on the extension of the reptiliferous and coal-bearing strata of the Karoo-series of the neighbouring regions. Granite and other crystalline rocks also abound, and copper in the form of malachite is not unfrequent.

The Rev. W. B. Clarke has communicated to us some papers on the geology of Australia. We have a paper on the occurrence of obsidian bombs in the auriferous alluvium of New South Wales, and another on the occurrence of fossil bones in the same deposit. After comparing this latter fact with the occurrence of mammoth remains in the auriferous alluvium of Berezof, in the Ural Mountains, Mr. Clarke observes that their presence would seem to imply that the gold in this deposit was collected at a comparatively recent date.

Mr. H. Rosales has also communicated to us some fresh information respecting the gold-fields of Ballarat, and of the Eureka and Creswick Creeks, in Victoria, the alluvial deposit in which the gold is now found, and the quartz-veins from which it has been derived. Mr. Odernheimer has also forwarded, through Sir R. Murchison, some new details respecting the geology of part of the Peel River district. His attention had also been directed to the auriferous beds and the gold-bearing quartz veins, and he has added some interesting remarks on the formation of the gold, observing that he has no doubt that it is derived from auriferous iron pyrites.

Palæontology.—Our active Assistant-Secretary, Mr. Jones, has published in the 'Annals and Magazine of Natural History' some interesting notes on Palæozoic bivalved Entomostraca. In these remarks he has described some species of *Beyrichia* from the Upper Silurian limestones of Scandinavia. Drifted fragments of these limestones occur abundantly in the diluvial sands and gravels of Mecklenburg, Brandenburg, and Pomerania. Mr. Jones having obtained fragments of this rock from the gravels of Prussia and Silesia, proceeded to examine their contents with a view of comparing the British forms with those published by Klöden as portions of the carapace of small Trilobites, and of reviewing the nomenclature of the species and the terminology of the subject. Mr. Jones describes the different fossil contents of five distinct fragments of limestone, of which one is from near Berlin, and the others from the vicinity of Breslau. The result of this examination was the discovery of no less than eight species of *Beyrichia*, together with *Cytheres*, *Leptæna lata*, the two latter occurring in every fragment, *Tentaculites*, and Encrinital remains. Mr. Jones then proceeds to describe these species of *Beyrichia*, illustrating by a plate the several forms obtained from the limestone-fragments; and by another plate, in a subsequent paper, several British and Foreign species of the same genus.

He has also published in the same periodical an interesting account of some species of *Leperditia*, another family of Palæozoic bivalved Entomostraca, larger than the *Beyrichiæ*, and characteristically distinct. They are also from the Silurian rocks of Scandinavia, Russia, Arctic America, and England, except one from the Devonian rocks of Normandy. After narrating the general facts of our knowledge of these minute entomostracan bivalves, peculiar to the palæozoic formations, Mr. Jones describes the principal forms of the genus, comprising seven species, accompanied by two plates of illustrations; and, after some observations on the genus itself and its points of resemblance with the more recent and the existing forms of Limnadidæ and Cypridininæ, he observes that the study of this peculiar group may be of use not only in showing the difficulty that exists in coordinating the fossil genus specially referred to (so far as the remains of the carapace will help us) with its known allies, but also to some extent in illustrating another example "of the combination in extinct animals of characters which are separately manifest in existing species."

The same publication also contains a notice by Dr. Thomas Wright of a new genus of fossil *Cidaridæ*, to which he has given the name of *Hemipedina*. He observes that in his memoirs on the Cidaridæ of the Oolites, three species were described, of which the true generic position seemed even then uncertain. The materials then known did not justify the proposing of a separate genus for their reception. The subsequent discovery of an interesting series of new congeneric forms has now enabled him to rectify the determination and to propose the new genus *Hemipedina* for the group. Sixteen species from different liassic and oolitic beds are described, which, with the exception of four from France, are all English.

Mr. Thomas Davidson has published some remarks on the Systematic arrangement of recent and fossil Brachiopoda, in the 16th volume of the 'Annals of Natural History,' for the purpose of submitting a more perfect arrangement of classification than the one published in 1853. But even this classification Mr. Davidson admits must not be considered as finally correct. The paper contains an improved table of the families and genera in the form in which it will be published in the forthcoming foreign editions of the introduction to his work on British fossil Brachiopoda, and also explains the changes which have been proposed in the different genera and subgenera. The author also adds some remarks on certain interesting observations published abroad, but which appear to have been overlooked by British naturalists.

Amongst the many palæontological works by which the past year has been distinguished, none are more deserving of notice than the two additional numbers of the *Palæontographica* published by Dunker and Hermann v. Meyer. These are the third and completing fasciculus of the fourth volume, and the first of the fifth volume. They are, as usual, accompanied by plates in no way inferior to those of the preceding volumes.

Baron P. de Ryckholt has published the second part of his *Mélanges Paléontologiques*, with six plates of fossils. This number is devoted to a description of the fossils found in the neighbourhood of Visé, on the banks of the Meuse below Liège. The formations here observed are given by the author in the following ascending series:—1. Devonian; 2. Carboniferous; 3. Clay with kidney-shaped masses, of the age of the cretaceous gompholite of Aix-la-Chapelle; 4. Greensand with *Belemnitella quadrata*, d'Orb.; 5. Gravel with clay; quartzose and siliceous pebbles mixed with ossiferous diluvium.

I must also mention, however briefly, Prof. King's ingenious communication on the *Pleurodictyum problematicum**. After carefully describing the appearance of the specimens he obtained from the Upper Devonian sandstone of the Eifel, which he shows to be casts, he alludes to the curious vermiform appendage which winds tortuously through the substance of the cell-walls, and which, while the Pleurodictyum was supposed to be a coral, was considered as an extraneous serpuliform body. Prof. King then endeavours to prove that this vermiform appendage is an integral organic portion of the fossil, and for this and other reasons connected with its structure, he maintains that it cannot be regarded as a member of the class Corallaria. The appendage he believes to be the cast of a fleshy tube included in, and protected only by, the substance of the cell-walls,—in fact the cast of a tubular chamber which enclosed the intestinal canal of Pleurodictyum, the animal consequently having had two orifices to its digestive organs. In this point of view it would bear some affinity to the Bryozoaria. In other respects again it would present affinities with the Zoanthic type, inasmuch as there would be only one appendage to all the cells. Its occupant may therefore, it is suggested, have been a Zoanthoid Bryozoon! In conclusion, the author observes, that if his view of the position of Pleurodictyum in the animal kingdom be correct, it will represent a type which, although not known as living, is one that there is no difficulty in conceiving to have existed, since it forms exactly the link that is wanting to connect the true Corals with the class Bryozoaria. We should thus have another example of what has been described as "the combination in extinct animals of characters which are separately manifest in existing species." But time and space will not permit me to allude to the many interesting memoirs connected with geology and palæontology which have been published during the past year. I regret that I can only refer you to them generally; but there is scarcely a scientific periodical published in this country, or on the continent in France, in Germany, or in Italy, which does not contain some valuable information connected with one or other of these branches of our science.

Miscellaneous.—The subject of cleavage, on which we had several communications read before this Society in the preceding year, has not again occupied our attention during the past year; but another geologist

* Ann. Nat. Hist. vol. xvii. p. 131.

has in another publication entered very largely on the consideration of this question. Mr. Henry Clifton Sorby has published in the Philosophical Magazine a valuable paper on slaty cleavage, as exhibited in the Devonian limestones of Devonshire. The question which he proposes for consideration is, whether slaty cleavage be the result of crystalline or mechanical action; and he observes that a most careful examination of these rocks, which he considers as peculiarly suitable for the purpose, in the field, microscopically, chemically, and by means of the polariscope, has convinced him that the structure on which their slaty cleavage depends may be completely explained on mechanical principles. The author's arguments are well put together, and with regard to many supposed cases mathematically correct; but whether applicable to all cases of cleavage is perhaps more than can fairly be assumed, nor does it appear to be a necessary consequence, that because a rock has been exposed to enormous pressure, its surface must therefore have spread out over a more extended space in proportion to that pressure, as the author seems to assume in the account of his practical experiment with the pipe-clay, and the scales of oxide of iron. The author concludes by observing that the cleavage of the limestones varies directly as the amount of mechanical compression to which they have been subjected, and that he cannot therefore hesitate to conclude that slaty cleavage is the result of mechanical, and not of crystalline forces.

Amongst the works of a more general character, I must remind you of the publication of Sir Charles Lyell's last edition (fifth) of the 'Manual of Elementary Geology,' or the ancient changes of the earth and its inhabitants, as illustrated by geological records. It is distinguished by much additional information, derived both from the extended observations of the author himself, and from the labours and researches of other geologists. A most interesting chapter in this volume is the detailed account of the Canary Islands, and the celebrated Island of Palma, regarded by the late Leopold von Buch as the type of what he called a "crater of elevation," or "Erhebung's Crater." Sir Charles Lyell has recently personally examined these localities, in company with Mr. Hartung of Königsberg, to whose zeal and talents he was indebted for much assistance, and the result of the examination has been to call in question the "elevation theory" of the celebrated Prussian geologist.

After carefully describing the physical features of the district, and the various strata of scoriæ, lapilli, and lava which constitute the different beds, Sir Charles points out several remarkable circumstances which militate against the elevation-crater theory. He particularly alludes to the absence of fractures in the rim of the great cavity of the Caldera, which must have been the result of any elevatory action. He fairly shows the greater probability of the mass of inclined beds and strata round the orifice being due to the accumulation of ejected tuffs, lapilli, and scoriaceous matter falling round the crater, from which they had been ejected, and thus forming a compact mass of igneous matter of various kinds, sloping in every direction, at a considerable angle.

At the same time there are phænomena which even this theory fails to explain satisfactorily, and we shall probably not greatly err if we assume that, while the chief amount of altitude is due to the accumulation of ejected matter round the orifice, a certain amount of paroxysmal elevation has taken place, although not sufficient to support the entire theory of the late Leopold von Buch.

I may also mention that this work contains much additional information respecting the tertiary deposits of Germany and the age of the associated brown-coals.

Prof. Ehrenberg continues his investigations respecting the Infusoria with his wonted energy. Interesting notices of his discoveries, and his communications thereon, will be found in Leonhard and Bronn's Jahrbuch for the past year. The remains of many forms of Polythalamia have been found by the Professor in the green sands of various formations, some of which are so well preserved that they have led to interesting physiological discoveries.

A question of great interest, both to zoologists and to geologists, has recently attracted the attention of the Geological Society of France and of the Academy of Sciences. The habit of several species of zoophytes and mollusca to perforate rocks of different kinds is one which has not yet received a satisfactory solution. Whether this result is produced by chemical or mechanical means has not yet been fully proved, although the balance of evidence seems now leaning towards a mechanical solution. In this state of the question, and while many persons are still disposed to believe that these perforations have been produced by other means, the statements lately made in Paris, and the specimens laid before the Institute and the Geological Society, are sufficiently interesting to merit notice on the present occasion. It was originally supposed that calcareous rocks alone had been perforated by these animals, but the same phænomena have recently been observed in other rocks. M. Caillaud of Nantes has found the granite of Poulinguen, in the Bay of Croisie, perforated by *Pholades*. In this case, the striæ in the hollows corresponded with the spinous processes of the shells, and left no doubt that the effect was here at least due to mechanical action. Here, however, the decomposed state of the granite may have facilitated the operation.

At a more recent period, M. Eugène Robert exhibited a block of Silurian sandstone, belonging to the transition formation which forms the shore of the great bay of Douarnenez, perforated by numerous holes made by *Echini* living in them. Each circular cavity was exactly proportionate, both in size and shape, to the Echinoderm in it.

Prof. Long, of Grenoble, well known for his many able geological memoirs, has recently requested M. Valenciennes to lay before the Academy of Sciences several specimens of perforating *Echini* which have established themselves in the granite of Guérande, in the Bay of Croisie, near Turballe, not far from Piriac. This granite is similar to, and in the same state of decomposition as, that of Poulinguen, and is perforated over a space of several kilometres by Mollusks and Echinoderms, and the *Echini* are evidently of the same species as those which have perforated the Silurian sandstones of Douarnenez. Whether it is the same species as the *E. lividus* (Lamk.) from the Mediterranean, with which it has the greatest resemblance, remains to be proved.

I understand that when these or similar specimens were exhibited before the Geological Society of France, a lively discussion took place as to the cause of the hollows in which the Echini dwelt; whether the Echini had themselves made the cavities, or had only crawled into cavities already made for them by other means. When I was at Paris last summer, my attention was attracted by a fine specimen of granite rock, worn into numerous cavities, each containing an Echinus, exhibited at the Palais de l'Exposition. This was long before the discussion at the Geological Society took place, and I can only say that the decided impression on my mind was that the cavities in question were made by the animals themselves. It would be impossible to explain, on any other supposition, the remarkable coincidence between the size of the Echinus and the depression in which it dwelt. This hollow, it should be observed, never exceeded, even in the case of the largest, half an inch in depth. The Echini were there of all ages, from half an inch to two inches in diameter, and in every case the circumference of the depressions, crowded as they were on one another, invariably coincided with the Echinus in it. In some cases, when the cavities had been vacated, a new comer had attached itself, not in the pre-existing cavity, as might have been expected, but on the intervening border, and thence wearing down the rock had caused a depression, intersecting both the neighbouring hollows.

A notice has reached me, announcing the intended publication of a work entitled Etudes Géologiques, by M. Fauville of Perpignan. Should the work thus announced ever see the light, it will contain more novel doctrines and bolder statements than the most ingenious or paradoxical Members of this Society are in the habit of putting forth. Our greatest efforts will be small indeed by the side of the ambitious doctrines of M. Fauville, who proposes to describe the history of the earth from its first existence in a nebulous state, and at an enormously greater distance from the sun than at present, through the immense spiral course which it has described in space, passing successively through the actual positions of Neptune, Uranus, Saturn, Jupiter, Vesta, Juno, and Mars, to the moment of its final volatilization in the immediate vicinity of the Sun, to which, in the spiral course laid down for it by the author, it is gradually tending.

Geological Maps.—I must not omit to call your attention to the New Geological Map of Europe, by Sir R. Murchison and Professor Nicol, which was exhibited and explained by one of the authors at the recent Meeting of the British Association at Glasgow, and which is now published. This map is in fact an extension to the whole of Europe of that of Russia and the Ural, published by Sir R. Murchison in 1846. It is on the same scale, and with the same colours to designate the various formations. It gives us, for the first time, an idea of the geology of Spain, for which we are mainly indebted to

M. de Verneuil and those Spanish geologists and miners who, with M. Casciano de Prado, have for some years been actively employed on the geology of that country. Indeed, had it not been for the wish of the authors to delay its publication until they had obtained the materials collected by M. de Verneuil respecting the geology of the Peninsula, the map would have been published long ago. We are greatly indebted to them for having thus filled up this blank in European geology. Still all is not yet done in the Peninsula, notwithstanding the labours and exertions of MM. d'Archiac, de Verneuil and others. M. d'Archiac, it is well known, was the first to establish the existence of the Trias in Spain, and I have no doubt that we shall soon obtain from him and his fellow labourers and associates in that field much additional information on this subject.

The following account of the progress of the geological map of Germany, which has been recently forwarded to me from one of those who are actively engaged in the undertaking, will, I am sure, be read with interest:—

"In Bavaria, the surveys of the Fichtelgebirge, of the Bavarian Forest, and of the neighbourhood of Regensburg, under the direction of Prof. Gümbel, are completed. In Darmstadt the following sections, Bredenkopf and Gladenbach, prepared by Herr v. Dechen, that of Budingen by Ludwig, and Giessen by Dieffenbach, who is, alas! no more, are already finished and in the engraver's hands. The district of Friedberg is published. The Hessian Government has provided ample means, and everything is progressing satisfactorily. The German Geological Society has given over all the original sketches and plans to M. v. Dechen, to prepare a new general Index Geological Map of Germany. He has completed his task, and will shortly publish the map. You probably already know that Rhenish Prussia and Westphalia are entirely laid down, and that two sections of the Westphalian cretaceous district have already appeared. The execution is the finest I have seen in Germany. In Baden, all our preparations are made, and I believe we shall commence in a short time, if peace is secured."

I must also inform you that M. v. Dechen, the distinguished Prussian mining engineer and geologist, also exhibited at Paris a Geological Map of the Rhenish provinces of Prussia and of Westphalia. This map, on the scale of $\frac{1}{80,000}$th, has been prepared entirely by M. v. Dechen, by order of the Prussian Government, and is a worthy monument of his talent, his zeal, and his exertions.

In alluding to Mr. Mylne's large MS. Map of the Geology of London and its immediate vicinity, exhibited at Paris, it is impossible to praise too highly the attention and care with which the materials have been collected, and the artistic skill with which it has been executed. It is to be hoped that Mr. Mylne will not long delay the publication of it.

Before concluding these observations, which, however imperfect they may be, have nevertheless, I fear, greatly exceeded the usual space allotted to these Addresses, I am desirous of saying a few words on a subject closely connected with the highest considerations of our science, and which has been argued with great ability by one of the most philosophical writers of the day. I allude to the Essay of Professor Baden Powell on the Philosophy of Creation. One of the many great and transcendental questions discussed in this Essay is the controversy as to whether we are to give a preference to the old doctrine of the immutability of species, or to the more recently introduced theory of transmutation. The question is undoubtedly one of great difficulty, but it is not the less necessary that we should endeavour to form a definite opinion on the subject, founded on the fullest and most authentic information we can obtain. It may indeed, in some respects, be said to be one of the most important questions in geological investigation. Why do we endeavour to obtain correct information respecting the true order and arrangement of stratification? Why do we endeavour to obtain the most perfect collections of the organic remains of each stratum and formation, and to ascertain the different classes and groups of organized beings which have dwelt and flourished on the surface of the globe at the different periods of its existence? Surely not for the sake of such collections and such knowledge of stratification *per se*. For, although, owing to peculiar circumstances, many geologists may not have the opportunity of carrying their investigations beyond these points, it should never be forgotten that all such information is but a stepping-stone to higher generalizations. It is but the alphabet of one of the languages in which Nature speaks to us, and by means of which we must endeavour to unravel the past history of our globe, and to form some idea, so far as our finite faculties permit us, of the first origin, and inductively of the final objects, of creation. In this point of view, the question as to the immutability or transmutation of species is one which touches the very existence of our science, and I am therefore desirous of briefly pointing out what appears to be a fallacy in some of the statements of Prof. Powell on this subject.

The arguments of the various writers on both sides are fully and fairly given in this work, and the author professes merely to point out the bearings of the question, the difficulties in which it is involved, and to controvert what he considers hasty and untenable assertions on either side. But while doing this, it is impossible to avoid the conviction that he has a decided bias to one side, that he considers the doctrine of transmutation of species more consistent with sound philosophical induction than what he calls the hypothesis of an eternal immutability. I shall not pretend to occupy your time by going through arguments so well known to every palæontologist and geologist. I only wish, as I said before, to point out one or two conclusions which involve what appear to me a fallacy.

After showing how the successive investigations of the great comparative anatomists and zoologists of the last half-century have resulted in the establishment of the doctrine of the unity of composition of animal forms, a result to which the researches of Prof. Owen have mainly contributed, he proceeds to the examination of the question of species. He points out the existence of subspecies and varieties, many of which become permanent, and alludes to the number of *new* species constantly discovered which have to be inserted between other allied species already known, inferring that the specific differences between each must by such additions tend to diminish continually, and that all species tend to be connected by more and more close affinities. Thus, he argues, all differences gradually disappear, and there results no greater difference between two allied species than between varieties of the same species, and consequently no difficulty in admitting that the difference which does exist is not greater than what might be expected as the result of local circumstances, modifying external forms, and thus practically producing transmutation. Indeed he goes still further, and adopting an infinite duration of time, and an infinite number of species, he argues that there will ultimately be no perceptible difference at all between two allied species. The following is his argument :—

"But, while the number of species thus tends to become infinitely great, the extreme difference between man (let us suppose) at one end and a zoophyte at the other end of the scale is constant and finite; hence the average difference between any two species tends to become *infinitely* small; multiplied by the number of species, it must still be equal to a *finite* quantity; and the product being *finite* if the first factor be *infinity*, the second must be *zero*."

This argument appears to involve a fallacy. If this infinite number of allied species is to prove the transmutation of one form into another by showing that the difference between them is infinitely small, it would be necessary to prove either that they had all existed contemporaneously together, or that the allied forms immediately succeeded each other. But when the author calls in the aid of long geological epochs in which some of these closely allied forms existed at long intervening periods, I cannot see how the question of transmutation is thereby strengthened. If A, B, and C are the allied forms, and A and C existed either together or in immediately succeeding periods, and B, which is the connecting link to fill up the gap between them, is only found to exist after many millions of years, or even only after the other two had died out, the theory of transmutation cannot be supported by assuming the gradual change of A into C, through the intervening form of B. If every possible gradation of form existed in the fauna of one period and of one region, or of successive periods and neighbouring regions, then indeed the advocates of the transmutation theory might endeavour to maintain that all these forms were only varieties of one type occasioned by the peculiar conditions of life in which each was placed; but this conclusion is no longer valid when long periods have intervened between the existence of one form and that of the other. The utmost argument that could be drawn from such premises would be a confirmation of the great doctrine of unity of plan in the creation of all organized life, extending through all ages of the world.

Another fallacy may, I think, be detected in the manner in which Prof. Powell, after stating the arguments on both sides, points out the real alternative. He says, "the only question is as to the sense in which such *change* of species is to be understood; whether individuals naturally produced from parents were modified by successive variations of parts in any stage of early growth or rudimental development, until in one or more generations the whole species became in fact a different one; or whether we are to believe that the *whole race* perished without reproducing itself, while, independent of it, *another new race*, or other new individuals (by whatever means) came into existence, of a nature closely allied to the last, and differing often by the slightest shades, yet unconnected with them by descent; whether there was a propagation of the same *principle of vitality* (in whatever germ it may be imagined to have been conveyed), or whether a new principle or germ originated independently of any preceding, *out of its existing inorganic elements*."

In the sentence which I have just quoted, there are two sets of alternatives, and I think that in each set the author has inserted a fallacy in stating the second alternative respecting the theory of immutability. In the first set he has assumed, without any warrant, that a whole former race has perished and is succeeded by another of a closely allied nature and often differing only by the slightest shades. In such a case, viz. where the difference is very slight, it may be possible that the second race is really the descendant of that previously existing, slightly modified by the external conditions of life in which it was placed. But the author has omitted all reference to those species which occur in the new or upper formations, whose resemblances or analogies to those of the preceding period are very distant or imperfect, and which cannot therefore be looked upon as the descendants or modifications of the pre-existing forms. There are undoubtedly species which have been continued through many geological periods, have survived many local disturbances, and which, while others may have perished, have been kept alive by greater vital energies or other influences, and have become the associates of new forms introduced for the first time and having no resemblance to or analogy with the forms which had preceded them. We know that some species pass into many varieties, sometimes even contemporaneously with the existence of the typical form; there is, therefore, surely nothing inconsistent with the theory of immutability in supposing, under peculiar circumstances, that varieties of some species may also take the place in a subsequent period of the original typical form. This, however, is the exception, and not the rule.

With regard to the second set of alternatives in the passage I have quoted, I think Prof. Powell is too much begging the question when he concludes the sentence with these words: "out of its existing inorganic elements." Surely this is taking too physical or material a view of the matter, and one not required by those principles of inductive philosophy which he so strongly supports. The advocates of immutability of species do not generally talk of a principle of vitality originating out of inorganic elements. When old forms die out, and are succeeded by new, the *matter* of which the new consist is derived from the existing inorganic elements; but the life or principle of vitality by which it is animated must proceed from a different source, from that same source, mysterious it may be, which first breathed life into those creatures which dwelt in the oldest palæozoic ages. Organic life on this earth must have had a beginning, and that beginning must have proceeded from a source very different from that dead matter which formed the visible body; and from that same source proceeded the principle of vitality which animated the new forms when successively created on the earth. And with reference to this question, I must emphatically deny the right assumed by Prof. Powell, when he puts what he calls an imaginary case of a truly new species making its appearance, to question those who deny the theory of transmutation, how this new species made its appearance; whether it appeared as an ovum or seed, or at what period of growth, &c. When Prof. Powell can state in what form the first living organisms appeared on the earth's surface, he may demand an answer to this question. It is the more remarkable that Prof. Powell should make this demand, as he has stated, in a former part of the Essay, that in a geological point of view the term "Creation" signifies the fact of origination of a particular form of animal or vegetable life, without implying anything as to the precise mode of such origination: not that I think this definition altogether satisfactory, but yet it might have precluded him from making such a demand.

But I have been led into a longer statement than I had intended. I will merely add that, notwithstanding these criticisms that I have ventured on, the essays of Prof. Powell deserve a careful and attentive reading. They are eminently suggestive and replete with deep thoughts and scientific views, and form an interesting element of the geological, or rather geognostic, literature of the day.

As in some measure connected with the same subject, I must direct your attention to a paper published by Mr. Alfred Wallace* on the law which has regulated the introduction of new species. Mr. Wallace is a naturalist of no ordinary calibre. His travels in South America and elsewhere are a sufficient guarantee of his high merits; he now writes from Sarawak, Borneo. From a careful examination of the actual distribution of existing forms of animal life, and the gradual but complete renewal of the forms of life in successive geological epochs, he has deduced the following law:—*Every species has come into existence coincident both in space and time with a pre-existing closely allied species.* The question is one of great importance, and deserving the careful investigation of every geologist; but I think it may be doubted whether this assumed law can be maintained as a universal generalization.

Gentlemen,—Having thus, however imperfectly, gone through my allotted task, it only remains for me, before quitting this Chair, to thank you for the forbearance you have shown to my shortcomings, and to entreat your indulgence for what I may have neglected during the period I have had the honour of presiding over this Society. I know that there are many who might have brought more varied information and geological knowledge to bear on the discussions at our

* Ann. of Nat. Hist. vol. xvi. p. 104.

Evening Meetings; but I think I may also say that there are none who take a livelier interest in the welfare and prosperity of the Society. And whether it will be our destiny long to occupy these apartments, with which our existence almost seems identified, or whether we shall one day find ourselves located in some scientific palace in juxtaposition with other scientific bodies, I trust that you will ever find me taking the same warm interest as now in our proceedings, and ready to afford all the assistance in my power towards furthering the objects of our common cause. I congratulate you on the choice of my successor, which you have this day made. I feel that I resign this Chair to one who is intimately acquainted with all the details of the Society, to one who has long lived and moved and spoken amongst us,—who is thoroughly acquainted with every branch of our science, and who will at the same time impart fresh vigour to our proceedings, and give additional interest to the further progress of geological research.

THE

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PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

NOVEMBER 7, 1855.

William Harrison, Esq., was elected a Fellow.

The following communications were read:—

1. *On the* COAL *of the* NORTH-WESTERN DISTRICTS *of* ASIA MINOR. By H. POOLE, Esq. Communicated by the Foreign Office.

(Abstract.)

MR. POOLE, in his Reports to Government on the result of his journey to Asia Minor to examine into the probability of workable coal being found in the country near Brussa and Ghio* (Bithynia), in which coal had been reported to occur, states that he travelled from Ghio inland along the south bank of the river flowing from the Lake Ascanias, around the shore of the lake by a south-east route, passing Nicæa and along the north shore, until he returned to the village of Ortokoi, without finding any trace of coal. Marble and limestones prevailed along the whole line, except at Solis, where a narrow band of nearly vertical sandstone cropped out. On the south

* Known also as Gemlik.

and east sides of the lake a conglomerate occurred, dipping with a slight inclination towards the lake. Ouram Mountain, in the rear of Nicæa, appeared to be composed of tufa. Tufa also occurs on the shore near Keramid.

Between Ghio and Brussa the prevailing rocks are limestone, conglomerate, and sandstone.

In consequence of rumours of the existence of coal near the Lake of Apollonia, Mr. Poole travelled round that lake, but met with none. Limestone and sandstone prevail there.

Subsequently Mr. Poole went from Yallova (in company with Mr. Sandison) inland to Ortokoi, without finding any traces of a coal-formation. He next went from Yallova westwards along the coast as far as Kourikoi, where a bed of lignite, 9 inches thick, occurs; this is said to have been worked to some extent (by a 60 yards' level) by the Armenians four years since; thence he went inland to Sulimanli without seeing any indications of coal. He then proceeded to visit Arli Effendi's coal, near the village of Tchoukurkoi, S.E. of Yallova at three hours' distance. Along a ravine here lignite occurs in a seam varying from 1 to 4 feet in thickness, and dipping S. 23° E. at an angle of 52°, with coarse sandstone above and below it. This lignite also has been worked some years since by the Armenians. It was from this lignite that samples had been sent to Mr. Sandison*; but in Mr. Poole's opinion it is of no promise.

Another excursion was to the Lake Sabandji, where a thin seam of lignite crossing the road on the south of the lake, and a lignite at Ak Sophé, to the east of the lake, were visited. Nowhere did Mr. Poole find proof of the existence of good workable coal in the districts above referred to.

Subsequently he proceeded to visit the Kosloo and Zungeldek coal-district.

In a letter† to Sir R. Murchison, Mr. Poole makes the following observations on the geology of the districts through which he passed on his last tour of inspection. Going from Constantinople to Yallova in an open boat, he observed that at Touzla Point the limestone has been squeezed into zigzags, with intervening concentric bands, as if pressure had been applied from below. Salt is made from a small lake near the Point; and lead-mines are worked at two hours' distance.

From Yallova, writes Mr. Poole, I rode to the top of the ridge which overlooks Ortokoi, where I had been on my former tour; after crossing the plain, I found coarse sandstone dipping S.E. at about 45°. The next ridge had soft red sand overlying micaceous rock, which dipped 23° N. 34° W. After crossing the ridge, the rock was nearly vertical, dipping S. and E. I then crossed to the west side of the brook, and found limestone all along its western side.

Going along the shore from Yallova in a westerly direction, at Ghiuz Tepè, I met with sandstone, dipping S. 48°, full of broken

* See Quart. Journ. Geol. Soc. vol. xi. p. 476.

† Dated Constantinople, Sept. 21, 1855.

shells; at Sivri Tepè the sandstone dipped 20° S. 80° W.; and a little further on thin seams of lignite occurred, dipping 42° S. 75° W. Between Yallova and Ghiuz the earth was much cracked by the late earthquakes; and in some places large pieces had sunk 20 to 40 feet perpendicularly down. Near Kourikoi is another seam of lignite (referred to above, p. 2).

I then rode inland to visit the Sultan's Baths at the back of Sulimanli. The first hills were of white limestone; and in the valley was white marl, with thin seams of lignite. After an hour's ride we crossed a vein of greenstone, 4 feet wide, dipping 62° to 68° S., and striking E. and W. The next hill was of coarse conglomerate, dip 21° S. 45° E.; the ground then became much disturbed, and at the baths the limestone is nearly vertical; strike N. and S. The temperature of the spring was 148° Fahrenheit. On the south side of the Baths the rock was clay-ironstone, dipping E., nearly vertical.

North of the village Tchoukurkoi (where Arli Effendi's coal is) we found the soil to be red and white marls; and we followed the river until we reached the shore of the Sea of Marmora, along which we rode until we got to Dil Point, from thence we crossed by a ferry to the northern shore. Here blue limestone, dipping N. 58°, came down to the water's edge: thence to Tauschandjik, the rocks were white sandstone and coarse conglomerate. About one mile from Iskeli are large caverns in the limestone, which dips about S.E.; this was succeeded by coarse conglomerate; the rocks then receded from the shore, and from the pieces on the road and in the brooks appeared to be red sandstone.

The cliffs at the Lake Sabandji are very high, and composed of rounded stones and sand, evidently an ancient beach. The tradition is that the lake was formed at the same time that Nicomedia was destroyed by earthquake: there is no outlet from the lake, though several streams run into it.

From Lake Sabandji we went through Ada Basar, crossing the Sangarius three times, to the shore of the Black Sea. White limestone prevailed until we got to Ak-caia (about one hour east of Atsche shehr); this Point is some hundred feet high, of fine sandstone, nearly perpendicular, full of large concretions; a great many also lie on the shore with the waves breaking over them.

The rocks were principally limestone until we reached Heraclea, which is built on a coarse sandstone. The road is so bad and tedious from Heraclea to Kosloo that we went in a boat. Mr. Barclay has promised to make you during the winter a plan of the Coal-district; which is not continuous, but in patches along the coast for several miles, and averaging about one and a half mile in breadth; therefore I shall not attempt to describe it at the present time. There are ten known seams at Kosloo; and four are seen in one hill-side at Zungeldek.

I found *Stigmaria*, *Calamites*, and *Sigillaria* in the floor of the coal, but they are scarce; some Ferns were found in one of the seams formerly worked at Kosloo, but I could not meet with any.

There is not any later formation overlying the coal-formation, and in many places the coal-deposits have been removed. The mines are much disturbed by faults crossing in every direction, and the seams are in general inclined at an angle of about 30°.

The particulars of his first journey in Asia Minor in search of coal are not referred to in the above abstract, but have been communicated by the author since his return to England.

On this occasion Mr. Poole travelled from Ghio to the Lake Ascanias and thence by Bazarkoi to Ortokoi; and in the ravine between Ortokoi and Yenikoi he examined five seams of lignite, dipping for the most part at a high angle to the N. From one of these seams, 20 inches thick, a quantity had been obtained for a steamer and found useless. The thickest and lowest seam, about 7 feet thick, is full of small shells (*Planorbis* and *Limnæus*?). Mr. Poole also examined the Hassan Deré seam, in a ravine to the westward. This much nearer approaches coal in its character, and has been worked by the Armenians to some extent; but the works were destroyed by the late earthquakes (Quart. Journ. Geol. Soc. vol. xi. p. 543). At Hassan Deré the Nummulitic Limestone, dipping to the south, occurs within 200 yards of the coal, which dips to the N.W.; but, from the very much disturbed state of the stratification, the relations of the several rocks are not apparent.

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2. *On the* Newer Tertiary Deposits *of the* Sussex Coast. By R. Godwin-Austen, Esq., F.R.S., F.G.S.

(Abstract.)

[The publication of this Paper is deferred.]

From Brighton, westwards, between the chalk-hills and the sea, the surface of the country is formed, first, by a raised terrace of "red gravels," lying on the sloping base of the chalk-hills, and on the old tertiary deposits; secondly, the gravels of the Chichester levels, or the "white gravels." These latter are distinctly bedded and seamed with sand, and are more water-worn than the red gravels which pass under them; thirdly, the white gravels are overlaid by "brick-earth," which is somewhat variable in its characters. These, with their equivalents, are the Glacial deposits of the district in question.

The coast-sections, though very limited in extent, exhibit several important phænomena illustrative of the history of these newer tertiary accumulations. At Selsea, where the Glacial deposits are about 25 feet thick, the underlying Eocene clay is seen, at extreme low water, to be perforated by a very large variety of *Pholas crispata*, and to be overlaid by a deposit containing *Lutraria rugosa*, *Pullastra aurea*, *Tapes decussata*, and *Pecten polymorphus*, contemporaneous with the *Pholades*. Elsewhere brown clays, or local ferruginous gravels, cover unconformably the Eocene beds. The surface of the brown clay is deeply eroded, and bears a yellowish clay, which contains large chalk-flints, and a great variety of pebbles and boulders of granitic, slaty, and old fossiliferous rocks, such as are now found in the Cotentin and the Channel Islands. One boulder of porphyritic granite measures 27 feet in circumference. A few sea shells (*Littorina*, &c.) occur in the yellow clay.

This deposit the author regards as the equivalent of the "white gravel" in its extension southwards, the gravel having been littoral, and the clay with boulders a deposit formed in somewhat deeper water of this portion of the glacial sea.

The coast-sections exhibit the surface of the yellow clay as having been eroded and covered by a variable deposit, sometimes gravelly and sometimes sandy, and containing marine shells (*Cardium edule, Ostræa edulis, Turritella terebra*, &c.). This band contains also fragments of the old crystalline rocks, obtained from the destruction of the underlying yellow clay.

On the shelly and pebbly band lies the brick-earth, an unstratified earthy clay deposit, with small fragments of flint, and a few pebbles, and with occasional silt-like patches.

The particular subject of this paper was the occurrence of the granitic and slaty detritus in the yellow clay. These blocks are especially numerous near Bracklesham, Selsea, and Pagham. The author explained the difficulties that lie in the way of supposing that they were derived from the Cornwall coast, or direct from the shores of Brittany or the Channel Islands. His previous observations, however, on the bed of the English Channel had prepared the way for the explanation of the hypothesis he now advanced—of the former existence of a land-barrier, composed of crystalline and palæozoic rocks, crossing from Brittany to the south-east of England, and forming a gulf or bay open to the west.

Into this bay the marine fauna represented by the *Pholas crispata* and its associates extended from the westward; and in the hollow of the bay, at a rather later period, coast-ice brought the boulders from along the old shore-line, which is now represented by a sunken peak in mid-channel and a shoal of granitic detritus.

Alteration of level succeeded; and the partial destruction of the yellow clay deposit afforded the overlying pebble-bed, and, in the author's opinion, the granitic blocks found in the old raised beach at Brighton.

Mr. Godwin-Austen thinks it probable that the superficial brick-earth of the district under notice was formed in a land-locked lagoon, subject to periodical freezing; and that the "elephant-bed" at Brighton is one of its many and variable equivalents (in this case probably subaërial).

The brick-earth area has been subsequently encroached upon by the estuaries of Pagham, Portsmouth, &c.; and the successive oscillations in the level of the land are evidenced in the estuarine deposits and submerged forests of Pagham, Bracklesham, Portsmouth, &c.

With regard to the latest movements, the author's observations showed that from Lewes Levels to Chichester Harbour, and on to Hurst Castle, the coast exhibits signs of undergoing elevation at the present day. The coast of the Isle of Wight opposite seems, on the contrary, to be suffering depression; whilst the back of the island exhibits some curious signs of local oscillation.

November 21, 1855.

James Gay Sawkins, Esq., was elected a Fellow.

The following communications were read:—

1. *On the* Boring *through the* Chalk *at* Kentish Town, London. By J. Prestwich, Esq., F.R.S., Sec. G.S.

It is little more than half a century since Artesian wells were brought into use in and around London. The success of the first works led to so rapid an extension of this mode of procuring water that the source of supply, which was from the sands under the London Clay, proved insufficient for the demand. Consequently, in order to obtain a better supply of water, a large number of the wells more recently constructed have been carried down to variable depths into the underlying chalk. Nevertheless, the water-level in the Artesian wells, which, in 1822, rose to the level of Thames high-water-mark, now stands in London at about 50 feet below that level, and continues to fall at the rate of about 1½ to 2 feet annually.

From a previous acquaintance with the London Tertiary district, and from the attention which the question of the water-supply attracted at the time, I was led, in 1849, to make some inquiries into the bearing of the geological structure of the country around London with reference to the question of the deep-well-supply. The result of that inquiry I published early in 1851 *, and the conclusion to which I arrived was that the dimensions of the Lower Tertiary sands were insufficient to furnish any increased supply, and that the chalk not being, properly speaking, a water-bearing deposit, *i. e.* one transmitting water freely in all directions through its mass, could only yield at that depth beneath the surface, and from its outcrop, an uncertain and moderate supply. I further showed, that from beneath the chalk there cropped out, both to the north and south of London, a large mass of light-yellow, ochreous, and white siliceous sands, geologically known as the Lower Greensand, 300 to 500 feet thick, extremely permeable, and yielding generally, in its surface-wells and springs, water of good quality. As I found that the effective area and thickness of this deposit was ten times greater than that of the Lower Tertiaries, and its outcrop considerably higher,

* "A Geological Inquiry respecting the Water-bearing Strata of the country around London." 8vo. Van Voorst, 1851.

I was led to anticipate a water-supply proportionately larger, and capable of rising through Artesian wells to a height of 100 feet or more above the level of the Thames at London*.

The practicability of such a work was proved a few years since in France by the Artesian well of Grenelle at Paris, which, after traversing 148 feet of Tertiary strata, and 1394 feet of Chalk, reached the Lower Greensand, and from this source a large and well-maintained supply of excellent water has since been continually flowing, and rises 130 feet above the surface. There are several such wells through the Chalk at Tours, Elbœuf, and elsewhere, some for private, and others for town supplies, and the greater number are perfectly successful. In London the conditions for a work of this description appeared even more favourable than in Paris, for the Lower Greensand in England is much thicker than in France, and the outcrop is nearer to London than to Paris and relatively higher.

The only apparently serious objection urged against such a work here was the thickness of the chalk, which was variously estimated from 1000 to 1700 feet thick; but I showed, that, although it had proved to be more than 1000 feet thick at Saffron Walden, it was probably much less at London, for there was reason to believe that the upper beds of the chalk had been extensively denuded, as they trended towards the area of the Weald, before the Tertiary period, and that the chalk with flints around London, which it had been customary to call the Upper Chalk, belonged in reality to the Middle Chalk. Taking the mean of several sections drawn through London, I concluded that the chalk would not be found to be more than 600 to 650 feet thick. Adding to this 200 feet as the thickness of the superimposed Tertiary strata, which at London vary from 100 to 300 feet, and assigning 40 to 50 feet to the underlying Upper Greensand, and 100 to 150 feet to the Gault, I estimated that the Lower Greensand beneath London might be reached at a depth not exceeding 1000 to 1100 feet. I suggested that the experiment should be made in low ground, and instanced St. James's Park as a favourable locality for obtaining by this means natural fountains rising to a considerable height above the surface.

We are indebted, however, to the Hampstead Water-Works Company for the first attempt to solve this problem practically; but, as the surface of the ground at their Works at Kentish Town is 174 feet above Thames high-water-mark, the situation is not so favourable as might have been wished. A few years since this Company sunk a well through the Tertiary strata (at that spot 324 feet thick), to a depth of 215 feet in the chalk, making a total depth of shaft of

* I calculated the effective area of the Lower Tertiary sands to be 24 square miles, and that of the Lower Greensand 230 square miles; whilst I estimated the mean thickness of the permeable beds of the former to be 19 feet, and of the latter 200 feet. As it appears that the present water-supply obtained from Artesian wells in the Lower Tertiary sands amounts to about 3 to 4 million gallons in the twenty-four hours, I considered it not improbable that from 20,000,000 to 30,000,000 gallons might be drawn from the Lower Greensand by means of Artesian wells, without affecting the permanence of the water-level.

539 feet. The supply of water from this source being found insufficient for their purpose, the Directors of the Company, in 1852, consulted MM. Degousée and Laurent, the eminent well-engineers of Paris, on the advisability of sinking through the Chalk into the Lower Greensand. In November of that year these gentlemen came to London, and I accompanied them to those places in the neighbourhood of Merstham and Reigate where the outcrop of the chalk and underlying clays and sands is best exposed. The conclusion to which they arrived was precisely similar to my own, and on their report the Directors resolved to undertake the work. Accordingly, on the 10th of June, 1853, boring was commenced in the chalk at the bottom of this well.

At a depth of 569 feet from the surface the chalk with flints ended; greyish chalk without flints, becoming more argillaceous in descending, was then traversed for a thickness of 294 feet. (See the sectional list of strata traversed by the boring, pp. 13 & 14.) The chalk-marl next succeeded, and continued for 47½ feet. This would give a total thickness to the chalk of 586 feet. The chalk-marl passes so insensibly into slightly sandy marls representing the Upper Greensand, and these into the Gault, that it is difficult to draw any satisfactory lines of division. I have taken as the representative of the Upper Greensand the more arenaceous and chloritic beds. They are 72½ feet thick. These strata, however, were here, on the whole, so argillaceous that they were not permeable, and they consequently afforded no additional supply of water. The Gault was found underlying the Upper Greensand in the usual order, and presented the ordinary character of a fine grey calcareous clay, 130½ feet thick. At the base of this mass of clay a layer full of the phosphatic nodules, so common at the base of the Gault at Folkestone and elsewhere, was met with.

Thus far all the strata were in regular succession, and there was every reason to believe that the same order which prevailed at their outcrop, and with which there seemed to be nothing to interfere, would be continued underground; and that after traversing this band of phosphatic concretions, the light-coloured siliceous sands of the Lower Greensand would succeed. The ordinary probabilities of the geological sequence being maintained throughout this central area seemed then so strong, that when the works were at that point, just a year since, having occasion to speak on the subject at the Institute of Civil Engineers, I did not hesitate to express my conviction that a very few more turns of the auger would tap these sands. This opinion has unfortunately proved incorrect. Instead of meeting with loose sands, the next bed which presented itself was one of red argillaceous sand and sandstone, 1 foot thick: 12 feet of red clays (some mottled light bluish-green) and sandstones then succeeded; followed by a singular conglomerate, 2 feet thick, containing pebbles, of a considerable size, of various old and crystalline rocks: amongst these were dark grey syenites, greenstones, red claystone-porphyry, trap-rock, a grey semitranslucent quartz or hornstone, and a granular schist with traces of fossils. Then came 26 feet of red clays, underlaid by red sand and a bed of small rolled pebbles. These were followed by 42 feet of alternating beds of very hard light grey and red sandstones, sometimes concretionary and calcareous, and of argillaceous reddish sands. Then by thick beds of red clay, with subordinate seams of micaceous red and light green sandstones and of reddish argillaceous sands, to a further thickness of 74 feet; ending at a depth of 1302 feet in a hard micaceous light-coloured sandstone*.

The only spring of water met with beneath the Gault was in the thin sand and pebble bed, No. 40. A rise took place in the water-level of the well of 3 feet when this bed was first reached, but it was not maintained.

The bore-hole, which commenced with a diameter of 12 inches, was first reduced to 10, and then to 8 inches. It is tubed through the chalk, gault, and the first 60 feet of the red beds, but the last portion of 128 feet is not yet tubed.

The result of this important work is very unexpected, and presents great geological difficulties. It raises a question of much interest both in a scientific and practical point of view, and it will require further careful inquiry and observation to enable us to determine to what series these red clays and sandstones may belong, and thus estimate whether or not there is a probability of meeting with water-bearing strata at a yet greater depth. Do these red beds form an exceptional condition of the base of the Gault? Are they local beds of the Lower Greensand? Do they belong to the mottled clays and sandstones of the Wealden? Or are they to be placed with the New Red Sandstone? On the first three suppositions beds of water-bearing sands may yet occur; on the last, however, the chance of finding water would be more doubtful, although even then not altogether impossible. The Lower Greensand crops out with so much regularity both to the north and south of London, and skirts the Gault so continuously, that from a surface-examination of the ground there could be no apparent reason for supposing that the same deposit was not continuous underground and would be met with beneath London. I must confess that I never contemplated the probability of any break in the order of superposition; but, although it may prove that my anticipations were wrong, still I would observe that geology had nevertheless indicated the possibility of other conditions; for Mr. Godwin-Austen, taking a wider field of observation, and basing his deductions upon phænomena carefully studied in Belgium and the west of England, came to the remarkable conclusion, communicated to this Society last spring, that the axis of the Ardennes was prolonged under the cretaceous series of the south of England, and reappeared again on the surface in Somersetshire; and he inferred that it was probable that the coal-measures might be found under part of the London Tertiary and Wealden districts. The evidence adduced by Mr. Austen is of that nature that I am prepared to admit the possibility of such a case, and therefore consider that the

* Since writing the above the property has passed into the possession of the New River Company, and the works are at present suspended at this point.—[J. P., January 1856.]

phænomena presented by the Kentish Town well must be taken into consideration in connexion with his ingenious hypothesis*. The exact state of the question remains, however, yet to be decided. No satisfactory proof of these beds belonging to the New Red Sandstone group has hitherto been met with. In mineral character they certainly closely resemble the Red Marls, and unless some proof on other grounds can be adduced to the contrary, it is a point in favour of such a correlation.

As it is well known that the Gault in some places passes into a red clay, I at first considered it possible that these strata might be the result of a like change, but the great thickness of the beds and the alternations with sandstones militate against that view. Secondly, I would remark, that near Dorking the Lower Greensand is capped by a local bed of bright red clay; but it is only 8 feet thick, and therefore the same objection holds, although the possibility of such a variation is indicated. Next, with regard to the Weald clay: there is here no objection with regard to dimension, and the occurrence of mottled red clays and subordinate sandstones is a common feature in this deposit; still the absence of all freshwater fossils does favour this correlation. With respect to the evidence obtainable from organic series in these red beds, if the nature of the work, at so great a depth and so far out of reach, did not present an unavoidable source of error, we have evidence such as might solve the difficulty presented by mineral characters. Several fragments of apparently cretaceous *Ammonites* and *Belemnites* have been brought up by the auger, but it may be doubtful whether those may have fallen down the sides of the bore-hole. Still, on the other side, it is to be observed that no such fossils were found in the Gault itself, and that the bore-hole is tubed to the depth of 1172 feet; and M. Jus, who has superintended this work, and carefully noted the occurrence and position of the fossils, informs me that it was in one bed especially, viz. the pebble bed (No. 40 of the sectional list, p. 13), at a depth of 1158 feet, that a small Belemnite was particularly abundant, and that in one case the fossil was imbedded in sandstone and not loose. For the last week all the fresh clay has been carefully washed and sifted, but no more fossils have been found.

Mr. D. Sharpe has had the kindness to examine these fossils, and the following are the remarks he has made upon them:—

"17 Soho Square, 16th November 1855.

"MY DEAR SIR,—Among the fragments of organic remains from the Artesian well at Kentish Town, there are very few which admit of even a conjectural determination, and only one which can be named with certainty; this is the *Ammonites inflatus*, Sow., which also passes under the name of *A. rostratus*; the specimen is sufficiently large and perfect to show all the distinctive characters of the species, viz. a strong keel, back broad, sides flattened, with strong

* Still, admitting such a possibility, the Lower Greensand must range up to the flanks of this ridge, and might, therefore, nevertheless be found underground at other points at or near London, beyond the interference of the central axis.

slightly curved ribs, either single or bifurcating, and thickest near the back, where they are crossed by several transverse furrows, which in the cast are but faintly seen; the lobes of the septa are fully shown in the specimen, and exactly agree with those of *A. inflatus*; so that no doubt can exist as to its identity. In mineral condition also the specimen exactly agrees with that of the same species from the phosphatic nodules in the brick-fields near Cambridge, which are supposed to belong to the top of the Gault.

"The species is also common in the Upper Greensand in many localities; M. d'Orbigny quotes it as found throughout France in the *Craie chloritée* and in the upper part of the Gault, so that everything conspires to lead us to place the bed in which this specimen was found, marked No. 80, 1196 feet (No. 53 of following section), as belonging to the upper part of the Gault.

"In the tray marked No. 97 (str. 60) is a small fragment of an Ammonite which I think to be *A. cristatus*, De Luc, a species only known in the Gault; but the fragment is so small and so much worn, that I name it with the greatest doubt; it is in a reddish clay.

"In tray No. 97, in company with the last-named Ammonite, and also in the tray labelled '353,84 mètr.' (str. 40), are several fragments of small *Belemnites*, which correspond in size with *B. minimus* of the Gault; but I can state almost with certainty that they do not belong to that species; their section is more square than in *B. minimus*, and the sides have not the double line which marks that species. One specimen differs from all the rest; it is the point, and appears to have a furrow down each side as in *B. bicanaliculatus*, Blainville, which M. d'Orbigny places in the Neocomian beds; it is, however, possible that these apparent furrows may have been produced by the friction of the borer, as the fragment is evidently rubbed. On the whole, no safe conclusion can be drawn from the fragments of *Belemnites*. In the tray '353,84 mètres,' there are also some fragments of *Ammonites*, of which nothing can even be guessed.

"I can form no opinion whatever about the specimens in the other trays; some of them are organic, others appear to be only nodules.

"Yours sincerely,

"*Joseph Prestwich, jun., Esq.*" "DANIEL SHARPE."

Specimens of these clays and sands have been examined by Mr. Rupert Jones and Mr. Roper for the smaller microscopic fossils, and I am indebted to these gentlemen for the following observations.

"Tachbrook Street, Nov. 21, 1855.

"MY DEAR SIR,—The blue clay (Gault) of the boring at Kentish Town has afforded to my friend Mr. W. K. Parker a plentiful supply of *Foraminifera*, which I find to be characteristic of the Gault of Kent, &c.; the red clays and sands, however, of which I have washed and examined four or five specimens, have yielded nothing organic, as far as Mr. Parker or myself have been able to discover.

"Yours sincerely,

"T. RUPERT JONES."

"*J. Prestwich, jun., Esq., Sec. G.S. &c. &c.*"

"Pembury Road, Clapton, 19th Nov. 1855.

"My dear Sir,—Agreeably to your request, I have made as careful an examination of the three specimens from the Kentish Town well that the limited time would allow, and my opinion is that no traces of *Diatomacea* or other siliceous organized matter will be found in any of them. The specimens, Nos. 56 and 102 (str. 33 & 63), appear to contain a considerable quantity of lime, but I was unable to detect any remains of *Foraminifera* or other shells of which it might be expected to form a component part.

"Yours very truly,

"F. S. S. Roper."

"*J. Prestwich, jun., Esq., &c. &c.*"

If the position of the fossils could be accepted without a doubt, we should feel obliged, however perplexing and exceptionable the mineral characters might be*, to consider these beds as belonging either to the Gault or to the upper part of the Lower Greensand, and there would then still be a reasonable possibility of finding beneath these red clays and sandstones in the one case the yet intact mass of the Lower Greensand, or in the other case a considerable thickness of sands forming a lower division of this group. Otherwise in mineral character these beds closely resemble parts of the New Red Sandstone. The boring tools also seemed to indicate that the strata had a very considerable dip. It is possible, however, that this may arise from the laminæ of false stratification as well as from true bedding. This is the more probable, as M. Jus states that for the last few feet the strata seem to be horizontal.

The object of bringing this paper before the Society is to describe briefly the principal features of this very interesting work, and to elicit some further opinion upon the probable age of these singular red clays and sandstones. As the point involves the important question of an additional source of water-supply, we must necessarily feel much interest in the success of the operation. I have abstained from treating of the difficulties of the undertaking, of the sure and skilful mode of proceeding, and of the rate of progress, in order to confine attention to the more essential considerations involving the probability of its successful termination. Many of these considerations I have but slightly touched upon, for the paper has unavoidably been drawn up at a very short notice, but I trust I have omitted none of the main facts.

A careful record has been kept of all the strata traversed in the boring. These particulars I annex. As I have not introduced all the subdivisions of the Chalk made in the original document, the numbers of the strata will not agree with those there given. In the beds beneath the mass of the Gault I have, however, given each mineral change as noted in the course of the work.

* On recently examining one of the few small, well-rounded pebbles of Stratum 40, it seemed to me closely to resemble some of the light-brown, waxy, semitransparent chert of the Lower Greensand of Kent and Surrey. If so, it would be a satisfactory proof that this red series was newer than some portions of the Lower Greensand.—[J. P., Jan. 1856.]

Section of the Boring at Kentish Town.

			ft.	in.	Depth. ft. in.
TERTIARY STRATA, 324 ft. 6 in.	*London Clay* (236 ft.).	1. Yellow clay	30	6	
		2. Blue clay, with *Septaria*...............	205	6	
	Woolwich and Reading Series (61 ft. 6 in.).	3. Mottled (red, yellow, and blue) clay	37	6	
		4. White sand, with flint-pebbles	0	6	
		5. Black sands; *passing into*	2	0	
		6. Mottled green and red clay	1	0	
		7. Clayey sands	3	0	
		8. Dark-grey sands with seams of clay	9	6	
		9. Quick-sands, ash-coloured	6	6	
		10. Flint-pebbles	1	6	
	Thanet Sands (27 ft.).	11. Ash-coloured sands......................	10	0	
		12. Argillaceous sands	4	0	
		13. Dark-grey clayey sands	11	0	
		14. Bed of angular green-coated flints...	2	0—	324 6
CHALK, 586 feet.	*Middle Chalk with flints* (244 ft. 6 in.).	15. Chalk with flints	119	6	
		16. Hard chalk without flints	8	0	
		17. Chalk, less hard, with few flints ...	31	6	
		18. Nodular chalk, with three beds of tabular flints	13	6	
		19. Chalk, with seams of tabular flint and a few nodular flints	32	6	
		20. Chalk, with a few flints and some patches of sand	9	6	
		21. Very light-grey chalk, with a few flints	30	0	
	Lower Chalk without flints (294 ft.).	22. Light-grey chalk, with a few thin beds of chalk-marl subordinate...	133	0	
		23. Grey chalk-marl, with compact and marly beds and occasional pyrites	161	0	
	Chalk-marl (47 ft. 6 in.).	24. Grey marl...................................	20	0	
		25. Harder grey marl, rather sandy and with occasional iron-pyrites	27	0	
		26. Hard rocky marl	0	6—	910 6
	UPPER GREENSAND (72 ft. 6 in.).	27. Bluish-grey marl, rather sandy; the lower part more argillaceous......	58	9	
		28. Dark-green sand, mixed with grey clay	13	9—	983 0
	GAULT (130 ft. 6 in.).	29. Bluish-grey micaceous clay, slightly sandy	39	0	
		30. Ditto, with two seams of argillaceous greensand	6	7	
		31. Micaceous blue clay	84	11—	1113 6

[*continued at* p. 14.

Section of the Boring at Kentish Town (continued).

		ft.	in.	Depth. ft. in.
188 ft. 6 in.	32. Red and yellow sands, and sandstone	1	0	
	33. Compact red clay, with patches of variegated sandstone.	4	0	
	34. Pure dark red clay	4	7	
	35. Red clay, whitish sands, and mottled sandstone	3	0	
	36. Hard red conglomerate, with pebbles of syenite, greenstone, trap-rock, quartz, hornstone, red claystone-porphyry, and fossiliferous schist, well rounded, and varying in size from a marble to a cannon-ball	2	0	
	37. Micaceous red clays, mottled in places	26	0	
	38. Seams of white fissile sandstone and red sand	3	8	
	39. Mottled sandstone	0	4	
	40. Red sand and sandstone with small pebbles and *Belemnites*, and a few small phosphatic nodules	2	0	
	41. Seams of red sandstone and white sands	4	0	
	42. Pebbly red sands, and fissile sandstone	1	0	
	43. White and red sandstone	5	0	
	44. Fine light-red sands	2	9	
	45. Hard fissile sandstone	0	3	
	46. Very fine light-red sand	4	0	
	47. Pure red clay	2	0	
	48. Red and mottled clayey sands, with some iron-pyrites	1	3	
	49. Red sandy micaceous clay with fissile sandstone	2	5	
	50. Compact hard greenish sandstone	10	0	
	51. Very micaceous red clay	1	0	
	52. Grey and red clayey sands	1	1	
	53. Light-coloured soft sandstone with fragments of *Ammonites*	2	1	
	54. Red sand and sandstone (highly inclined?)	6	2	
	55. Greenish sandstone	4	0	
	56. White and grey clayey sands, with iron-pyrites	2	0	
	57. Reddish argillaceous sands, with seams of sandstone	3	8	
	58. Micaceous red clay	18	4	
	59. Seam of greenish sandstone	0	5	
	60. Red mottled and micaceous clay, with patches of light-coloured sand, and fragments of *Ammonites* and of a *Scaphite**	14	6	
	61. Red compact micaceous clay, with *Belemnites*	20	0	
	62. Red quartzose and micaceous sandstone	2	0	
	63. Brownish-red clayey sand and sandstone	4	0	
	64. Very hard micaceous sandstone, with small pebbles of white quartz	4	0	
	65. Light red argillaceous sand	10	0	
	66. Red sandstone, micaceous and quartzose	8	0	
	67. Light red clayey sands (with small angular fragments of chert or flint?)	2	0	
	68. Whitish and greenish hard sandstone (horizontal?)	6	0	
				—1302 0

Note.—The upper strata are grouped in conformity with the divisions I have established elsewhere. The grouping of the Chalk, Greensand, and Gault is rather arbitrary, for the change is so gradual that it is impossible in a mere boring to say where one ends and the other begins. I have introduced those divisions which seem to me most in conformity with those I have noticed at the outcrops. They are slightly altered from my first reading of them.—[J. P., January 1856.]

* This specimen was mislaid before Mr. Sharpe had an opportunity of examining it.

2. *On the* Discovery, *by* Mr. Robert Slimon, *of* Fossils *in the* Uppermost Silurian Rocks *near* Lesmahago *in* Scotland, *with* Observations *on the relations of the* Palæozoic Strata *in that part of* Lanarkshire. By Sir Roderick Impey Murchison, D.C.L., F.R.S., V.P.G.S., and Director-General of the Geological Survey.

Contents.

Introduction.—At the last meeting of the British Association, Mr. Robert Slimon brought to Glasgow two remarkable collections of fossils from the extensive parish of Lesmahago, in which he practises as a surgeon. One of these collections was derived from the bands of carboniferous limestone, which there alternate with coal, and are characterized by a great abundance of fine specimens of *Producti, Encrinites*, Corals, and other remains peculiar to deposits of that age. The other consisted of specimens of Crustaceans in dark-coloured schist or flag, and to two or three specimens of which my attention, as President of the Geological Section, was fortunately called by Mr. Page. The magnificent collection of Mr. R. Slimon had, in fact, remained almost unobserved, in a hall which few geologists visited.

The moment I cast my eye over these remarkable Crustaceans, which much resembled *Pterygoti*, and saw the matrix in which they were imbedded, it occurred to me that they probably pertained to the Uppermost Silurian zone. It became, therefore, necessary to visit the locality in question, chiefly for the purpose of ascertaining the physical relations of the dark schist with large Crustaceans to the Old Red Sandstone. For, as I was aware that the genus *Pterygotus* had been found as low in the Silurian rocks as the Upper Caradoc band, it might prove that there was the same great hiatus near Lesmahago as had up to this time been supposed to prevail all over Scotland, and that no representative of the Uppermost Silurian existed. On the other hand, the band in question might prove to be that which I shall endeavour to show it is—viz. the true representative of the highest Silurian zone, as developed in Herefordshire, Shropshire, and Westmoreland in England, in Russia on the Continent of Europe, and also in North America.

Having requested Professor Ramsay to accompany me, we visited Lesmahago together, and there found to our gratification, that the worthy and modest Mr. Slimon had not only a much richer collection of the fossils in question than he brought to Glasgow, but had also an accurate acquaintance with many of the prominent and detailed features of the tract. Guided by him to the best natural sections, and particularly to the spot on "Logan Water," hitherto famous only in Scottish song, where he had found the Crustacean fossils, we afterwards endeavoured to obtain a general notion of the relations of all the rock-masses of the district. For the better understanding of the subject I induced Mr. Slimon to prepare a rough geological map, which is exhibited, and to the sides of which he has annexed two sections explaining the order of the carboniferous strata of two tracts in his neighbourhood (see Appendix, p. 25). I also submit a rude approximation to what will in the sequel be better worked out, by exhibiting the County Map of Lanark, on which I have endeavoured to combine the outlines of Mr. Slimon's Map as correcting those of other observers; no one having previously indicated any more ancient rock in this tract than the Old Red Sandstone; the tract which I now consider to be Silurian having usually been coloured as Carboniferous*.

I must at once apologize for the imperfections necessarily attached to this slight sketch of a district of which no real map exists. As soon, however, as the Engineer Corps under the able direction of Colonel James shall have published the first outlines of the Ordnance Survey, I can assure my associates that the Geological Surveyors will vigorously set to work to determine all those relations which are now briefly touched upon in an essay, which is simply intended as a temporary frame to hold together a few materials which are of deep interest in palæozoic geology.

General Relations of the Rocks of the Lesmahago District.—In a former communication, I invited attention to the general direction of the great masses of the Silurian rocks of the S. of Scotland, which have been described by various authors under that name since the discovery in them of many well-known Silurian fossils†. I then suggested, that judging from some of those organic remains, as found in the environs of Girvan, there were indications, in that parallel, of an ascending order from the Lower Silurian rocks (which unquestionably form the great mass of the S. Scottish greywacke) to the Upper Silurians. At the same time it was noticed, that the strike of the Girvan strata would carry them nearly to the Silurian rocks of the Pentland Hills S. of Edinburgh, which have the same general direction, *i. e.* nearly from N.E. to S.W. Now, if a line be drawn from the rocks N. of Girvan to the northern face of the Pentland Hills, it is seen to pass over an intervening tract, throughout which basins of carboniferous rocks, surrounded by girdles of old red sandstone and diversified by a great abundance of igneous rocks (porphyry, greenstone, &c.), are represented in all the published geological maps. The discovery made by Mr. Slimon of fossils which prove to be of Upper Silurian age, over a considerable area in the extensive parish of Lesmahago (for this Scottish parish has a length of twenty-five miles), has advanced therefore the northern frontier of the Silurian or slaty rocks; some of the localities in question being not less than twenty miles to the north-west of their previously defined boundary. The extent to which the Lesmahago Silurians may be hereafter shown to

* See the maps of M'Culloch, Phillips, Knipe, &c.

† Quart. Journ. Geol. Soc. vol. vii. p. 137.

be connected upon the surface with those of the tracts around the Lead Hills and other parts of Ayrshire and Dumfriesshire, on the S. and S.E., must be a work of future labour. That work will demonstrate whether these Lesmahago rocks constitute an advanced Silurian promontory or headland, or whether, as is most probable, they form an outlier of that age.

The large parish of Lesmahago is pre-eminently distinguished in its western part by dome-shaped hills, which rise to the S.W. of the River Clyde, and on the left bank of that river, where it forms the well-known beautiful Falls of Bonnington and Stonebyres, near the town of Lanark. The rock over which the Clyde cascades is the Old Red Sandstone, which formation, extending to the W. and S.W. to the village and parish of Lesmahago, is overlaid on the north and south by carboniferous limestones and coal; whilst on the south-west it is underlaid by the dark and schistose rocks to which attention is now specially invited.

Upper Silurian Rocks.—The relations of these dark grey, schistose strata of clay-slate to the Old Red Sandstone are seen on the banks of the Nethan River and also on those of other tributaries of the Clyde, particularly the Logan Water, on each of which rivers Mr. Slimon has marked the junction between the grey Silurian and the Old Red rocks. The Silurian beds rise up into several hills of considerable altitude, one of which (Nutberry, 1715 feet above the sea) we ascended. Judging from the outline of the country, and the extensive range of similar high moorlands, I am disposed to think that these rocks may be found to spread north and westward over the hills

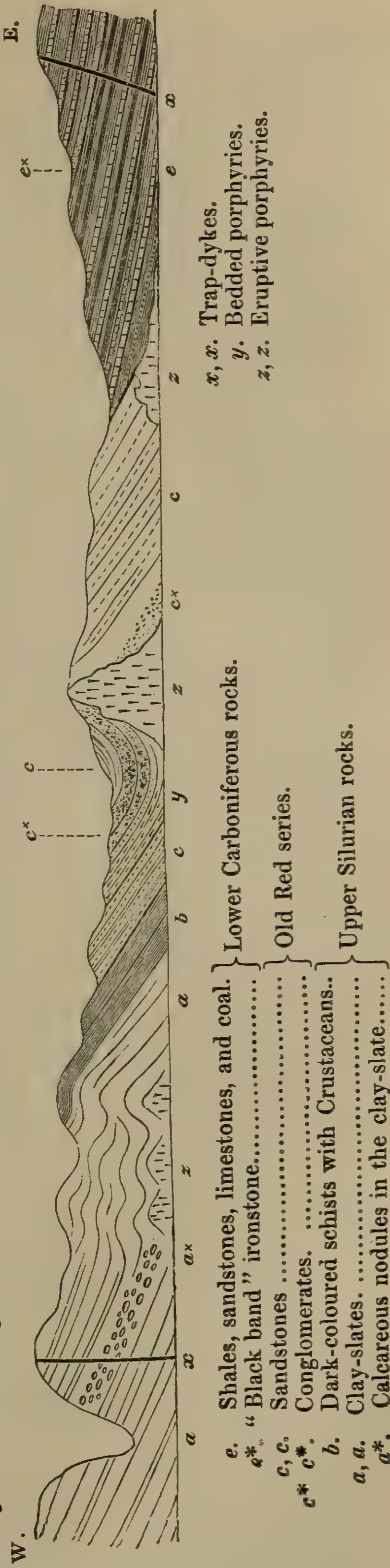


Diagram exhibiting the General Relations of the Palæozoic Rocks in the Parish of Lesmahago. Distance about 7 miles.

of Dunside and Middlefield, 1300 to 1500 feet high, and may even range to Cairn Table on the south, the summit of which according to the Trigonometrical Surveyors is 1944 feet above the sea. Advancing eastwards from the range of hills on the flank of Nutberry, in one part of which Mr. Slimon discovered an Orthoceratite, and descending the Logan Water to about a mile below the farmhouse of Dunside you reach the uppermost band of the grey strata in which were discovered those remarkable Crustaceans, which have been above referred to.

The lowest portions of the Silurian rocks which fell under the inspection of Prof. Ramsay and myself are those which are traversed by the Nethan River as it flows from the Priest Hill and Nutberry Hill to Cumberhead. Several dislocations and convolutions which are seen on that line among the Silurian strata, as well as in the contiguous Old Red, are well explained by the frequent protrusion of porphyry (usually a red quartziferous porphyry). On the whole, however, it was manifest to both Prof. Ramsay and myself, that in receding from the Old Red boundary, and in ascending to the higher hills by the course of the Nethan, we made a gathering, descending section—because the strata succeeding to each other with a prevalent dip to the N.E. or E.N.E. consisted successively of differently constituted materials. Thus, whilst the uppermost strata were dark grey and schistose, other layers of lighter colours were more siliceous and formed stone-bands. These are followed by other courses of shale and schists in which are nodular concretions, occasionally calcareous, in which we looked in vain to find a few fossils which could have led us to suppose what they might very well prove to be from mineral aspect, the representatives of the Wenlock formation. It is from one of these strata that Mr. Slimon procured the Orthoceratite above alluded to, but which is too imperfect to be specifically determined. With some undulations and several breaks, particularly in the proximity of the intrusive porphyry, all these Silurian strata are inclined towards the E.N.E. and N.E., and at angles varying from 12° and 15° to verticality where they roll over in flexures.

The inferior beds exposed in the section of the Nethan are here and there mineralized, and specially so where trap-rocks, chiefly green-stone, have penetrated the strata; veins of lead-ore and much sulphate of barytes being there apparent on the surface.

The section, however, which best exhibits the relations of the Silurian rocks to the Old Red Sandstone is seen on the banks of Logan Water between the farms of Dunside and Ach Robert. The last of the decidedly dark grey and schistose beds observable in descending from the flanks of the Silurian hills (Nutberry, &c.) are those in which all the fossils described by Mr. Salter (see p. 26) were found by Mr. Slimon. These dark fossiliferous rocks, the clay-slate of mineralogists, are immediately overlaid by and pass up into red sandstone, in which there are several alternations of more or less greyish or greenish-grey bands; the whole, like the beds in the Nethan, dipping to the E.N.E. or N.E., as represented in the generalized Section, p. 17.

Old Red Sandstone.—In the traverse along the Logan Water I did not observe any unconformity between the grey beds with Crustaceans and other fossils and the overlying red sandstones, the lowest courses of which are marked upon Mr. Slimon's map as "Red Silurians." For my own part, however, I would rather consider these red strata as constituting the base of the Old Red Sandstone, because they graduate up into and alternate with pebbly conglomerates which are largely developed near Ach Robert and Waterside.

Some of the porphyries which are associated with the red rocks in this part of the series seemed to be interstratified and of age contemporaneous with the sandstones with which they dip symmetrically, and like which they are jointed and exhibit the way-boards of sedimentary deposits. In mineral characters and in their interstratification with red sediments, these rocks, though of much older date, present much the aspect of some of the porphyries of the Rothe-todte-liegende of the Permian age in Germany.

The conglomerates of the Old Red of this tract differ strikingly from those of the same age in the North Highlands, where the so-called lower conglomerate is usually a very coarse breccia, the huge fragments of which are more or less angular; whilst here they are all worn and rounded pebbles, the largest of which scarcely ever reaches a foot in its greatest diameter.

Most of the pebbles consist of grey and pink quartz-rock, but these are mixed with other varieties of crystalline and some igneous rocks. This conglomerate zone, which is fairly interstratified in red sandstone and ranges from N. to S., as laid down on Mr. Slimon's map, is much nearer to the dark grey Silurian on the Nethan river than it is to the same rock on the Logan Water; whilst on the Kype Water the two rocks are still further removed from each other. Time and detailed examination will determine whether this deviation of outline be due to breaks and unconformable arrangements, or simply to changes in the degree of inclination of the strata. By comparing the only watercourses which we examined, I am led to think that the difference of the angle of dip may sufficiently explain these diversities of superficial area; because on the Logan Water we found the inclination varying from 7° to 12° only on an average; the red beds with imbedded porphyries and conglomerates as well as the inferior grey beds sloping off to the N.E. or E.N.E. at these low angles except where they rolled over bosses of porphyry. On the Nethan banks, on the contrary, the beds are more highly inclined.

In ascending order the Old Red Sandstone, including all that portion of it which lies above the conglomerate and extends by Lesmahago to the Clyde and Lanark, is usually of a lighter colour and freer quality than the subjacent beds, and occupies a very varied outline in reference to the carboniferous limestone and coal-fields on either side of it and under which it is seen to dip. On the banks of the Nethan Water where we examined them, the junctions are much broken, and on the whole it would appear, that the older rocks have been so convoluted as to form the southern edge of the great central Scottish Coal-field, or the complete girdle of the Douglas coal-basin; the S.W. side of which is flanked by the Old Red of the Hawkshaw Hills, and also, according to Mr. Slimon, by the Silurian rock of Bremerside Hill.

Lower Carboniferous Rocks.—The lower edges of the Carboniferous rocks being attained, the ascending series from them through various bands of limestone and interstratified courses of coal and iron-ore is admirably exposed in the beds of some of the watercourses which flow from the loftier hills of older rocks*.

Upon the only instructive traverse which we made, and to which we were conducted by Mr. Slimon, viz. up the Coal Burn and along the steep banks of the Poniel Water, which flow through grounds now occupied by the productive coal and iron works of Brockley, &c., we were highly gratified in seeing a splendid development of limestones, shales, sandstones, coal, and ironstone, a precise account of which and an accurate register of the fossils in each zone are much to be desired. We examined the so-called "black band" of ironstone at Coal Burn (see Appendix, p. 25), and found it to be associated with an indurated bituminous shale, which in Staffordshire would be called "black bat." The strata being very slightly inclined, the ironstone (8 inches thick) is worked by a gallery on the side of the slope. In this locality the black band dips under a succession of strata of shale and sandstone, to which five seams of coal are subordinate as well as one band of limestone. On the other hand, the black band is here underlaid, as seen indeed in the open sections of the watercourses before alluded to, by a much thicker succession of similar shales and sandstones, including seven seams of coal and three limestones. The lowest of the latter is a hard, concretionary, nodular, white limestone, which immediately lies upon the Old Red Sandstone; but no fossils have yet been found in it. The massive and thick-bedded limestone, however, which overlies it, with the intervention of some sandstone only, is laden with the large and small *Producti*, a profusion of *Encrinites*, and many characteristic shells, some of which are also found in the limestone near the top of the series.

As Mr. Slimon has obliged me by preparing a working section of the beds passed through in this tract of Coal Burn and Brockley, and another of the Auchenheath Pits, situated on the opposite or northern basin, and not far from the junction of the Nethan with the Clyde (see Appendix, p. 25), the geologist who compares them will see how, with a strong general petrographical resemblance, the order of the carboniferous strata on the other side of the dividing Old Red of Lesmahago is distinguished from that upon the south flank of the same formation; particularly in the much fuller development of strata above the "black band" of ironstone. At Auchenheath the shafts pass through a much more copious series of sandstones, shale, and limestone before that iron-ore is reached; there being no fewer than five calcareous zones above it. For, whilst in a much less vertical space in the Coal Burn tract there are five seams of coal above the black band, the very deep sections of Auchenheath there present three seams of coal only superior to that ironstone. If it be objected that the black band is merely a casual and accidental layer of rich iron ore, and that when these fields shall have been elaborately worked out, similar ore may be found to exist in more courses than one, and at various levels—a feature which is by no means improbable,—still in reference to the very limited area now under consideration, where the

* A notice of the Lesmahago and Douglas Coal-field was read by Mr. Bryce at the British Association Meeting at Edinburgh; see Brit. Assoc. Rep. 1850, Sect. p. 77.

two localities compared are a few miles only distant from each other, the geologist must see, by the facts laid before him, how very rapidly mineral matter of one sort thins out and is represented at a short distance only by a very different stratum.

When the trigonometrical surveys of these important mining tracts shall have been published, the geological surveyors will determine the extent to which the coal-fields of Scotland can be distinguished as consisting of lower and upper masses, a subject already treated of by Mr. Page*, and will explain with precision whether to the south of Edinburgh there are or are not strata of younger age than those now alluded to. In the mean time it is clear, that all the coal-tracts around Lesmahago belong to the older or Mountain Limestone series. They are, in short, of the same age as the coal-fields of North Northumberland, Berwickshire, and other tracts in Scotland; and in foreign countries, as those of the Donetz in Southern Russia, and of Kosloo in Asia Minor, both of which are subordinate to bands of Productus-limestone.

Igneous Rocks of the District of Lesmahago.—Allusion has already been made to certain porphyries, some of which alternate with bands of the Old Red Sandstone and conglomerate, and others of which seem to have been erupted through the Upper Silurian rocks and the Old Red also. According to the map of Mr. Slimon, these porphyries, of which there are two varieties, felspathic and quartziferous, are both chiefly associated with the Old Red Sandstone, and never occur in the coal-fields.

One of the largest bands of porphyry traverses the River Clyde below the Fall of Stonebyres, and, trending to the S.W. and S. through the Old Red Sandstone, sends off several branches, three or four of which curve round and cross the Nethan River.

Another branch runs to Dunduf, from whence it ranges to Todlaw. This last-mentioned dome was probably a great centre of eruption, from whence a long course extends from Ach Robert to the flank of Bremerside Hill.

In short, these porphyries seem to have been the active agents, which, at one period alternating with the red sediments, afterwards burst through the Old Red Sandstone and raised it into those dome-shaped masses which separate the great coal-fields of the Clyde from the detached coal-basin of Douglas. Tinto Hill and its south-western ramifications constitute another and much more extensive outburst of similar porphyry, which forms the south-western portion of that long range of igneous rocks which extends on the E.N.E. to the Pentland Hills.

But independently of these porphyries, the parish of Lesmahago is distinguished by a remarkable dyke of greenstone, which Mr. Slimon has traced from the coal-field of Douglas, across the Old Red Sandstone of the Hawkshaw Hills, and then through the porphyry zone of Todlaw and the Old Red Conglomerate, and which he has further followed for several miles across the heath-covered Silurian hills in nearly a rectilinear course. Where Prof. Ramsay and myself examined this dyke, *i. e.* high up the Nethan Water, we found it to be a fine-grained greenstone of about 25 paces in width; having the direction of 33° S. of E. The Silurian schists on either side of it

* See Report British Assoc. Advancement of Science, 1854, Sect. p. 92.

preserved their prevalent slight inclination to the N.E. and seemed to be but slightly altered. The prisms of the greenstone being as usual at right angles to the cooling masses on either side, really resembled beds (slightly disturbed only) in the general mass of the schist or shale—so much do the two classes of dark rock resemble each other, until the hammer is applied to them—and even then the trap-rock is seen to have assumed to a considerable extent the scaly or fissile character of the Silurian deposit which it bisects.

On following this dyke from the Nethan to the very summit of Nutberry Hill which it occupies, we observed that its width (varying somewhat in different spots) was marked by the grassy verdant tint of the vegetation above it, as contrasted with the brown colour of the heath on either side of it upon the schist.

In descending the Logan Water, and at a short distance from the junction of the Upper Silurian and Old Red, a boss of intrusive porphyry appears, and again red sandstones follow with another and stronger course of porphyry which has a hornblendic character. A conglomerate then appears, succeeded by other red fissile sandy schists, and next red rocks alternating with light greenish or bluish-grey and slightly micaceous sandstones, which are, in fact, intercalated in red rocks ; other thin courses of porphyry are then observable, and then a pebbly conglomerate, between which and the ordinary Old Red Sandstone of the parish of Lesmahago there is a considerable development of porphyry, which seemed to be regularly bedded and to dip away in conformity with the sandstones.

Whilst some of this porphyry has all the aspect of having been emitted contemporaneously with the sandstone and aggregated under the same waters in which that formation was deposited, other bosses, one of which is hornblendic, have manifestly been intruded into the strata after their formation ; for both the conglomerates and the sandstones are seen to be arched over such intruding rock and occasionally dislocated by its protrusion.

Conclusion.—The preceding sketch of the general relations of the palæozoic and igneous rocks of the parish of Lesmahago indicates the value of the researches of Mr. Slimon, more particularly in his discovery of the uppermost Silurian fossils. Having incited that gentleman to send to the Museum of Practical Geology a complete suite of his carboniferous fossils, all observations on the deposits of that age are reserved for a future occasion.

In regard to the Old Red Sandstone it has been shown, that its inferior member in this district is dovetailed into the grey Silurian schists and flagstones beneath it. Hence I conclude, that the greater part of the red rocks exposed on the slopes of the higher greywacke hills of the parish of Lesmahago belong truly to the lower division only of the system of deposits which in the North Highlands (Sutherland, Caithness, and Ross) constitute the Old Red Sandstone, as there composed of inferior sandstone and conglomerate, central flagstones and bituminous schists, and overlying red sandstones. If my readers will refer to the abstract of a communication which I made to the Geological Section at the last meeting of the British Association, copies of which I have addressed to this Society, they will see how different in grandeur and diversity of structure is the great North Highland Series, when compared with the Old Red Sandstone of Lanarkshire. This last constitutes, as I am disposed to believe, little more than one of the three great divisions of that vast northern series which is, I conceive, a full equivalent in time of all the rocks called Devonian in any region of Europe.

In Lanarkshire neither the micaceous red flagstones associated with the conglomerates, nor the beds beneath or above them, have as yet afforded any trace of fishes, even under the vigilant eye of Mr. Slimon. If such should be discovered in the uppermost of these red strata of Lesmahago, and that they be found to belong to *Holoptychius*, then indeed we may infer that we have here a representative, though on a very small scale only, of the upper member of the group. But, not speculating further on this collateral point, I beg to conclude with a very few observations upon the Crustacean beds of the newly discovered Upper Silurian rocks of Scotland.

Rising out as these dark grey beds do, upon the Logan Water banks, from beneath the Lower Old Red, they occupy precisely the same horizon as that uppermost zone of the Silurians of Shropshire and Herefordshire which includes the bone-bed and the Downton Castle building-stone, and to which, as it graduates up into the Old Red, the name of "Tilestones" has from its flaglike character been given.

Near Ludlow, Hereford, and several other places, the thin course with small fish-bones has been traced over an extensive area, and in several places where the fishes are wanting the band is still well characterized by the associated large Crustaceans, chiefly *Pterygotus*. Recently Mr. Banks has discovered in those strata near Kington which I formerly referred to this age, some very beautiful forms of this genus, of which he sent me the drawings and descriptions, and which have been submitted to the Society. Together with the *Pterygoti* Mr. Banks found fossils formerly confounded with the genus *Cephalaspis*, Ag., but now separated. The species are new, but much like *C. Lloydii*, Ag., hitherto known only in the overlying Old Red.

Large Crustaceans of the group of *Eurypteridæ* * (Burmeister), to which the *Pterygotus* belongs, have also been found in the Tilestones of Westmoreland, and it is curious to observe that in most of these localities they are accompanied by the small *Lingula cornea* (Sil. Syst.) of the Ludlow district.

In Podolia similar large Crustaceans analogous to *Pterygoti* were found in strata rising out from beneath rocks which are known to be of Devonian age, and to these Dr. Fischer gave the name of *Eurypterus tetragonophthalmus*. Recently M. Eichwald† has detected several of these large Crustaceans, one of which he figures as *Eurypterus remipes*, Dekay, in the Isle of Oesel in the Baltic,—*i. e.* in a limestone which my colleagues and myself referred to the highest Silurian stage; so that in the North as in the South of Russia, the zone under consideration, when clearly exposed, is everywhere characterized by large and peculiar Crustaceans of this group, no one of which has ever been found low in the Silurian rocks.

* See Palæoz. Fossils Cambridge Museum, Fasc. 1.

† Bull. Soc. Imp. Nat. Moscou, 1854, vol. xxvii. p. 100.

In North America it has been long known, from the writings of Dekay and Harlan, that large *Eurypteri* occur in a so-called black greywacke slate at Westmoreland in Oneida County, New York, which will probably be found to be on the parallel of the Upper Ludlow Rock. The discovery of the large *Eurypteridæ* in the same zone as at Lesmahago in other regions is therefore peculiarly satisfactory. It is however to be observed, that in tracts far removed from each other, different, though closely allied, species make their appearance. Thus, whilst the *Pterygotus* is perhaps the usual and most characteristic type, the species found in Scotland* is said to be different from that known in the Silurian region. Near Kendal in Westmoreland the genus *Eurypterus* occurs with *Pterygotus*; whilst in Russia the former seems to be the prevalent genus.

In the Lanarkshire case, Mr. Salter finds the same sculptured plates which have been usually referred to the *Pterygotus*, and also the small *Lingula cornea* and *Trochus helicites* of the Uppermost Ludlow Rock. With these he has also detected in the rich collection of Mr. Slimon five or six new forms of a large crustacean which he terms *Himantopterus*, and describes in the following memoir, p. 26. With them too, another genus, the *Leptocheles* of M'Coy†, has been found, which the fine specimens now collected show to be simply the caudal portion of the *Ceratiocaris*, a genus which is found as low as the Wenlock Limestone. And yet, with these distinctions of varying forms, which are everywhere recognizable in the Silurian zones of similar age in distinct regions, we find this group of animals consistently and uniformly defining the same zone of sediment over the Northern hemisphere.

Wherever these large Crustaceans are found, and with them small *Lingulæ* and other fossils, we may be sure that we are at or near the very summit of all rocks to which the term Silurian can be applied, and that the next overlying stratum belongs to the first *great* æra of fishes, the Devonian or Old Red Sandstone; for the thin transition-band now under consideration still remains what I stated it to be twenty-one years ago, the lowest in which the trace of a true vertebrated animal has been detected.

In Scotland, where we had despaired of finding any representative of the Ludlow formation, the discovery of Mr. Slimon is indeed highly gratifying. Perforated as are the lower edges of the coal-basins which occur along the northern frontier of the Silurian rocks of the South of Scotland, by various igneous rocks which have to a great extent upheaved the Old Red Sandstone, we may, after this discovery, look to the detection of other links to connect the Orthoceratite-rocks of the Pentland Hills with the shelly deposits of Girvan and the younger strata of Lesmahago, and thus evolve a full series of both Lower and Upper Silurian Rocks in North Britain, where their very existence was until recently almost ignored.

* I have directed that these remarkable Crustaceans, as well as others of the same age in Herefordshire, be figured and fully described in a Decade of the Memoirs of the Geological Survey of Britain.—R. I. M., January 1856.

† See Pal. Foss. Cambr. Mus. Pl. I E. fig. 7; Quart. Journ. Geol. Soc. vol. ix. p. 13; and also a full recognition of Prof. M'Coy's ability in separating some of these crustaceans from fishes with which they had been confounded, in "Siluria," p. 236.

Sections of the Coal-measures near Lesmahago, by Mr. R. Slimon.

Section at Coal Burn.

Superficial soil, sand, and gravel.	ft.	in.
Blaise and limestone	10	0
Blaise	4	0
Freestone	15	0
Blaise and blue freestone	4	6
Blaise	3	6
Gas and dross coal	1	4
Faikey blaise	4	0
Freestone and blaise	21	0
Dross coal	3	6
Fire clay	0	11
Dross coal, with 6 inches Horn coal	3	11
Fire clay	2	0
Freestone	7	0
Blue faikes	4	0
Coal	3	0
Fire clay	3	6
Coal	2	9
Freestone	6	0
Faikes	2	0
Blaise	4	0
Black band, ironstone	0	8
Blaise	3	9
Clay band, iron	0	7
Blaise	3	0
Smithy coal	0	9
Fire clay	1	6
Coal	4	0
Bastard stone	0	7
Coal	4	7
Fire clay	16	0
Faikes and blaise	8	0
Clay band, iron	0	3
Blaise	6	0
Clay band	0	4
Blaise	2	4
Clay band	2	2½
Blaise	12	0
Fire clay	3	0
Coal	1	6
Blaise	3	0
Coal	1	0
Blaise	12	0
Freestone and blaise	11	0
Fire clay and blaise	3	0
Coal, with 6 inches of stone	6	0
Faikes and tills	42	0
Blaise and ironstone band	12	0
Coal, stinking	5	0
Fire clay	1	6
Blaise	5	0
Freestone	16	0
Blaise and ironstone	12	0
Limestone	1	8
Grey blaise	20	0
Ironstone	0	8
Blaise and limestone	46	0
Sandstone.		
Nodular limestone.		
Upper Old Red.		
Old Red Sandstone.		
Red Silurian (Slimon).		
Silurian, upper black.		

Section at Auchenheath.

Superficial soil, sand, and gravel.	ft.	in.
Freestone		
Sand shales with flouers		
Faikey blaise and freestone	40	0
Limestone	1	6
Blaise	10	0
Arden limestone	5	0
Fire clay	1	3
Hard sandstone	2	0
Freestone	30	0
Tills	4	0
Limestone	1	6
Blaise	8	0
Limestone	3	8
Fire clay	4	0
Freestone	8	0
Blaise	4	0
Freestone	60	0
Blaise	10	0
Limestone	5	8
Fire clay	5	0
Freestone	6	0
Blaise	5	6
Freestone	43	0
Blaise	6	0
Whinstone	5	9
Blaise	9	6
Freestone	4	0
Blaise	0	10
Smithy coal	1	4
Faikes clay	1	6
Coal	4	0
Faikes	5	0
Freestone	4	0
Blaise	4	0
Faikes	2	0
Gas coal	0	10
Black band, ironstone	0	5
Tills, ironstone balls	3	8
Coal	0	8
Fire clay	1	6
Dross coal	3	0
Freestone	7	0
Blaise	8	0
Freestone	9	0
Blaise	20	0
Freestone	4	0
Blaise	4	6
Freestone	2	0
Coal	0	10
Tills	5	0
Gas coal	1	9
Ironstone	0	4
Fire clay	1	3
Coal	0	6
Freestone.		
Limestone.		

[The coal is 35 fathoms above this.]

3. *On some new* Crustacea *from the* Uppermost Silurian Rocks. By J. W. Salter, Esq., F.G.S. *With a Note on the* Structure *and* Affinities *of* Himantopterus. By T. H. Huxley, Esq., F.R.S.

The occurrence of large *Crustacea* other than Trilobites in the older Palæozoic rocks is so rare, that we are scarcely prepared for the simultaneous discovery of five or six new forms, of dimensions equalling those of the crabs and lobsters of the present day.

Except the large *Pterygotus* of the Tilestone beds, and the *Ceratiocaris* from Westmoreland, scarcely any remains of these have yet been made out in Britain. But there have been sundry indications in the occurrence of large tail-spines and fragmentary carapaces, all of which have been most carefully treasured up to wait for further evidence, such as that now afforded by the discoveries of Mr. Slimon*. His admirable collection not only fully explains the meaning of much that was fragmentary before, as in the case of the *Ceratiocaris*, but gives us new forms of a group of which we knew very little, except that it contained the gigantic *Eurypterus* of De Kay and the *Pterygotus* of Agassiz, and was doubtfully referable to the *Pœcilopoda*.

Of the affinities of the *Eurypteridæ* I am not called upon to say much here, as we hope to fully describe these specimens in the publications of the Survey. The family has been regarded as a group of the *Palæadæ* by Burmeister; but their relation to the Trilobites seems more than doubtful. Since then Ferd. Römer† has suggested their affinity with *Limulus*, pointing out, however, the great differences in the feet. Prof. M'Coy has adopted this view, and united *Pterygotus* and *Eurypterus* in the family *Eurypteridæ*, Burm., the principal character of which, as distinguished from the *Limuli*, is the very obvious one of the free-jointed rings of the abdomen. And in this association I should have been content to leave them, but for the suggestion of a much more complete affinity by Mr. Huxley, which will, I think, when he has worked it out for us, explain not only these forms, but also the group of *Ceratiocaris* and its allies above mentioned, which are far from uncommon in the Ludlow rocks. And it may, perhaps, include my Cambrian genus *Hymenocaris*, and thus relieve the *Phyllopoda* from the burden of these old and anomalous Palæozoic forms. As Mr. Huxley has promised to add a full note upon the subject, I will not enter further into it here.

The beautiful figure by Ferd. Römer of the *Eurypterus remipes*, and Eichwald's late discovery of the *E. tetragonophthalmus* in the Isle of Oesel‡, have furnished good materials for understanding that genus. The latter zoologist especially has been enabled to figure clearly the jointed feet and the sculpture of the rings of the body. And this sculpture is so exactly that of *Pterygotus* on a small scale,

* See the preceding paper, p. 15.

† Palæontographica, vol. i. p. 193.

‡ Bulletin de la Soc. Imp. des Naturalistes de Moscou, 1854, no. 1. p. 100. pl. 1.

as to suggest immediately an affinity between that large Crustacean, with strong didactyle pincer-like feet, and these with the principal feet, at least, adapted for swimming ("ruderblättchen"). The entire form of *Pterygotus*, however, is so little known, that it is impossible to say it did not possess a pair of natatory feet*, and large pincer-like antennæ; and, on the other hand, the anterior pair in our fossils are chelate organs, and nearly all the figures of *Eurypterus* show something of the same kind. The affinity then with *Pterygotus* may be closer than we yet know of.

Eurypterus, De Kay, is a large and elongated Crustacean, with an entire semioval or subquadrate carapace, on which the large sessile eyes are placed, in the manner of those of *Limulus*, wide apart, but towards the middle of the head. The body is ovato-lanceolate, broad in front and attenuated behind, and terminated by a pointed or acuminated tail. There are 10 or 11 body-joints, exclusive of the tail-joint; and the hinder (abdominal) rings are subquadrate; the anterior (thoracic) rings widely transverse.

The limbs or appendages are three on each side, according to the very perfect figures given by Eichwald; the two anterior of which are simple appendages, of about five joints each, with small chelate tips. The hindermost pair are much broader and longer, consisting of five joints, of which the two terminal ones are rather suddenly dilated and form a long-oval palette.

Himantopterus, gen. nov.

In the specimens here described, although the general form is much the same as that of *Eurypterus*, there is this essential difference, that the eyes are placed, not on the surface of the head, but on the anterior or antero-lateral margin, and quite at the edge. Together with this, the swimming feet are of a more linear form or rather thong-shaped. The name *Himantopterus*† may be therefore appropriate for the genus to which these specimens belong.

They are closely allied to *Eurypterus*, like which they have a comparatively small carapace, with the single pair of maxillary feet for swimming, but, so far as we yet know, with only one pair of antennæ. These latter organs are linear, narrower than the paddles, and consist of few joints; the last joint is strongly didactyle, with rather long chelæ. The accompanying woodcut (p. 28) shows the general characters of the genus.

A genus nearly allied to this has been described by H. von Meyer and Dr. Jordan, from imperfect specimens in the coal of Saarbruck‡. Von Meyer's genus differs at a glance from our fossils in the sudden reduction of width in the abdominal joints; there are

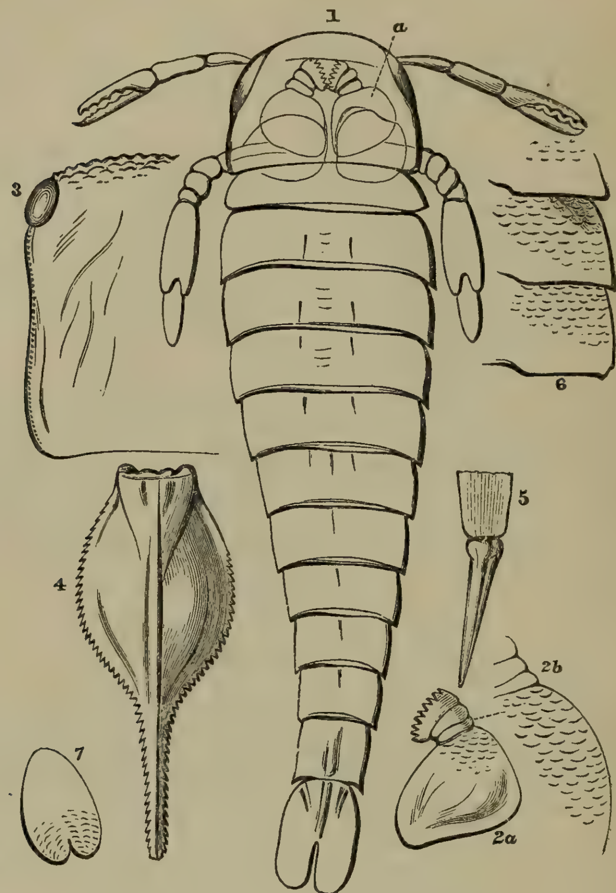
* Agassiz's figure of the principal limb (Poiss. Foss. Vieux Grès Rouge, tab. A) looks exactly like one of the swimming feet of *Himantopterus*: and the very large pincer-like limbs in that case must surely be antennæ.

† From the Greek ἱμὰς, ἱμάντος, a thong, and πτερὸν, a wing.

‡ Dunker and Von Meyer's Palæontographica, vol. iv. pt. 1. p. 8. pl. 2. fig. 1.

six wide thoracic rings, somewhat falcate at their outer extremities; but the number of joints of the abdomen, the position of the eyes,

Figs. 1–7.—*Diagrams of* Himantopterus.



1. *H. bilobus*; half the nat. length; position of the jaws, on the under side of the head, indicated at *a*.

2 *a*, one of the jaws and its scale-like markings; 2 *b*, a portion magnified.

3. *H. maximus*; part of the head, one-fifth the natural length.

4. *H. acuminatus*; tail-joint, one-third the length.

5. *H. lanceolatus*; last two joints, about one-half the natural size.

6. *H. perornatus*; part of three thoracic rings, to show the fulcral point and the scale-like sculpturing on the forward half.

7. Scale-like appendages; many of these lie loose on the surfaces of stone in which the fossils occur.

and the appendages are not known; and we should not be justified therefore in uniting the two forms on such fragmentary evidence. From the figure I should suspect the eyes are lateral, as in *Himantopterus*; the sculpture is like that of our fossils, and the size not less than that of our smallest species.

There are five species of *Himantopterus* in the Lanarkshire locality, and one from South Wales, already known.

1. Himantopterus acuminatus, sp. nov. Fig. 4.

H. pedalis et ultra, elongatus, articulis 12, quorum quinque ultimis subquadratis, penultimo oblongo; caudâ magnâ, ovatâ, et in apiculum serratum longum productâ.

Of this fine species, which must have been nearly 2 feet long, we have specimens which show the whole of the thoracic and abdominal segments united. The former are broader than, but not abruptly distinct from, those of the abdomen. They are transverse, a little produced at their posterior lateral edges, and have along the middle of the dorsal line either one or two (probably one) short spines projecting backwards.

The abdominal segments are but little broader than long. The penultimate, indeed, is quite as long as broad; and the terminal joint, of which we have specimens 5 inches long, is contracted and convex at the base, then rather suddenly expanded into an ovate form, and produced into a long apiculus (fig. 4). A keel runs the whole length of the segment, and the sides both of the expanded portion and of the apiculus are crenate (less strongly than in our figure).

We have but little of the carapace, and cannot be sure that the next described species does not belong to it. Of the limbs, there are the large swimming feet, consisting of a very large basal joint (coxa), and five others: the first narrow, the second irregular in shape, the third, where the backward bend of the limb takes place, subtriangular but rounded in front. The penultimate joint is much longer than broad, and deeply bilobed at the tip; the terminal one is an ovate palette, two and a half times as long as broad. The scaly sculpture occurs on all the joints of the limb.

With these limbs lie a pair of antennæ (?) of equal length. They consist of about five rather inflated joints, terminated by a small uncinate joint. They appear to be united at the base.

2. H. maximus, sp. nov. Fig. 3.

H. capite ferè 8 uncias longo, $5\frac{1}{2}$ lato, oblongo, vix suburceolato, lateribus anticè contractis; fronte rotundato; oculis magnis, oblongis, ad angulos externos fixis; margine antico et laterali tuberculato-crenatis.

If we estimate the length of this species by taking the proportionate length of the head to the body, which we find in the *H. bilobus* (fig. 1), the entire creature must have been at least 3 feet long; or, if we suppose it to have had the same proportions as *H. acuminatus*, which has more elongated body-joints, the case would not be different.

We have two specimens of the head, and both present the same characters in the eyes, and in the rugoso-crenulate anterior margin.

3. H. BILOBUS, sp. nov. Fig. 1.

H. 6–7-uncialis, ovato-elongatus; articulis 11 vel 12, omnibus transversis, ultimo subquadrato; caudâ oblongâ, ad apicem profundè divisâ.

Of *H. bilobus*, which is the common species at Lesmahago, we have more materials for illustrating the generic characters than of any of the others. There are complete specimens with the head, five or six thoracic, and six abdominal rings, tail, swimming-feet, and antennæ all in their places; and several specimens show these various parts dissected. It is only in this species that we can see the maxillæ in their right position, with their serrate edges and broad foliaceous basal joints. The antennæ also (probably only one pair) are in their position, attached to the anterior part of the head. They are linear, of few joints, and are deeply chelate at the tip. The swimming-feet, attached to the posterior parts of the cephalic shield, are short; the portion which projects from beneath the carapace, and is directed backwards, being not above one-fourth the entire length of the body, and reaching to the fifth ring. The specimens being all nearly of a size, it is presumed we have the adult form.

The body, in our best specimens, is elongate-oval in front, and gradually attenuated into the abdomen, from which it is not easily distinguished. If we reckon the five * anterior rings for the thoracic ones, these are widely transverse, the length even of the last ring being not more than one-third its width. Their posterior angles are very slightly produced backwards. The six posterior rings are all much wider than long, except the penultimate joint, which approximates to square. Its hinder angles are produced to lap over the rounded anterior edges of the caudal joint. The latter is only two-thirds as wide as long, and fully double the length of the penultimate joint. It is widest behind, with the posterior angles rounded off, and is deeply cleft more than half way up. No median keel like that of *H. acuminatus* can be detected on any of the body-joints except the last but one; the upper part of the tail is keeled also for a short distance.

The carapace is half-oval, and only one-fifth wider than long. The position of the eyes is very forward on the sides, and they somewhat interrupt the general oval contour. They are broadly crescentic and convex; and their extreme length is rather more than half that of the head. No lenses can be seen on their smooth surface.

The maxillæ (or mandibles) occupy nearly all the under side of the head; they are 4-jointed; the basal joint greatly the largest, and somewhat of a spherical-triangular form; the second and third joints are narrow and wedge-shaped, and the terminal one short and

* Or six. There is some evidence of a narrow anterior segment in addition to the eleven body-rings; and, as three other species have the anterior segment narrow, and eleven rings behind it, it is probably the case here; and we have so represented it in the diagram (fig. 1, p. 28).

wide, with a strongly serrate edge. The whole surface is ornamented with scale-like sculpture. The hypostome, or anterior part of the under side of the head, is transverse, and from beneath it spring the linear but rather broad antennæ, which are considerably longer than the carapace.

The swimming-feet are formed of six joints, the basal or coxal joint very large; a second, third, and fourth of irregular shape; the angle of the bent limb being formed by the third (rather than the fourth, as in *H. acuminatus*); and the fifth and sixth are elongated, but not much wider than the rest; the penultimate joint is the larger of the two, and is notched to receive the terminal ovate palette. These swimming-feet always start exactly from the angle of the carapace, where it joins the first body-ring; and we are able hence to ascertain the true hinder edge of the carapace when it is otherwise obscured by pressure.

There are some flat appendages, of a cordate-ovate form, which are frequently associated with this species, but their nature is wholly unknown. It is possible they may be scale-like appendages at the base of the antennæ. One is figured in the woodcut (fig. 7).

4. H. PERORNATUS, sp. nov. Fig. 6.

H. magnus, pedalis et ultra 4 uncias latus; capite sublævi; thorace valdè sculpto, et ex segmentis 6 latissimis curvatis composito; segmento primo angusto lateribus rotundatis, secundo subfalcato, reliquis subparallelis; segmentis omnibus anticè squamulis minutis ornatis, posticè sublævibus; angulis capitis acutis; oculis anticis (minoribus?) granulatis.

Of all our specimens this one only shows the true consistence of the corneous crust, and the slight general convexity, which, it is probable, all the species possessed. The head is fully half a broad oval, and has the eyes rather forward, but small (in proportion to those of *H. bilobus*), and these show the lenses well.

The head is smooth, or at least shows none of the peculiar sculpture so visible on the thorax-rings; and these only show it on the anterior half and on the sides, the posterior half of each segment being smooth. The sculpture consists of short scaly markings, directed backwards like those of *Pterygotus*, but far smaller; and these are very prominent, though of small size, and rather irregular as to the amount of curvature. They are very like those on the *Eurypterus* figured by Eichwald, and above referred to. Probably this sculpture is characteristic of the whole family of the *Eurypteridæ*.

The fulcral point of these wide body-segments (fig. 6) is very near ($\frac{5}{8}$ths of an inch in a segment 4 inches broad) to their ends, and the forward curve of the segment is changed at this point for a straight outward direction. One of these pleuræ, broken out from the specimen, showed that there was an incurved sculptured portion for a short distance on the under side, like that of the Trilobite.

5. H. LANCEOLATUS, sp. nov. Fig. 5.

H. elongatus, posticè attenuatus; articulis 12, quorum 10 transversis, penultimo oblongo, caudâ acutâ productâ.

This is the smallest of the Lesmahago species. It is elongate, attenuated behind, consisting of twelve body-rings, which are sculptured anteriorly, as in the last species, and are all transverse, except the penultimate, which is elongate-oblong. The tail-joint is a gradually pointed spine, longer than the preceding joint, and appears to be keeled along the middle. (Its base is less bulbous than it is in our figure.)

The swimming-feet are narrow, and extend back to the sixth body-joint.

Locality.—All the above are from the same locality,—Lesmahago in Lanarkshire; and were discovered in the uppermost Silurian rock by Mr. Slimon*.

Another species of the genus occurs in the Tilestone of Kington, Herefordshire, and has been for some time known to me. I propose to call it *H. Banksii.*

6. H. BANKSII, sp. nov.

H. parvulus, 2–3-uncialis; capite convexo, parabolico, ad frontem subangulato; oculis gibbis lateralibus, ad medium capitis, prominentibus; annulis trunci valdè transversis.

This small neat species, of which we have many specimens in the Museum of Practical Geology, occurs with *Pterygotus* and spines both of Crustaceans and of Fish, in the yellow tilestone beds of Kington, Herefordshire. It is there associated with the *Platyschisma? helicites* and *Lingula cornea.* These are the two species of shells which appear to accompany the fossils of Lanarkshire above described,—a good argument, therefore, even without other evidence, for regarding those beds as the uppermost portions of the Ludlow rock.

The head is $1\frac{1}{8}$ inch long, and fully as much broad; it is semioval, produced and angulated anteriorly, regularly convex, with a thick margin, on which the prominent oval eyes are placed rather more than half-way up the head. They are small in comparison with those of some of the other species. The posterior head-angles are retuse, and the hinder margin is quite plain and even, as in the other species. We do not possess the body, except imperfect portions of the first nine rings; and these agree in general form with those of the *H. lanceolatus.* Both have a close scale-like sculpturing on their forward margin, and together with them at Kington occur also tail-spines, scattered in the rock, which may possibly belong to them, and which are narrower than those of the Lanarkshire fossil. As

* See the preceding paper, by Sir R. I. Murchison.

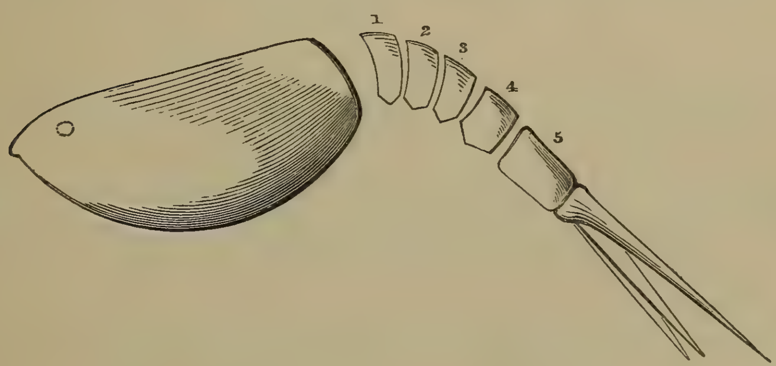
we do not yet know the head of the latter, we must for the present keep the species distinct; and I propose to dedicate it to Mr. R. Banks of Kington, who has lately been making discoveries amongst the tile-stones, and has sent good specimens of this and other fossils to London.

Phyllopoda?

Among the Lanarkshire specimens, so well collected by Mr. Slimon, are perfect forms of the genus *Ceratiocaris*, M'Coy*. Only the carapace has hitherto been discovered; but the occurrence of body-rings in the Dudley limestone has been for some time known; and in the Ludlow Museum I lately saw such body-segments connected with the long triple tail-spines now known under the name of *Leptocheles*†.

Fortunately these specimens from Lesmahago have all the parts in juxtaposition, and show the animal to have been a large Apus-like Crustacean, with a carapace bent sharply down the dorsal line, pointed anteriorly and truncated behind, and with an elongate abdomen of at least five, if not six, joints,—the hinder ones longest. The last joint is a thick striated spine, with a bulbous articulation, and has a pair of lateral spines or appendages at its base, nearly as long as itself.

Fig. 8.—*Diagram of* Ceratiocaris, *M'Coy, with body and tail-spines attached; from perfect specimens found in Lanarkshire.*



The resemblance to *Hymenocaris*, except in the presence of the strong caudal spines, is sufficiently clear from the accompanying woodcut (fig. 8).

Now that we know the entire structure of this genus, it must be removed from the *Limnadiadæ*.

It has a nearer resemblance to *Apus* and *Dithyrocaris*, but differs at once from the latter genus by the deflected sides of the carapace, and apparently too by the want of regularly-shaped smooth eyes, for

* Synopsis Brit. Pal. Foss. Cambridge Mus. fasc. 1. p. 137.
† M'Coy, Syn. Brit. Pal. Foss. Camb. Mus. fasc. 1. p. 175.

we have no evidence that the prominent spot (described by M'Coy) on the anterior portion, is an eye, though it is very probable that there are lenses at this point.

Perhaps there may be no true relation with the Phyllopods in this form any more than in *Himantopterus* with the Pœcilopods. It may be, as Mr. Huxley suggests, also one of the *Stomapoda*; and there are some indications of long antennæ, which may perhaps, with the apparent absence of abdominal appendages, help to connect it by analogy with some known forms of the group last mentioned.

In the meantime it is curious to see how gradually we have arrived at our present knowledge of its structure. The carapaces had been known for some time; but from their resemblance to bivalve shells had lain unnoticed in cabinets. Prof. M'Coy and myself both independently recognized their Crustacean structure, which he fully published in his work on the Cambridge fossils; and he discovered the eye, which I had not observed. In the meantime Prof. M'Coy and M. Barrande both recognized the Crustacean character of the tail-spines; the former distinguishing them from fish-defences*, with which they had been confounded; and the latter, from better specimens, making them out to be the tail, and not the pincers, of an unknown Crustacean.

In the Dudley limestone the carapace and some of the body-joints were found near together, by Mr. John Gray of that place; and in the Ludlow Museum, as above noted, are the joints of the abdomen connected with the terminal spines. Lastly, Mr. Slimon's specimens show the entire form, and give some hint as to the appendages. It is hoped ere long to illustrate them fully.

Observations *on the* Structure *and* Affinities *of* Himantopterus. By T. H. Huxley, Esq., F.R.S.

From what has been stated in the preceding pages, it would appear that the following propositions embody all that is at present certainly known with regard to the great structural features of the genus *Himantopterus*.

1. The body is composed of a comparatively small carapace, succeeded by eleven or twelve free segments, the last of which is bilobed, lanceolate, or wide anteriorly and acuminated posteriorly.

2. At the margin of the carapace on each side lies a rounded or oval eminence, which there is every reason to regard as an eye.

3. The free segments have no appendages. The cephalothorax presents three pairs: an anterior, probably chelate pair, occupying the position of antennæ; a middle pair of broad, short, foliaceous, serrated organs, which have the appearance of mandibles; a posterior pair of long flattened, jointed appendages, terminated by an oval palette, and not improbably having an articulated filamentous appendage attached to their penultimate or ante-penultimate joint.

* Quart. Journ. Geol. Soc. vol. ix. p. 13.

4. Lastly, many parts of the body of *Himantopterus* present a peculiar imbricated sculpture, resembling that exhibited by *Pterygotus*.

Assuming these data to be correct, the question is,—In what group of animals can we find an analogous structure? and there are obvious reasons for at once narrowing the field of inquiry to the *Crustacea*, and confining the search to the different subdivisions of that great group.

Analogies, if not for *Himantopterus*, at least for the very closely allied genus *Eurypterus*, have been sought by different naturalists among the *Pœcilopoda*, the *Phyllopoda* (particularly *Apus*), and the *Copepoda*; and M. Milne-Edwards has suggested that *Eurypterus* possibly holds an intermediate position between the *Copepoda* and the *Isopoda*.

1. If we compare *Himantopterus* with *Apus*, we find points of resemblance in the form and position of the sessile eyes,—in the position of the antennæ and of the great natatorial feet, and, to a certain extent, in their form,—in the structure of the jaws,—and finally, if *Apus productus* be compared with *Himantopterus acuminatus* and *H. bilobus*, in the terminal segment.

The discrepancies, however, are even more striking and important. The number of free segments in *Apus* is thrice as great as in *Himantopterus*; the carapace extends as a free fold far back over them; all the thoracic, and the great majority of the abdominal segments possess foliaceous appendages (which would certainly have been preserved in as perfect a state as other similarly constituted parts, had they existed in *Himantopterus*); and lastly, the penultimate segment carries long articulated styliform appendages.

2. A certain similarity between *Himantopterus* and *Limulus* in their carapace and eyes, the large size of the terminal segment and the chelate form of the antennæ in both, may be regarded as the most salient resemblances of the two genera. To these might be added a sculpture, not altogether unlike that of *Himantopterus*, on some parts of *Limulus*, and a certain resemblance in fundamental structure between the last ambulatory feet of *Limulus* and the great swimming members of *Himantopterus*.

The differences consist in the number and great development of the locomotive members in *Limulus*, the coalescence of its abdominal segments, their well-developed appendages, and the much smaller total number of segments.

3. *Himantopterus* resembles many Copepods in the form and relative proportions of the carapace and free segments, in the sessile position of the eyes, in the great locomotive antennæ and post-buccal appendages, and in the absence of the majority of the abdominal appendages.

But the thoracic appendages are always well developed in the Copepods, and the number of free segments is never so great as in *Himantopterus*.

While the relations of *Himantopterus* with the Pœcilopods, Copepods, and Phyllopods, then, must by no means be overlooked, they would appear not to be sufficiently close, while the differences, on the other hand, are too numerous to justify its arrangement in either of these families.

There is another Crustacean group, however, which presents a much greater approximation to *Himantopterus* in some of its forms, —the family of the Stomapods.

This small and not very well-defined group occupies nearly a central position among the *Crustacea*; and its members, like those of most central groups, while presenting a strong general similarity, differ very widely in details. The genus usually regarded as the type of the family—*Squilla*—is not more like *Himantopterus* than an ordinary Macruran would be; but if we turn from *Squilla* to *Ericthys* and *Mysis*, and thence to *Cuma* and its allies, we shall find we have passed by a series of insensible gradations from the close ally of the Podophthalmous *Macrura* to a sessile-eyed Crustacean, with the internal antennæ almost rudimentary, with a very small carapace, like that of a Copepod in its proportions, and with twelve free segments, the anterior of which only carry appendages, all the abdominal ones, except the penultimate, being in some cases deprived of them.

The characters just mentioned are common to the genera *Cuma*, *Bodotria*, *Alauna*, and *Calyptoceros* (the last a new genus lately discovered by myself in the Bristol Channel): and, in addition, *Calyptoceros* (and probably *Cuma*) exhibits very markedly that peculiar sculpture which forms so prominent a feature of *Himantopterus*.

The differences between these "Cumoid" crustaceans and the latter genus consist principally in the shape of the antennæ and the development of the thoracic appendages in the former, each thoracic segment being provided with a pair of simply constructed members. In addition there is a pair of appendages to the penultimate abdominal segment, of which no trace has been found in *Himantopterus*.

As regards the two former discrepancies, however, we find in *Ericthys* that the three posterior pairs of thoracic appendages are reduced to mere rudiments, even the two pairs which precede them being very small. The largest of all the thoracic appendages are the first and second maxillipedes, the former being terminated by an oval plate-like joint. The external antennæ carry a similar oval plate on a long stem.

Reductions and modifications of the appendages of a Cumoid Crustacean of a similar character to these would produce a form wonderfully similar to *Himantopterus*.

But such reductions and modifications carried still further, and bringing us still nearer the ancient form, are to be met with, not, indeed, in any adult Crustacean at present known, but in those remarkable larvæ of the Podophthalmous *Malacostraca* which were once known under the name of *Zoœa*.

In their earliest condition these larvæ possess sessile eyes, a short carapace, a long jointed abdomen without appendages, and with the terminal segment sometimes entire, sometimes bifid; the only appendages beside the minute trophi, consisting of a single pair of antennæ and a varying number of maxillipedes, so modified in form, as to serve, in conjunction with the abdomen, as a powerful swimming apparatus.

The nearest approach to *Himantopterus* which could be constructed out of the elements afforded by existing Crustacea, then, would be produced by superinducing upon the general form of a Cumoid Crustacean such a modification of the appendages as we find among the Zoææform Macruran larvæ.

It must not be supposed, however, that, because on this account *Himantopterus* may with some propriety be termed a "*larval*" form it is therefore an "*embryonic*" form, or represents any *embryonic* stage of Crustacean development. On the contrary, so far as it is "*larval*" so far it is not "*embryonic*," inasmuch as the form of the Decapod larva is a wide and sudden deviation from the regular course of embryonic development in the Crustaceans, in apparent adaptation to peculiar exigencies.

Nothing has produced more confusion in the application of natural history to geological problems than the ambiguous use of the word "embryonic," applied as it is, sometimes in the sense of "correspondence with a developmental stage," sometimes in that of "similarity to a larval condition." The structure of *Himantopterus* is anything but embryonic in the former, proper sense,—very much so in the latter.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

On the Possible Extension *of the* Coal-Measures *beneath the* South-Eastern Part *of* England. By R. Godwin-Austen, Esq., F.R.S., F.G.S.

[Read May 30, 1855*.]

[Plate I.]

Contents.

Introduction.—The views contained in the present communication, and which are essentially speculative, require the admission of certain generalizations, from which, however, competent geologists will not perhaps be disposed to dissent.

1. The early palæozoic strata, like all others, were formed by the gradual accumulations of coast-line waste; and, so far as the evidence goes which is to be derived from the districts hitherto observed, the nature of the change from the older to the newer palæozoic groups

* For the Proceedings of this evening's Meeting, see vol. xi. p. 532.

was one of contracting areas, by the conversion of sea-bed into land-surface. This process was one of almost endless alternation from one state to the other; but the general tendency was to an increase on the side of dry land. It is only towards the upper portions of the palæozoic group that we acquire any definite boundaries for areas of land and water: it is on the correct restoration of these lines that the following speculations are mainly founded. With respect to those terrestrial masses which are represented only by the *oldest* palæozoic groups, it may suffice to say that they have mostly disappeared. We can, however, ascertain something as to their mineral composition, and the spaces they occupied; and in this way we can sketch out the surface of the Northern Hemisphere under its *earliest* arrangements. These differed widely from such as obtain now. The land was mainly extra-European; and it must be obvious to every geologist who has a clear view present to him, of the large proportion in which sea-bed of subsequent date constitutes the present European land-area, at how early a date some of these early features began to be effaced. Any restoration of the European surface for this very *early* period must be purely ideal; whilst the restoration of the many land-surfaces of the true Carboniferous period is real,—what was dry land then has, in many instances, continued so ever since, and is so now.

2. Of the widely spread terrestrial surface of the true coal-measure period, portions attained a considerable vertical elevation. The evidence of this may be derived either from the character of part of the vegetation of the period; or from the scale of the alluvial action of that time. In contrast to this, there is a feature which seems to distinguish this period physically from all subsequent periods, and which consists in the vast expanse of continuous horizontal surface which the land-area presented, bordering on, and at very slight elevations above, the sea-level.

3. All coal may be taken as the product of a vegetation which grew on the spots where it is now found: the extreme purity of the carbonaceous matter, however thin the seams may be, is sufficient proof of this. There may have been accumulations of drifted vegetable matter then, as now; but no true coal-stratum was ever so formed. The botanical character of the coal-vegetation does not belong to this inquiry; it can, however, be divided into upland and lowland; and as to that of the low-level surface, it must have been composed of dense growths of like plants, such as were capable of maintaining them selves, like the peat-vegetation of modern times, for indefinite periods over the same spots.

From the Valley of the Roer to that of the Scheldt, near Valenciennes, there extends for 170 miles from E. to W. a continuous band of productive coal-measures. This great coal-field has usually been described as situated on the north-west edge of a mass of older rocks, of which a principal part is known as the Ardennes range: such is, however, rather a geographical than a geological account of its position, as it omits considerations of some importance. On the north-east this coal-band is overlaid in the direction of the Valley of the Rhine by Upper Tertiary sands, and is lost for an interval of 40 miles, when it reappears in Westphalia, under exactly the circumstances of position which it has in Belgium. On the south-west of Valenciennes the coal is worked beneath White Chalk, and a subjacent conglomerate (Tourtia) of the age of the Gault.

The national importance of the Valenciennes coal-field gave rise from early times to numerous speculations as to its probable extension; trial-shafts were sunk at various times and at enormous cost over a very wide area, which, though unremunerative so far as the adventurers were concerned, may have served to indicate the line of the present workings. The continuity of the coal-beds beneath the chalk of the north of France may be considered to have been proved for 80 miles west of Valenciennes, along a line passing by Douay and Bethune and south of Lillers.

For a long time the engineers of the School of Mines, guided by theoretical considerations, directed their researches towards Arras; even now speculations based on the supposed parallelism of one part of the coal-field with the "System of the Hundsrück," and of another with that of the Vendée, of M. Elie de Beaumont's theory, are put forward; and in this way the line of the coal-measures is carried by Ferques and Hardinghen into the Boulonnais, of which the several small coal-basins are represented as the natural termination (Burat, p. 361).

M. Dumont has also apparently adopted this view, from the direction which he has conjecturally given as that of the coal beneath the Chalk.

These last speculations would not, perhaps, have been ventured on had the real structure of the Boulonnais been better known. The coal-series of this district is interposed between two great groups of limestone, of which the upper, with *Terebratula elongata*, represents the upper Mountain Limestone of Visé, which underlies the productive coal-measures of the Liège basin. The Boulonnais coal is most probably a great expansion (the result of more favourable physical conditions) of M. Dumont's middle division of his "Condrusian" group, consisting of "Psammite, Macigno, and Anthracite."

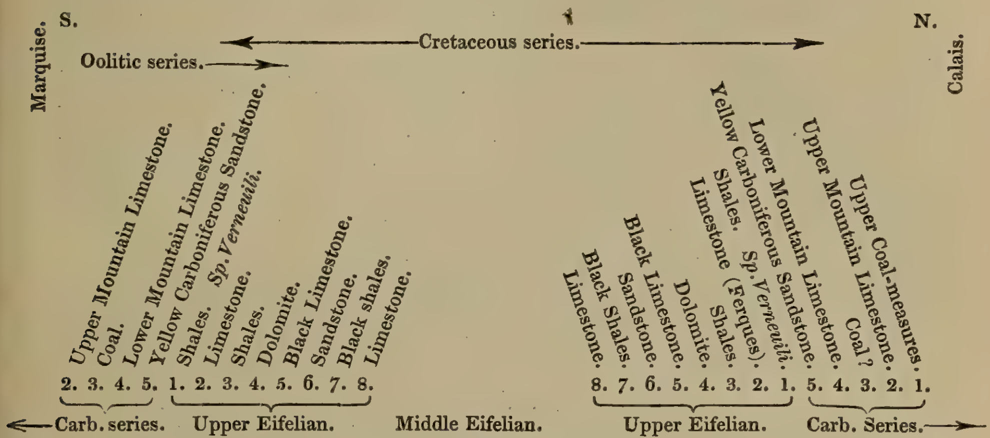
It may be as well to state here distinctly that the fragmentary character of the Boulonnais coal-formation is not in any way dependent on original conditions of formation, but of disturbances of long subsequent date: viewed apart from these accidents, the palæozoic group dips away beneath the oolitic series in the south-west, and no doubt whatever can be raised as to its continuity in that direction*. The upper or true coal-measure series of the Franco-Belgian frontier is not presented in the Boulonnais denudation; but will probably be found to occur beneath the oolitic rocks on the south of Marquise.

When my communication on the Boulonnais† was read, the trial-shaft at Guines had not been carried through. This was soon after

* Quart. Journ. Geol. Soc. vol. ix. p. 233. † Ibid. p. 231, &c.

effected, and the White Chalk and certain subjacent beds, altogether about 800 feet, were found superposed on palæozoic sandstone and shale.

At Calais, which is about 18 miles to the north of the old coal-works at Ferques, an artesian well was carried through the thickness of the Chalk, and at a depth of 1100 feet beds were met with which have been identified as true coal-measures*. By the aid of the foregoing data, it becomes easy to carry on the section of the palæozoic series, as exhibited in the Boulonnais†.



By this it will be seen that on the north the cretaceous strata immediately overlie a higher portion of the palæozoic series than the oolites do in the south, thus giving considerable extension to the area over which that series is wanting.

The circumstance, that a portion of the coal-measures should have been recognized so near us as at Calais, has suggested the following inquiries, which relate,—

1. To the amount of *à priori* evidence as to whether the coal-series may be continued further West, across the Straits of Dover, and so beneath our south-eastern counties.

2. Whether, if so, the coal-measures are likely to occur under such condition of depth, with respect to the overlying formations, as would render them available to us.

The solution of such questions depends on a great variety of considerations ; and more than ordinary caution is imposed on any one who would venture on an affirmative opinion. "Le problème qui, soulevent les recherches de mines de houille dans le nord de la France, se rattache en dernière analyse au plus grandes questions que la géologie puisse traiter relativement aux couches houilliers de ces contrées ; celle de la forme, encore indéterminée, du bassin dans lequel elles se sont déposés, celles de la disposition des terrains qui ont recouvert le terrain houillier dans une grande partie de son étendue."

* Prestwich, Geological Inquiry respecting Water-bearing Strata, &c., p. 208.
† Quart. Journ. Geol. Soc. *l.c.*

Such is M. E. de Beaumont's view both of the importance of the inquiry, and of the main points which it involves. The question itself may be of greater importance to France than to this country, from her relatively limited supply of coal; yet, considering the demand we are now making on our own coal-fields, it may not be amiss that the theoretical geologist should point out in every case such areas as may possibly furnish us with fresh supplies.

[*Note.*—As, in tracing out the progressive changes which took place in the physical outlines of Western Europe during early times, I had been led to a belief that the systematic representation at present in use is not the true one, I must be allowed to state that in the following pages the term "Carboniferous" will include the conditions—whether terrestrial, freshwater, or marine—from the Marwood beds and their equivalents upwards. This is the "Upper Palæozoic Group."

The "Lower Palæozoic Group" will designate all marine sedimentary strata up to "Lower Silurian," inclusive.

The "Middle Group" will comprise two series, which I cannot but consider to have been equivalent, viz. the "Upper Silurian" and the "Devonian."]

A. *Form of the Terrestrial Surface of the Coal-growths.*

British Area.

The restoration of the physical features of Western Europe in their earliest form can only be indicated here in outline. There existed a continuous range extending from the Arctic circle, perhaps as low as north Africa, running north and south, and nearly equal in extent with the great linear ranges of the American continent. Of this range the Scandinavian portion now remains, extending through 16° of latitude. It can be traced beneath the overlying deposits of Northern Germany; it reappears through the eocene series of Belgium; is preserved in the Spessart, Vosgean, and Schwartzwald ranges; expands into the central plateau of France on the west, and the Estrelles (Var) on the east, and is represented in the Mediterranean area by Corsica and Sardinia.

To the west, old land lay to the north and west of the British Islands group: this land did not wholly disappear until some long subsequent period, and in its southern extension formed the boundary of the great European basin; but, although this land encroached more on the Atlantic than land does now, yet that great valley, which from earliest times has been the parting line between two sets of representative and synchronous faunas, is a physical feature of *earliest* date.

The greater part by far of the earth's visible mineral *surface* being derivative, the sources of the oldest sedimentary strata must necessarily be concealed beneath what is now sea; indeed it would be difficult to fix on any masses which supplied the materials of the oldest British strata,—these masses have wholly disappeared. The arrangement of these early deposits was in subordination to masses having some such positions as above described; and, as there is an exact relation and balance between the amount of sedimentary matter and the coast-line from which it is derived, the extent and dimensions of the palæozoic masses afford an indication of how vast a region that was which has disappeared.

The lines of saliency and depression which have subsequently shaped out and formed our present Western European areas have been mostly transverse to the direction of the original lines. With reference to the present inquiry, we have only to compare the palæozoic region which extends south from the Department of the Manche with that of our own western counties, to ascertain what was the character of the changes of the middle and lower palæozoic periods.

If we take zoological considerations as a guide, the southernmost of these areas seems to have been subject to fewer changes favourable to the immigration of new and successive occupants than the Silurian region of Sir R. Murchison was. The nature of the difference is this, the sequence of animal life was not the same through the same periods of time over adjoining areas. The geographical variation in the marine fauna was, perhaps, greater during the palæozoic period than it is at present; but making every allowance for this, it will be found insufficient to meet the nature of the change which takes place.

I would indicate as an inquiry to be made,—why it is that the lower palæozoic group of Western France, as the slates of Parennes, and their equivalents, should differ so materially, as to their contents, from the Llandeilo and Bala groups, of which they are received as the synchronous products. Ascending higher in the same French series, the want of parallelism with our own becomes still more striking; and in estimating the value of this with reference to the restoration of any salient lines, it must be remembered, that the French sections show perfect continuity throughout*, and that the value of this evidence over-rides all other in a question of chronological sequence; and also that the palæozoic series of western France, as a whole, is synchronous with that of the British area.

In France the palæozoic series consists of a Lower Silurian, an Eifelian, and finally of a Carboniferous division, which last commences with a group corresponding to the Marwood beds, as in the Boulonnais. The observations of Mr. Haughton enable us to extend the area of like conditions for the lower carboniferous group as far as Anglesea.

In the total absence of any direct physical evidence, we are not warranted in supposing that any portions are relatively wanting between the palæozoic groups of Western France and England; but merely that in parts, and from local causes, what are true equivalents are differently represented. That which we recognize in the English series as an Upper Silurian fauna does not seem to have found admission into the area of the palæozoic seas of France, nor indeed into those of southern and eastern Europe. It may be suggested, perhaps, that the oceanic region then may have been one and the same, but

* Bull. Géol. Soc. Fr. vol. ii. pl. 11.

that the two areas were not under conditions alike favourable for the development of such a fauna. The answer to this is obvious;—the area over which a marine fauna such as we term Devonian comes in succession on a Lower Silurian one is so vast and so varied in the conditions which it indicates, compared with that in which an Upper succeeds a Lower Silurian, that it is physically out of the question that in the first-named area an Upper Silurian series of forms should have been wholly excluded.

With respect to the lower palæozoic group of the French and Southern European area, as known to us through the researches of M. de Verneuil and Mr. D. Sharpe, there is enough to warrant a comparison with our own typical Silurian series; still it is clear that at this early time there were two regions,—each having a facies of its own, dependent on community of forms, and the limits of which lay somewhere in the line of the Bristol Channel.

Zoological considerations such as these require and imply the existence of parting barriers, even where no physical evidence whatever of such may now remain. Geology in its future progress will be called upon to define the positions and extent of many lines of partage. The difficulty in the present instance is not great; assuming such a line we find the character of the accumulations on either side to be as such conditions would require. On the French side, the quartz shingle-beds at the base of the slate-series of Jersey,—the siliceous conglomerate and sandstones of the Cotentin, mark the early existence of coast-line in that direction. In this case palæozoic sedimentary strata are produced out of the abrasion of older portions of the same great series, as the result of the elevation of deep-sea sediment (already mineralized) to the sea-surface: and this change was progressive. The Silurian series of the West of France presents at least two groups separated by thick pebble-beds; and this change is accompanied by the transgressive passage of one series over the other, as in the "buttes de Clècy." These lines affect east and west directions, from the lowest ranges of the satiny and fibrous chloritic slate series upwards.

On our side of the English Channel, the successive bands of shingle subordinate to the Lower Silurian series of Cornwall equally require the presence of a former coast-line, in somewhat close proximity there. Attention was first called to the existence of rocks of this age in this quarter by Prof. Sedgwick*.

The direction of these bands indicates the relative position of the coast, for I am disposed to consider the conglomerates of the Lizard district to be of the same Silurian age. Guided by these considerations, and their bearing on the direction which upraised older palæozoic beds assumed, we may feel assured that the lower or western end of the Channel area was occupied by ridges or axes extending eastwards. It is this line whose influence may be *first* traced in the difference between the two Lower Silurian regions which have been indicated above; a divergence which becomes greater as the series

* Quart. Journ. Geol. Soc. vol. viii. pp. 10, 11, &c.

ascends, until at last it forms a barrier betwixt two distinct marine provinces.

The existence and progressive growth of an old ridge in this position does not rest on zoological considerations alone. On the advancing land of the Cotentin, the older palæozoic series is brought up along the coast east and west from beneath the sandstones and conglomerates of the Montagne de Roule, &c. On our side it is preserved in the fibrous chloritic slates of the Bolt and Prawle, and in the crystalline rocks of the Eddystone.

Prof. Sedgwick, speaking of the disturbances which have affected the South Cornish district*, expresses his opinion that a force has acted on the side of St. Austle, and a contemporary force on the south of the Dodman, and between these two forces the present surface has been broken and placed in its present contorted position ; and again (p. 19) he says "we have indications of an elevatory axis ranging (nearly east and west) along the south coasts of Devonshire and Cornwall."

These two axes, however, were not contemporaneous ; the Channel axis had a priority of origin, and was the line of resistance which contributed to cause the contortions in the sedimentary beds to the north of it, when the granitic intrusions of the west of England took place.

Another proof is to be derived from a new branch of Geological inquiry. Cleavage-structure of great masses is very generally admitted to have resulted directly from the mechanical tension to which they have been subjected in the process of elevation : the limits of an area of elevation are therefore clearly indicated,—being those within which the cleavage-planes have an arched arrangement. This law, for which we are indebted to Mr. D. Sharpe†, with the deduction from it,—that the lines of vertical cleavage are the partings of contiguous systems, will henceforth mainly guide us in determining the extent, succession, and relative ages of early ranges. Applying these considerations to our western counties, it will be found that, taken in its broadest part, Devonshire presents an arch extending north and south from Bickington to the South Hams : then follows a band of vertical cleavage-structure ; beyond this a second arc is seen to take its origin, and is continued south as far as the fibrous chloritic slates which form the coast-line of the Prawle ; all this area is only a small section of an arch ; but, by the aid of the foregoing law, it becomes as satisfactory a proof to the geologist that it was once continued on, as the face of a single stone on a ruined bridge may be to the antiquarian of the character of the structure of which it once formed a part. From this mere abutment preserved in the projecting headlands of South Devon, we may replace with certainty an elevated area to the South ; for without it, what now remains could not have been produced.

It might further be shown that the span of the Channel arch was

* Quart. Journ. Geol. Soc. vol. viii. p. 10.
† Phil. Trans. 1852.

not less than that of the Devon arch, and that in its extension (the direction of the major axis of the ellipse) it was carried as far eastwards as the meridian of London.

Passing over to the district of South Wales, we may apply considerations akin to those employed with reference to the South Devon and Cornish area, and with like results. A mass of oldest sedimentary strata makes its appearance near, and extends S. and E. of St. Davids; subordinate to which are bands of shingle. The lines of quartzose conglomerate occurring in the grauwacke overlying the former—so singularly like some of the beds of the Old Red Sandstone that they were at one time mistaken for them, but which are now known to be of Lower Silurian age—would imply that the source of such a form of detritus was not far distant.

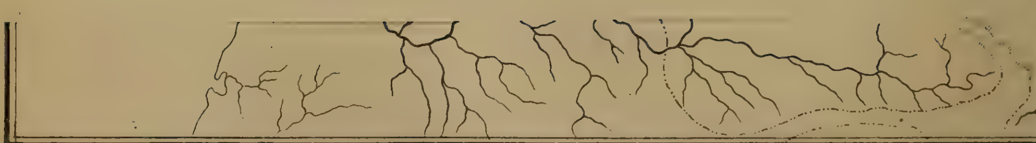
This Silurian section is interesting, inasmuch as, in the imperfect representation we get of the upper group, we see to what extent the character of that fauna becomes modified by local conditions; and also that local conditions, and the variations they produce, are not sufficient to account for that absence of the upper group which has been remarked upon with respect to Cornwall and the West of France.

In like manner the cleavage theory shows that the Bristol Channel area must at one time have been the line of an axis of elevation, of which the direction coincided with the strike of the old group of St. Davids, and that of North Devon. This was probably the eastern extremity of an elliptical area, of which the maximum breadth was placed at some distance to the west.

Independently of these considerations, there is to be observed in this same district the relation of unconformity between the Old Red Sandstone and the Culm-series, as also that of both of the foregoing with the Silurian and older rocks,—relations which must always exist towards the original limits of formations where the destruction and removal of mineral material alone take place. Here then as at the western opening of the English Channel we have clear indications of an old coast-line, and of land which has long since disappeared.

The whole terrestrial surface thus restored would present an indented outline produced by advancing ridges of old palæozoic sedimentary strata, and extending from the main Atlantic mass in east and west directions. This growth of land from the Atlantic side, towards the European area, by means of the successive elevation of palæozoic sea-bed, commenced from very early times. It was a physical change of this kind, which produced what may be designated as "the Mid European line," and which at length constituted a parting barrier between two hydrographical areas, in the northern of which the true upper Silurian fauna had its development together with northern relations, and of which the southern equivalent is that assemblage of forms which is usually known as the Devonian*.

* This view will form the subject of a special memoir, but it was necessary to state it here, inasmuch as it helps towards a determination of the form which the palæozoic terrestrial area of Western Europe ultimately assumed.



Explanation of the Map, Plate I.

The map which accompanies the present communication must not be viewed as a geological one—as representing the actual arrangement of the mineral masses which compose the present surface—nor yet as a map of Western Europe at any definite period of past time.

One of the objects of the memoir which it illustrates is to trace out the gradual formation of an old terrestrial area, that over which the coal-growths ultimately established themselves. It is hoped that the descriptive portions of the paper will be found nearly sufficient for this purpose, and that the introduction of a few leading lines, such as may serve to indicate the direction of the masses which in turn imparted a definite physical configuration to the area in question, is all that is requisite to guide the reader, and enable him to follow more easily the kind of evidence on which the conclusions have been based.

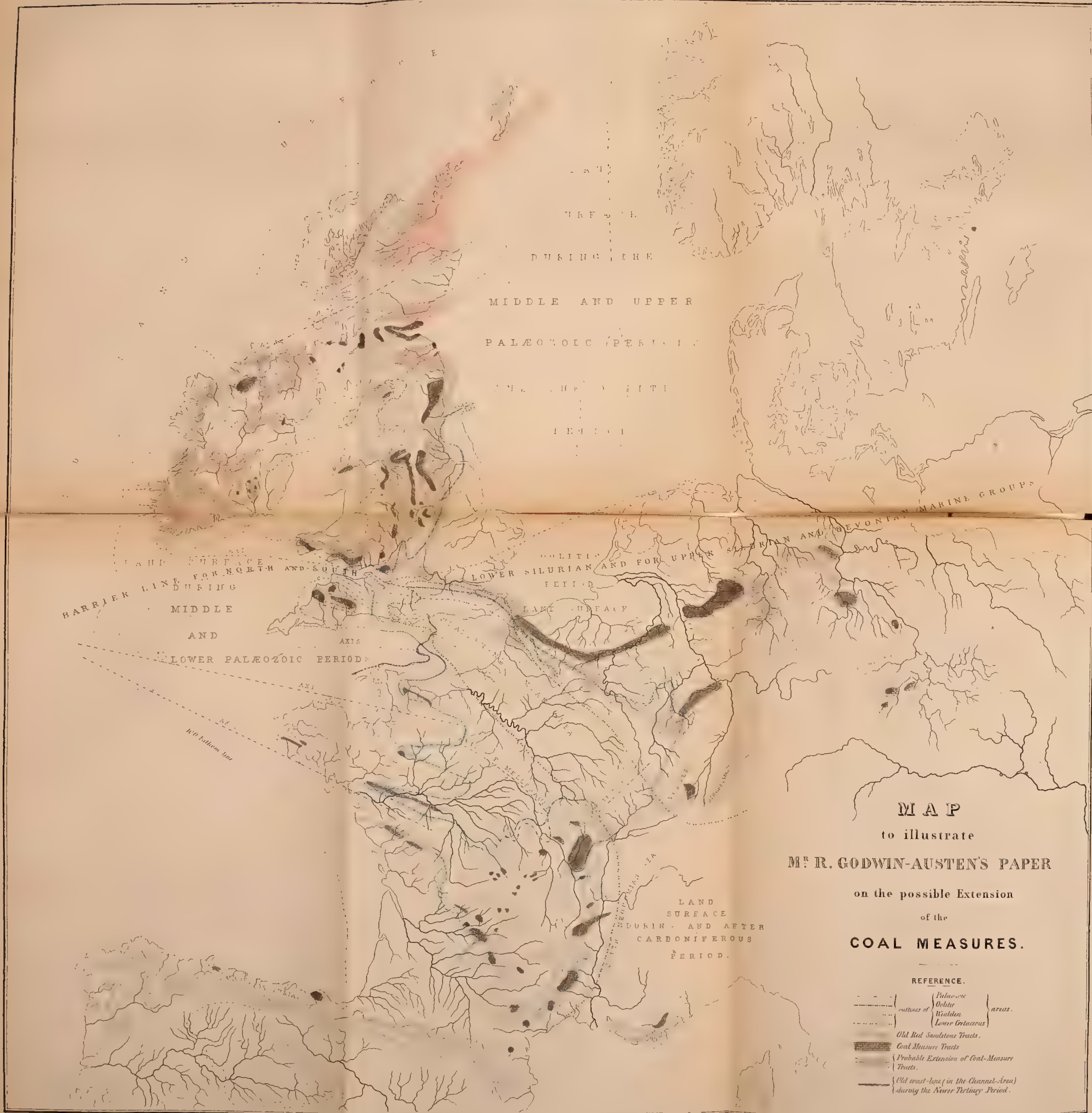
Over the British portion of the area, a local group, known as the "Old Red Sandstone," has been tinted, because it serves to indicate very definite physical conditions at a definite period. From the date of this group the Carboniferous formation may be viewed as a great fluvio-marine series of the later Palæozoic period, during the whole of which the *facies* of the contemporary marine fauna was such as is known as that of the Mountain-limestone series. It must however be borne in mind, that in the North of Ireland the distinction between the marine Carboniferous sandstones and lacustrine Old Red Sandstone has not been traced as it has for the South.

A very extensive series of maps would be required to convey any adequate representation of the successive changes which Western Europe underwent in its physical arrangement ere it reached the maximum extent of terrestrial surface which it presented at the time of the great coal-growths; but the time may come when general views as to past conditions will require to be thus illustrated.

The geographical arrangements on which the internal basin containing the Palæozoic fluvio-marine groups depended were preserved through a long subsequent period; the same area became that of the "New Red conglomerates, sands, and clays" of English geologists, and which, if in part "Permian" and part "Triassic," are such only in the form of equivalents, these groups being here the accumulations and depositions of lacustrine waters and their tributary rivers.

No restoration of the area of the coal-growths has been attempted on the side of the old Scandinavian chain; it could have easily been shown, however, that all the subsequent secondary and tertiary formations had their limits against this mass, and that all these lines have been carrried downwards by the progressive subsidence to which this chain has been subjected, even to times very near to the present. In the Coal-measure period the materials of the sandstones of our northern and midland districts must have been brought down by streams which had their origins in that region.

We have only to imagine an extension of the Scandinavian chain, encroaching on the area of the North Sea, and along a line north and


MIDDLE AND UPPER
DURING
MIDDLE
AND
LOWER PALÆOZOIC PERIOD
BARRIER LINE FOR NORTH AND SOUTH
LOWER SILURIAN AND FOR UPPER SILURIAN AND DEVONIAN MARINE GROUPS
LAND SURFACE DURING AND AFTER CARBONIFEROUS PERIOD.
100 fathom line
MAP
to illustrate
Mr. R. GODWIN-AUSTEN'S PAPER
on the possible Extension
of the
COAL MEASURES.
REFERENCE.
outlines of Palæozoic Oolite Wealden Lower Cretaceous areas.
Old Red Sandstone Tracts.
Coal Measure Tracts
Probable Extension of Coal-Measure Tracts.
Old coast-line (in the Channel-Area) during the Newer Tertiary Period.

south, to enable us to define the form of that internal depressed area over which the low-level coal-growths of France, Belgium, and Britain were accumulated.

The second special object of the memoir was to show that the area thus defined was subsequently disturbed, whereby lines of elevated strata were produced, one of which, having a general direction from east to west, has had the effect of placing the Coal-measures near the present surface along a great portion of its course. This line, as well as those which indicate the influence it has exercised with reference to the distribution and limitation of the secondary groups, are rendered sufficiently distinct, allowance being made for the scale of the map.

Such being the nature of the map, the names of places have been omitted; their positions, however, in many instances are indicated; and as the map has been carefully drawn, the reader will have no difficulty in following the exact course of every line indicated on it, by reference to any ordinary geographical map.

Belgian Area.

The lower tertiary strata of Belgium (Nummulitic formation), between Bruxelles and the great coal band, overlie a surface of palæozoic rocks, without the intervention of any member of the secondary formations. At Tournay these tertiary strata pass over the edges of the cretaceous rocks, and both are wholly unconformable with the carboniferous limestone there. From Tournay by Ath as far north as Hall, Wavre, and Jodoigne, there is a regular descending series of palæozoic groups, presenting a like series of undulations with those to be observed on the south side of the coal-band, as from Bellignies eastward, and which on that side rise into the ridges of the Condros and the Ardennes. The breadth for which this condition of surface, next beneath the Nummulitic series, can be traced north of the coal-measures is about thirty miles. In an east and west direction a like relation is known to exist from the meridian of Namur to that of Lille, or from eighty to ninety miles, whilst the trough-shaped arrangement of the coal-strata, in both directions as towards Liège and Lillers, leaves no doubt whatever that this rise of the older groups in the north has a much greater extension than what is here assigned to it.

A restoration of this palæozoic surface is given in the accompanying map (Pl. I.). If, in conjunction with this representation, a line of section should be drawn from the summit of the Ardennes across the whole series, it would present a plane surface, with a uniform slope northwards descending from an elevation of 2000 feet to somewhat below the sea-level. Of this surface every part stood in a like relation to the secondary formations; or, in other words, at their periods the palæozoic group north of the coal-band must have had an elevation equal or nearly so to that on the south,—it must have been part of the same raised area,—and it must have received its relative depression subsequently to the secondary period and synchronously with the overspread of the nummulitic group.

By means of the well-defined boundary-line of the oolitic formations of the Germanic area, we can extend this old palæozoic surface further north; and, guided by the lines of the coarse infra-liassic conglomerates of Malmédy and Stavelot, we may infer that at this early period the northern mass then had, relatively with the Ardennes range, a somewhat higher level: the island of Heligoland, distant about 300 miles north of the localities here in question, being the nearest spot at which we are certified of the existence of any infra-liassic strata*; and where the lower beds, consisting of sands, indicate shallow-water conditions at that time.

The Boulonnais.

I have elsewhere shown† that the middle and upper palæozoic

* Beiträge zur geognostischen Kenntniss des Norddeutschen Tiefland, von Otto Volger.

† Quart. Journ. Geol. Soc. vol. ix. p. 244.

series of the Boulonnais district present the clearest evidences of great variations in the depth of the sea in which their several component sedimentary beds were formed; and that the sea-bed at several successive periods had become terrestrial surface; yet for all this, such movements had not produced any sensible unconformity between different parts of the series. To this it may be added that the recurrence of a terrestrial vegetation in parts of the series where it is not usually found,—as first beneath the Ferques limestone, next in the yellow sandstone above, and again subordinately to the mountain-limestone,—would indicate, that such local phænomena must have been dependent on the permanent presence of an area of dry land, at no great distance and throughout the whole of the middle and upper palæozoic periods; such an area could not have found place to the east of the Boulonnais; and, for reasons which will more fully appear in the sequel, it may be fixed somewhere to the west, within the space now occupied by the English Channel,—an extension of that mineral axis which on other considerations has been shown to have occupied the lower extremity of that area.

Franco-Belgic Sections.

In the Bellignies section, distant about 100 miles to the east of that of the Boulonnais, there is a like concordance, extending down to the sandstone and conglomerate group which underlies the Stringocephalus-limestone; and a like general concordance holds true over the whole area from the Ardennes to the Belgian coal-field.

In the Pepinster section the series is a continuous one from the slates in the neighbourhood of Spa up to the highest portion of the coal-measures.

The Eifel series is again in perfect sequence from the Goniatite-shales, above the great calcareous group, down to the slates of the valley of the Lieser.

It was at one time supposed that the slates of the north-east of the Ardennes, as from Spa to Stavelot and Viel-Salm, which are undoubtedly of great antiquity, were unconformable beneath the series of the Pepinster section; but no such unconformity exists, nor are the lowest strata there older than the slate-rocks of the Middle Rhine (Coblentzien of Dumont).

The first question which arises out of these consideration is, whether the Stringocephalus-limestone, and its equivalent beds in the valley of the Vesdre, at one time formed a continuous mass with the Eifel series. An examination of the conglomerate beds which extend from Malmèdy to Stavelot is conclusive on this point. The materials of this conglomerate have been derived either from the Eifel limestones, or from the red arenaceous beds which next underlie them,—all the Eifel species might be collected out of it. The condition of the rolled corals shows that the limestone masses from which they have been derived more resembled such as occur on the Eifel side of the Ardennes than on the Belgian, consisting of friable beds, from which the included fossils would be easily separable, rather than of the compact flat-bedded limestones of the valley of the Vesdre. The destruction of such beds as those about Stadkyll and Gerolstein would produce just such a conglomerate as that of Malmedy.

If then we restore the whole of this area to its original position, we find, with reference to submarine conditions, that the Stringocephalus-limestone group on the Eifel side presents a great development of marine forms which lived there, whilst they diminish in the direction of the Vesdre beds, and it is also in this direction that the mineral character of the limestone group changes, and passes into shales,—this takes place from south to north.

The distribution of sedimentary matter being dependent on the moving power of water, and on the specific gravity of the materials moved, such conditions as those here indicated inform us that the land side of such an area of water must have been to the north of the group of deposits in question.

Again in the next subjacent group—that of which the conglomerate of Burnot forms a subordinate part, we meet with the clearest evidence of its relation to an old coast-line. The whole mass of this conglomerate is littoral shingle or gravel: along the valley of the Vesdre, it is some twenty feet in thickness: it is somewhat less in the wood of Stanu: in the Eifel country it has lost its marginal character and become a sandstone,—a change which marks the outward extension of the sea-bed to have been for this zone what it was for the limestone group—or from north to south.

With reference to the Bellignies section, the differences which this group there presents consist in the greater coarseness of the materials of the Cailloux du Diable, together with a greater thickness of the conglomerates and sandstones; where it rises again to the south, near Mondrepuis, its composition is not so coarse, being made up of small lenticular shingle, with thick beds of coarse sands. This conglomerate band again rises on the north of the Mons coal-basin; the distance between these extreme points gives forty miles for the width of the zone of marginal sea-bed here; as in former instances, the gradation in composition shows that the passage from coarse to finer sea-bed takes place from north to south.

Lastly the extension of a mass of shingle along a line 120 miles in extent, from near Valenciennes to beyond Eupen, is wholly inexplicable except under the supposition, that it marks the direction of old marginal and submarginal zones of sea-bed.

The limestones of the right bank of the Rhine, near Dusseldorf, are a prolongation of those of the valley of the Vesdre, and indicate similar conditions; but in the underlying group the conglomerate band disappears, and is represented by a sandstone series. The interval of the valley of the Rhine may be taken at about 35 miles, so that in a north-east direction there is a mineral change such as takes place in the south-east.

The line along which these data have been taken, and which trends irregularly east and west, shows with respect to certain beds, of which the mineral character affords definite indications, that at one part the coast-line must have been much nearer than at the other, and that, if we take the distance from Boulogne to Hirson at 300 miles, the middle portion of it is that which answers to such a position.

There are other considerations, should the foregoing not be deemed altogether sufficient, which bear out the inference that the coast-line to which these shingle-beds were subordinate lay to the north.

The only test as to whether any zone of an old sea-bed is complete, is the form of section it gives when measured at right angles to its greatest direction, such direction being always in certain parallelism with the coast-line. The littoral zone, commencing with the highest marginal beds, parts gradually with its well-known characteristics, and passes into the next lower zone of sands: in like manner the fine earthy sediment forming clays and shales is succeeded by that of lighter calcareous matter, and which from its specific gravity is capable of thickening out over wide areas, so that all geological groups, with a like mineral composition, when so measured, are found to be great lenticular masses: and such is the form of the Belgian subordinate bands.

It has been shown that the broad range of the Ardennes acquired an amount of relative elevation at some time after the completion of the series above the Eifel limestone: it could not therefore have been in a position to have furnished any of the materials towards the underlying conglomerate or shingle group; and, as this zone is a perfect one, the source of its materials must necessarily have been on the north,—a view which is further confirmed by the character of the materials which form the shingles and which enter into the composition of the middle and upper palæozoic sandstone groups.

So much of the palæozoic series as is to be seen north of the Belgian coal-field is nowhere of greater age than the middle Rhine beds; the sandstones which are subordinate to the Eifel (Givet) limestone, those of the next higher group with *Cucullæa Hardingii* and *C. trapezium*, those associated with the Boulonnais coal, and with our dark millstone grit series, all imply the synchronous existence of wide subaërial areas composed of crystalline micaceous rocks, as well as hardened and mineralized sedimentary ones. No such mineral masses occur along the axis of the Ardennes or Hundsrück ranges; and it is only on the north, therefore, that they could have found a place, where they may reasonably be supposed to have risen from beneath the old rocks of Hal and Jodoigne.

This old terrestrial area was a southern extension of the Scandinavian range: portions of it became depressed or broken down at definite geological periods; but subsequently to early palæozoic times it exhibited a salient mass, on either side of which the middle groups had their limits (Upper Silurian and Devonian), and the existence of which in parts can be traced upwards far into the tertiary period. The area over which the erratics of Western Europe (Germanic area) are distributed conforms to this extension of the Scandinavian range.

Along the Ruhr the true coal-measures have a visible breadth of at least sixteen miles; they have, however, a much greater real one inasmuch as they dip away under the cretaceous series of Westphalia, —beneath which they are worked,—they have a considerable width beneath the sands of Aix-la-Chapelle, but from this point they contract rapidly. This diminution across the Belgian area is not owing to any falling off in the thickness of the component beds, but results from the complicated folding of the masses, whereby they are caused to assume a deep trough-shaped arrangement, accompanied by an endless succession of zigzag folds. This part of the Belgian coal-band, if restored to its original horizontal position, would occupy more than four times its present surface-breadth.

From the expansion which the mountain-limestone takes west of Mons, it is evident that the whole series expands again; from which it may be inferred that the coal-measures beneath the chalk of the north of France will be found to have wider dimensions than has been generally supposed: that such is the case is already indicated by the extent which they have been proved to have west of Bethune; and it becomes an important consideration as to their western extension.

All dislocations of the earth's crust having been produced by the action of some force acting in the plane of the disturbed beds, such as that of contraction, any movements producing ridges such as those of the Rhenish-Ardennes System would be attended by the greatest amount of dislocation at any point where it had a pre-existent transverse range.

Such are the considerations by which we are enabled to sketch out some of the earlier physical arrangements of Western Europe.

The Carboniferous Series.

§ 1. *Old Red Sandstone.*

An early condition of the surface of part of the European area at this period is very clearly indicated by the arrangements and composition of the typical Old Red Sandstone formation.

Much confusion in the chronology of geological changes has been caused by the reference of this formation to the marine series. If due weight be allowed to the facts of an accompanying terrestrial and fluviatile vegetation, to the occurrence of the genus *Cyclas*, together with air-breathing oviparous quadrupeds and terrestrial Chelonians, the early suggestion of Dr. Fleming, though based on other considerations, will surely be adopted; and the Old Red Sandstone of Scotland will be referred to the lacustrine series of formations. The "Old Red Sandstone" Fishes offer a subject well worthy of special treatment, with reference to the conditions of the area of water in which they lived; but the conclusions would probably be in accordance with those of Dr. Mantell *—that these conditions were such as those of the *Lepidosteus* and *Polypterus*.

Of the three divisions into which Sir R. Murchison divided the

* Quart. Journ. Geol. Soc. vol. viii. p. 108.

"Old Red Sandstone" series of the Welsh area, the lowest or "Tilestone group," which alone contains the remains of marine forms, has been since very generally referred to the "Upper Ludlow" deposits. The two higher divisions alone represent the typical "Old Red Sandstone;" of these the argillo-calcareous or "Cornstone" group contains just such an assemblage of Fishes as is met with in the palæozoic fluvio-lacustrine deposits of Scotland; whilst the upper or "conglomerate and sandstone group," which as yet has only afforded the remains of a *Holoptychius*, includes somewhat abundantly the spoil of a terrestrial surface. On such considerations the "Old Red Sandstone" of Hereford, Monmouth, and Somerset becomes the representative of another freshwater area, the relation and extent of which are indicated in the accompanying Map (Pl. I.). Had not the true character of these two peculiar assemblages of depositions been misapprehended, the creation of a "Devonian System" would not have been needed.

We as yet possess very little detail respecting the so-called "Old Red Sandstone" of the Irish area: from a short communication on the South of that district by Messrs. Jukes and Salter *, we learn that the "Old Red Sandstone" is overlaid by the "Yellow sandstone" group, and that the two form one continuous series, characterized throughout by the remains of a terrestrial vegetation (*Knorria, Stigmaria*). It is in this series that the large Anodons (*Anodon Jukesii*, Forbes) occur both on the north near Thomastown and on the south near Cork, together with the remarkable Fern-like plant-remains (*Cyclopteris Hibernica*, Forbes); whilst no marine forms whatever have been met with either in the "Old Red Sandstones," or the "Yellow sandstones." Such being the case, we have satisfactory indications of a third fluvio-lacustrine deposit, of wider dimensions than those of the Welsh and Scotch areas, but yet hardly equalling in extent the larger members of the great lake group of North America.

The lacustrine formations of Ireland are everywhere overlaid by a great detrital series of marine origin, and containing the assemblage of carboniferous forms which occur in beds beneath the Mountain Limestone of Pembrokeshire, in the sandstones of Marwood, and in like sandstones in the Boulonnais †. Messrs. Jukes and Salter notice a very interesting fact with respect to the series above the "yellow sandstone" (which they have termed the "Coomhola grits"), which consists in its unequal thickness from E. to W.; so that, whilst in the E. it may be taken at from 50 to 60 feet, it has been estimated at 5000 feet in Bantry Bay. We know from this that the depression which brought the marine series over the lacustrine one was accompanied by a greater amount of depression on the W. than on the E.,—a fact which is further supported by other considerations.

The lacustrine "Old Red Sandstone" of Ireland everywhere over-

* Meeting of Brit. Assoc. 1855.

† Quart. Journ. Geol. Soc. vol. ix. p. 231.

lies a surface of "Old Silurian" rocks: the two are unconformable, and the older had already undergone those changes which imparted to it its present mineral character, at some time anterior to the newer formation, which has in fact been mainly derived from it. Again, the Irish area does not present that assemblage of marine forms which is known as "Upper Silurian," nor yet a true "Devonian" or "Eifelian" fauna; so that from these combined considerations we are justified in the inferences—1st. That the Irish area was wholly included in that movement of elevation which effected the olden Siluro-Cambrian sea-beds; and, 2ndly, that it became a terrestrial surface anteriorly to the oldest carboniferous depositions.

Lacustrine formations imply subordination to areas of land: with respect to the Irish area, the extension of this land was to the north and west, and as in all cases the extent of the lacustrine area may be taken as a fair measure of the terrestrial surface from which it was supplied, that land must have had great expansion, or elevation, or both.

The limits of the lacustrine Old Red Sandstone of the Welsh area are tolerably well defined; they hardly extended as far north as ordinary geological maps now carry that group, inasmuch as the red beds which underlie the coal-measures of Coalbrook Dale belong to the uppermost Ludlow beds, with *Lingula cornea*, &c.

In the South Staffordshire coal-district, and which may be taken as an extension of that of the Forest of Wyre and Coalbrook Dale, the coal-measures rest immediately on marine Silurian strata; and this relative position, to the exclusion of any Old Red Sandstone, is continued as far as Charnwood Forest, where the coal-measures rest on some of the oldest portions of the Palæozoic series.

This old ridge, which is thus clearly defined as to range, if not to its full former extent, was a limiting barrier to the "Old Red Sandstone," and a parting barrier to two areas of typical Mountain Limestone;—considerations which clearly indicate very early terrestrial conditions in this direction; or else that it was placed out of the reach of the depositions of that time, from another set of considerations, to which reference will be made in the sequel.

There are traces of "Old Red Sandstone" at intermediate places between the two great areas of Wales and Scotland; and these are of interest, as they indicate with equal clearness an immediate subordination to a terrestrial surface. The little patches which are dotted along the eastern skirts of the mass of the old slate mountains of Westmoreland and Cumberland are in every case so closely related to the rocks of the particular locality, as to suggest that they are the alluvial beds of the ancient valley-courses of that region. A like local relationship, as was long ago observed by M. Boué*, is to be traced along the whole of the junction-line of the "Old Red Sandstone of Scotland;" and here the accumulation often parts with its character of water-rounded conglomerate, and assumes that of the angular talus so common in subaërial detritus.

* Géol. de l'Ecosse.

We cannot trace the true "Old Red Sandstone" of the English area further S. and E. than Frome; and all that we can ascertain with respect to its boundary-line in that direction is derived from the consideration that it there consists of beds of rounded conglomerate,—or of a marginal character,—and that it does not appear in Normandy, where the true coal-measure series rests immediately and unconformably on the oldest slate-rocks of that country *. We may hence deduce, 1st, that the boundary-line coincided with, and was dependent on, the general direction of the land of the line of the Channel axis, whilst the character of the conglomerate itself about Frome would show that the line was not very remote.

Here, and before the remaining portions of the Carboniferous series are noticed, it may be as well to state that geological history viewed largely presents throughout a frequent recurrence of two distinct orders of change, dependent on cosmical laws, of the very nature of which we can as yet form but vague conjectures. Of these changes, the one consists in the formation at definite times of elevations and depressions of the earth's crust, and hence of definite geographical areas, of which we can in most instances determine, even now, the main physical features: with respect to this order of change, the direction in which the forces have acted would seem to indicate contraction of the earth's crust. At periods intermediate to these we have evidence of a process of adjustment, whereby areas co-extensive with great zones, or even hemispheres, of the globe have been brought into conformity with the oceanic level; and during which times marine deposits of wide range have been brought unconformably over all preceding conditions of surface. In both cases the progress of change was gradual. The line of demarcation between the two distinct Lower Silurian assemblages becomes one of absolute separation between the areas of the Upper Silurian and Devonian faunas. The Mountain Limestone and its equivalents, on the other hand, represents for the Palæozoic period both the greatest amount of expansion, and the greatest uniformity with respect to its included fauna;—its relations to the deposits of the great Palæozoic period are just what those of the Chalk and its equivalents are to the Cretaceous. It is by this law of physical change that we should be mainly guided in determining the minor equivalents of the geological scale of depositions.

In this way the several groups of "Old Red Sandstone" take their places as subordinate to an area of dry land, and as evidences of the positions and extent of the depressions of its surface: and inasmuch as the geological scale is one of successive *sea-beds*, the formation must be considered as *hors de série*, and be placed on a parallel and equivalent one; thus holding, with reference to the lower and upper Palæozoic formations, a position which corresponds with that which the Purbeck-Wealden series does to the Oolitic and Cretaceous groups.

* Proc. Geol. Soc. vol. ii. p. 2.

By placing the so-called independent formations or systems—the "Upper Silurian" and "Devonian"—as equivalents one of another, the "Old Red Sandstone" of the British area becomes disentangled from relationships which are wholly without the support of fossil evidence, and inconsistent with the progress and nature of the physical changes of the Mid-Palæozoic period over Western Europe.

§ 2. *Mountain or Carboniferous Limestone.*

No definite geological group, limited by mineral uniformity, can, by itself, be the representative of a period of time; this consideration has, however, been too often lost sight of; and in this way the "Old Red Sandstone" has been made to precede the Mountain Limestone, and each has been taken to indicate distinct periods.

The West-European area of typical Mountain Limestone—that over which it presents the largest dimensions, where it is less subdivided, and purest,—admits of most precise geographical limitation. It is included within an elliptical space, which may be represented by a line drawn from South Wales, through Somerset and Belgium, into Westphalia, and thence, through Hanover, back into Derbyshire. This was dependent on one hydrographic basin. Ireland presents another, and the Russian area a third. All these are synchronous with one another, though very unlike in the sequence and composition of their subordinate beds. It requires but a very trifling acquaintance with the law of change in the composition of sea-beds to lead to the conclusion that the Mountain Limestone presents the extreme outward depositions of waters charged with calcareous matter; whilst outside and beyond the area thus defined, it will be found to put on characters the significance of all which is equally clear. One definite form ever implies every other modification of sea-bed: in this case the Mountain Limestone serves to mark the *central* portion of an enclosed sea, around which must have been grouped every other gradation of detrital matter up to marginal sand and gravel.

Prof. Phillips was the first to call attention to the change which the Mountain Limestone series undergoes from Derbyshire into Yorkshire, and how also, by taking three distinct sections ranging somewhat S. to N. within the latter county, it could be plainly seen, that the group was constantly parting with its individuality from below upwards, by the substitution of earthy detrital beds for calcareous ones. This process is continued on into Northumberland, where the whole of the Great Scar Limestones become represented by an endless alternation of shales, limestones, sandstones, and coal. Whoever will carefully follow out the process of change presented by the Carboniferous series from our midland counties into Scotland will readily satisfy himself that it must be viewed as a synchronous whole,—that there is no descending order,—and that such a supposition, if fully set forth, implies a set of physical impossibilities, on which, however, we have not space here to enlarge. The Carboniferous series of Berwickshire is not older or inferior to the Mountain Limestone, but is its representative in a zone more nearly subordinate to the terrestrial surface of the time; such are also the calciferous grits of the Mid-Lothian district. The coal-growths alternated with every portion of these depositions, with the exception of those of some extreme depths; but even with respect to these, we see, as in the Boulonnais, that the continuity of the pure Mountain Limestone series was there once interrupted, by its elevation, first into the sand zones of the time, afterwards into subaërial conditions*, followed by a return of that surface to the region of pure marine calcareous deposits.

The area of pure Mountain Limestone has really a somewhat greater extension southwards than as above indicated: this is a consideration of some importance, inasmuch as every portion of this area of sea-bed appears ultimately to have been brought up into those conditions by which it became covered by coal-growths. The line through Belgium must be made to include the district of the Condros, and that known as "entre Sambre et Meuse." The Carboniferous series which thence passes beneath the Cretaceous beds of the N.E. of France is very extensive, and it is obvious that the calcareous mass of Berlaimont, conformably with the structure of the region to the east of it, requires considerable extension and expansion, perhaps equal to that presented in the Meuse section about Dinant; if so, it is not impossible but that some coal-beds may exist in the direction of Loquinol.

Tournay is the most N.W. point at which the Mountain Limestone is exposed in the Belgian district; but, as will be seen by the Map, it has a considerable spread beneath; it was found immediately below the chalk at and north of Lille, and it ranges thence to some point between Cassel and St. Omer†.

The massive character of the Carboniferous series in the Boulonnais, as it passes under the Oolitic deposits, west and south, indicates continuity in those directions: in like manner we may feel sure that the Mendip limestones are continued south and east from Frome; so that the Mountain Limestone area may be safely carried beneath our own S.E. counties across the eastern end of the Channel, and so into Picardy; but as such, it nowhere reappears from beneath the secondary formations round the great depression of the Paris basin.

This mere sketch may perhaps suffice‡; and without troubling ourselves with the progressive changes in the distribution of the areas of land and water during the Middle and later Palæozoic periods, or without overlaying the suggestions of the present communication by the mass of detail by which we may ascertain what the geogra-

* Quart. Journ. Geol. Soc. vol. ix. p. 243.

† See the Memoir of M. d'Archiac, Etudes sur la Formation Crétacée, &c., pp. 118 *et seq.*, in Mémoires de la Soc. Géol. de France, 2 sér. vol. ii.

‡ The object of the present paper is to point out lines along which coal may possibly be met with. The more speculative points will form the subject of an "Inquiry into the Physical Geography of the Palæozoic period," which will shortly be laid before the Geological Society.

phical arrangements of those times were, most of which, however, will be found indicated in the accompanying Map (Pl. I.), the following may be taken as an outline of the geography of Western Europe at that early time.

Outline of the Geography of Western Europe at the Coal-growth Period.

The central gneissic plateau of France was then a terrestrial area, supporting a rich coal-vegetation, with ranges of hills which must have had considerable elevation, and lines of valley of which we can still determine the directions, occupied by lakes and river-courses. The great linear depression of the Rhone had not then been effected. This area extended S. and E., so as to be connected with the old land of the Department of the Var*. Over all this tract there is to be observed a remarkable uniformity in the conditions under which the coal deposits have been formed, as well as in the *drifted* vegetation: it may be characterized as the "upland facies" of the Carboniferous period.

The Coal-measures here occupy depressions, which were such at the time of the coal-growths; the lowest beds consist of distinct subaërial detritus and alluvia, of which all the materials have been derived from the slopes immediately adjacent: the coal-seams, in their great depths, as compared with their extent, indicate the vast periods of uninterrupted growth of vegetable matter, and contrast strongly with the frequent alternations common throughout those deposits, which we know, from the subordinate beds, must have been formed at the sea-level. Lastly, in the peculiar Fern-like forms (*Cyclopteris, Odontopteris*) which so abound in the sedimentary beds and drifted sands of these basins, we have the indications, not of a different period of vegetation, but merely that of the higher regions of the district. Although the Coal-strata are now compressed, by the contractions which have effected the whole of this old central region of France, yet all these distinct features, as to the original arrangements of its surface, are sufficiently distinct. This district is moreover interesting, as it is one of those which ante-dates the period of the carboniferous deposits, and which must have served during that long lapse of time to renew the vegetation over that endless succession of submerged and terrestrial surfaces which the lower levels present.

The extent of this old land must not be estimated by what has been designated above as the Central gneissic plateau, as that is now circumscribed by the secondary group of depositions; because these last have been brought by a process of overlap, and unconformably, over these former terrestrial surfaces: nor must the present character of the surface be taken as a guide as to its original inequalities; for

* Mém. de la Soc. Géol. de France, 2 sér. vol. iii. p. 315; also Explication de la Carte Géologique de France, p. 470.

whether from local elevation, or from climatal conditions, there are certain appearances over the whole which imply that at one time the temperature must have been very low, as glacier-action can alone account for the presence of the large angular blocks which occur in the lowest detrital beds of many of the Southern coal-basins.

This central district of France was continued, and connected by means of the Eastern Pyrenees, with the old land-surface of the Spanish Peninsula.

In the Vosges mountains we find two distinct levels of coal-growth surfaces; one immediately beneath the Vosges sandstone, but unconformable with it, and belonging to the great Coal-measure period, or that of the widest range of terrestrial conditions; the other subordinate to the slate and limestone series there, and not in conformity with the higher group: this last may perhaps be of the age of the anthracitic seams in the Devonian or Eifelian series, in places contiguous to the land-surfaces of that time, as in Devonshire, the Cotentin, and the Boulonnais*.

The present depression between the Vosges and Schwarzwald ranges is of very recent date: anterior to this they constituted one group, which comprised the Odenwald in its extension northwards.

No marine remains have as yet been discovered in the Saarbrück coal group, nor in its extension towards Mayence; whilst the terrestrial forms which it is constantly affording, as well as the aspect of its sedimentary beds, give it all the essential features of an old lacustrine group,—an internal land-locked area,—of which the deposits have been accumulated over the edges of disturbed older Palæozoic strata: it has much of the character belonging to the estuaries or deltas of rivers carrying down great quantities of sand, and the cross-bedding which these beds now present suggests that the current was to the S.W., or that the area opened out into the sea in that direction. The great extension which is now being given to the Coal-measures beneath the plain of Lorraine points to the existence of a belt ranging in one direction towards the Vosges, and in the other towards Luxembourg.

Across the ranges of the Hundsrück and the Ardennes, the great Belgian coal-band presents very different relations to the underlying formations; it is in ascending sequence, offering the fullest and clearest succession of the Rhenane (Devonian) and Carboniferous groups, and resolving itself ultimately into a vast assemblage of earthy sedimentary strata, which alternate almost indefinitely with terrestrial surfaces. The evidence of this stage of conditions is preserved along a trough more than 150 miles in length, and of singularly disproportionate breadth. The abundance of shells of the genus *Unio*, at various levels, and overlying the coal-bands, would seem to give a fresh-water character to the whole series, but for the occasional intercalation of beds containing *Orthocerata, Goniatites, Aviculopecten,* such as occur in our own Yorkshire series, but which in Belgium range from the Alum-shales, or the base of the Coal-measures, at occasional levels, upwards.

* Mémoires pour servir, &c., par MM. Dufrénoy et E. de Beaumont, vol. i.

Combining these features and conditions with those presented by our own Northern, Midland, and Southern Coal-measure series, we arrive at the relative positions of areas of land in various quarters, and which, if taken in conjunction with the extent which has been assigned to the Scandinavian range, define the boundaries of an internal sea, around and occasionally over large parts of which the peculiar vegetation of the time was developed and entombed as the area rose and sank. A region with a central depressed area, such as Australia is supposed to present, and going down, by means of a long series of oscillations, would ultimately present just such an assemblage of deposits as our own Carboniferous group.

B. Axis of Artois.

In the physical topography of the old County of Artois there is a linear ridge, which, commencing at the S.E. extremity of the Boulonnais denudation, extends in a direction S. of Arras (W. 34° N.): its highest points are a little S. of Desire, the hill north of Senlecques, and near the windmill on the road from Boulogne to St. Omer, about two miles beyond the village of Escouilles, which reach nearly 700 feet: thence the line may be drawn by Bellevue, 616 feet, Coupelle Neuve, Crépy, Fiefs, 609 feet, Sains, Tangry, Valhum, Aulin, Orlencourt, 550 feet, to the E. of Tinques, and then S. by Pénin to Grand Rullecourt, 543 feet, the altitudes decreasing from N.W. to S.E.; nor does it cease near Arras, but trends away with a rather more southerly direction towards St. Quentin. On one side, the Lys, the Scarpe, the Scheldt, and other streams take their rise and flow into the North Sea. On the other, the Canche, the Authie, and the Somme discharge into the English Channel. It will also be seen by reference to the map that the physical structure of the whole district as far as the Valley of the Seine is in strict parallelism with the line of Artois.

In 1845, M. d'Archiac, in a memoir already referred to, pointed out the influence which a line, coinciding with that of the axis of Artois, had had on the character and limits of the Middle and Lower Cretaceous deposits. The most remarkable point connected with this axis was noticed by Monnet as far back as 1780*, who showed that along a line which lies a little to the north of the watershed the Chalk had been fissured, so that traces of the old world (Palæozoic strata) were to be seen in apposition with the new, as the Chalk was then considered.

If any relation can be traced between the lines of disturbances and fractures presented by the uppermost strata along the axis of Artois with those which have happened along the same line at times long antecedent to the formation of such overlying strata, and if this repetition can be referred to a necessary law, then the surface-structure throughout such lines becomes a serviceable indication of that of

* Description Minéralogique de la France, Atlas, pl. 3.

the older subjacent series: in this way our own Wealden area, as well as the districts around it, may be made to indicate the arrangement of the Palæozoic strata beneath.

The district of old sedimentary strata which bounds the coal-band of Belgium on the S. from Aix-la-Chapelle westwards gradually subsides and disappears beneath the Cretaceous series of deposits along a line from Valenciennes to Hirson, which runs somewhat transversely to the direction of the old range. This feature is due to a subsidence of post-cretaceous date, for the continuity of the coal-band is in no way affected by it; and, though the symmetrical form and direction of the trough are disturbed at Valenciennes, the phænomena which the workings present there are just such as would be caused by the passage of a line of fracture and flexure. Whoever has examined the line along which the old series disappears from Quievrain south, must feel satisfied that all the folds which it presents in the district "entre Sambre et Meuse" are continued on beneath the Lower Tertiary and the Cretaceous series of the adjoining part of France.

Subsequently to the formation of the folds or undulations here imparted to the Devonian and Carboniferous beds, the surface of the district became worn down, by a process for which it would be difficult to account or explain; and this took place prior to the superposition of the Cretaceous series. This appearance is met with again in the Boulonnais, with this difference only, that the Oolitic deposits there rest on the tabular surfaces of the folded Palæozoic series. English geologists are familiar with a like form of surface, with relation to the Oolitic series about Frome.

The form of the area in which the Carboniferous series was accumulated has already been indicated. The position of the coal-measures on the S. of the Hundsrück, where, in a trough parallel to the chain, they rest unconformably on Devonian or Rhenane strata, shows that the broad series of undulations which, commencing with the Hundsrück, are carried on through the Eifel and the Ardennes, the Condros and down into the Belgian coal-basin, must have had their origin on the S.E. before the commencement of the Carboniferous deposits on the N.W., the consequence of which is that over the French portion of the Carboniferous area its deposits are found resting unconformably. This transgressive passage of the uppermost portions of the Palæozoic group over the lower from N. to S., and which probably determines the condition and age of the beds ranging beneath the great Paris basin, is altogether distinct from the causes which have produced the arrangement of old surface beneath the Chalk axis of Artois.

The valley of the Meuse from Liège west presents a line of fracture, along which beds of the age of the Devonshire shales and limestones are brought to the level of the Coal-measures by great vertical faults, or else narrow ridges of still lower portions of the series are thrust up. It is owing to this that there is that want of uniformity and regular succession on the S. of the Belgian coal-field, which is to be observed on the N. This great line of disturbance can be traced as far as Quievrain, and has been proved by the works of the Valenciennes district. From this place the character of the older strata is only known from the trial-shafts, sinkings, and other works which have been now carried as far as Therouanne, along the course of the coal-trough, beyond which point the existence of productive coal-measures has not been proved. Numerous sinkings have, however, been made over the intervening area, ending with the Artesian well at Calais, where the coal-measures were again met with. An account of many of these sinkings will be found in M. d'Archiac's memoir*, from communications by M. Degousée. The results of these researches will be found recorded on the accompanying Map, and it is evident from these that the Mountain Limestone series westwards from Tournay takes the same expansion that it does eastwards of that place. At Houdain, on the S. side of the basin, older parts of the series are in juxtaposition to the coal, whilst at other places the limestone (either Carboniferous or Eifelian) intervenes, so that we have quite sufficient to warrant the conclusion that the line of fault and disturbance of the Meuse valley is carried on beneath the chalk of Artois, and with like relations to the coal-band. By a careful comparison of the rock-specimens obtained in the researches for coal in the Department of the Pas de Calais, and which are preserved in the offices of the several companies, the subcretaceous arrangement of the Palæozoic groups could be accurately laid down; and such a work would be a most important contribution to Economical Geology.

The character of the disturbance which ranges along the lower side of the Franco-Belgian coal-band is, that where, by means of a vertical fault, the coal-series and some lower portions are brought to the same level, the dimensions of the coal are greatest, and where the older series rises into ridges and anticlinals, the coal-band narrows: this is simply the result of that levelling of the surface before alluded to, which is so remarkable a feature of this line of disturbance, and by which portions have been planed off in exact proportion to the elevation they received: in this way the contraction of the coal-band towards Therouanne is the result of the widening of the anticlinal to the S.W. of that place. Here, on the line of greatest elevations of the axis of Artois, the thickness of the chalk is least; and where the line of abrupt fault is most marked, as from Houdain to Lievin, the mass of overlying tertiary strata is the thickest. *The whole line in its geological features and its structure is in strict agreement with the underlying older surface.*

Another feature which has influenced the contraction of the Carboniferous series in the direction of St. Omer is the rise and expansion of the older Rhenane series south of and beneath the hill of Cassel.

From such considerations we may infer that on the N. limit of the Boulonnais denudation there is a continuation of the Carboniferous and Devonian groups, by means of a great linear disturbance, as they are presented in immediate relation to the great coal-band from Valenciennes by Namur to Liège. *This is the old axis of Artois*; and the date to which the production of this line must be referred is

* Mém. de la Soc. Géol. de France, 2 sér. tom. ii. p. 118 *et seq.*

some time subsequent to the accumulation of the uppermost coal-measures; allowing time too for the accomplishment of all those changes in the beds of vegetable matter, as well as in the associated strata, whereby they became converted into mineral coal and crystalline limestones.

This line of disturbance traversed the district of the coal-growths, from E. to W., from the Boulonnais, far into the mid-European area.

To those who adopt implicitly the notions of M. Elie de Beaumont as to the correspondence between the ages and directions of linear disturbances, and as to the dependence of the obvious physical features of the earth's surface on such disturbances, it would be sufficient that we should here point to the structure of the S.E. portion of England* to satisfy them that it belongs, in all its incidents, to that band of flexures and disturbance which ranges from the Boulonnais eastwards; and the presumption based on such external physical characters would acquire the value of a certainty, when, as at Frome, the great sheet of Carboniferous Limestone, of the age of that exposed in the Boulonnais, is seen to emerge from beneath the Chalk axis with exactly the same relations to the Oolitic group, and having the Coal-measures in convenient proximity to the surface on the N.

The study of the structure of the axis of Artois suggests thus much, that there is a strict coincidence between the disturbances which its oldest and newest sedimentary groups present: this is a subject which might be extended to any length, both from its importance in physical geology, and from the abundance of illustration which this particular line of country affords; enough, however, for the results of the present inquiry will suggest itself to any one who can bring to this study of a good physical map a competent knowledge of the geological structure of the country from the Rhine to the West of England between the 50° and 52° N. lat.

The general law seems to be, that when any band of the earthy crust has been greatly folded or fractured, each subsequent disturbance follows the very same lines,—and that, simply because they are the lines of least resistance.

In this way, marked physical features in any region become unerring guides as to the character and extent of the earliest disturbances which took place there: the sharp axis of Artois is continued across our area by the range of the North Downs and those of Hants. There is this feature to be observed along the whole of this line, that on the north limit of this ridge the beds dip suddenly and rapidly, and hence a line of fractures, extending from near Arras to the E. end of the Boulonnais, and from the N.W. point of the Wealden denudation to the valley of Devizes. This relative depression on the north has preserved the Nummulitic series (Lower Tertiary), just as along the Franco-Belgian line the depression on the north was the cause of the preservation of the great coal-trough. Applying this consideration to the structure of our area from Kent into Somerset,

* See particularly Mr. Hopkins's map in vol. vii. of Trans. Geol. Soc.

we may feel sure that a like arrangement of the older strata runs from the valley of the Thames into that of the Kennet; *along this line the coal-measures may be reasonably supposed to have been preserved.*

Guided by the old surface from the Boulonnais eastwards, it is most probable that the breadth of elevated strata south of the above-named line, presented such a series of folds as is now to be seen "entre Sambre et Meuse" and in the Condros, and that this band was much denuded. In this direction, however, from the Boulonnais W., the Carboniferous Limestone contains a subordinate coal-measure series, and the Devonian group presents a like tendency beneath the Ferques limestone.

To what extent and in what area the denuding process may have extended over the surface of the Palæozoic strata to the S. of the line of Artois, both in France and England, we have but few data even from speculation: nor is the inquiry of much importance, inasmuch as, should the coal-measures be preserved, they could only be reached beneath enormous thicknesses of secondary strata. The most favourable places for investigation would be points on the S. of the Wealden denudation where the transverse valleys cut deep, and where the Lower Greensand is much reduced in thickness locally.

The axis of Artois, though a most important feature in its limited extent, is a portion then of a long line of complicated disturbance extending from the western to the mid-European area, the detailed history of which would be a most valuable contribution to physical geology. In the present communication I have only sought to draw attention to just as much as should show its age, its continuity, and its prominence through long periods subsequent to its first production.

C. Relations of the overlying Secondary Formations.

There are doubtless many areas beneath which the coal-measures of our own country may be fairly presumed to extend, but which could only be reached at such vast depths as forbid the prospect of their ever being rendered available: this consideration suggests the third point in the present inquiry, in which the great groups of the geological scale younger than the coal-measures will be taken in ascending order.

§ 1. *New Red Sandstone. Permian or Triassic.*

An enormous accumulation of conglomerates, sandstones, and clays are interposed between the Palæozoic rocks of the West of England and the lowest beds of the Oolitic group: it may represent in time either the Permian or more probably the Triassic series, or perhaps both. The local character of the conglomerate shows that it was bounded on the W. by a terrestrial area. A like assemblage occurs against the E. slope of the old rocks of the Cotentin and Calvados, and contains much rounded shingle; but it has no great extent, as the Oolite series of Calvados rests immediately on rocks of the Silurian age. No beds referable to either of these formations are to be found beneath the Oolites, from the Boulonnais as far as the valley between the ranges of the Ardennes and the Hundsrück, near Luxembourg. The Triassic group passes E. of the old land-surface, along the valley of the Weser, where it rests on the coal-measures near Osnabruck. Heligoland also presents characteristic Bunter-Sandstein and Muschelkalk. There is therefore a large extent of surface, ranging E. and W., over which beds of this age are entirely wanting. Researches which have been made beneath the Chalk show that it is wanting along a line of twenty-five miles to the N.E. of Marquise; and, as it is absent over the Mendip ridge, we may infer that it stands in like relation to any line which may connect these two points.

§ 2. *Oolitic Series.*

No beds of this age ever appear to have been deposited over an area more than equalling the whole of England in extent, ranging through eighteen degrees of longitude, from the German Ocean eastwards, and with a breadth of four degrees of latitude, if not more; for it is difficult to determine to what extent the German Ocean area was one of dry land at this period.

The Oolites of Yorkshire and Lincolnshire were dependent on a land which lay to the east; and this consideration is of importance, as far as antecedent geographical arrangements affect our present inquiry.

From Tournay to Hirson, no beds of Oolitic age occur between the Palæozoic and Cretaceous formations. At Hirson, deposits are met with which represent imperfectly any of our subdivisions of this series, but which may be taken as the equivalents of the sub-medial portion—from the Lias to the Cornbrash inclusive; the whole being much reduced in thickness, and overlaid unconformably by the Cretaceous group.

In the Boulonnais, which, though more than 100 miles distant, is the nearest point at which the Oolite series again occurs, the lowest beds are seen, as at Leulinghen, resting on Carboniferous Limestone. The Oolitic group, as here exhibited, extends from the Coral rag or Great Oolite up to the Portland beds; for here again, as at Hirson, the grouping of the fossils is not so definite as in our S.W. counties. About Marquise, the oolitic beds set on with all the usual characters of somewhat shallow-water conditions, and on a surface much worked over by perforating animals: in all respects the conditions correspond with those of the Department of the Aisne*, and showing that the Oolitic series was limited and influenced at both places by a pre-existing ridge of old strata. Beds of Oolitic age were wanting beneath the Cretaceous strata in the trial-shafts at Tilloy and Monchy-les-

* D'Archiac, Mém. de la Soc. Géol. de France, tom. v.

Preux, S.E. of Arras. This intermediate point gives an approximate outline for the range of the Oolite series beneath the Chalk of the North of France; and this, it will be seen, is parallel with the present axis of Artois: we hence infer that the limitation of the Oolitic group arose from the same physical barrier along the whole line.

Taking the two extremities of this line, there is this difference to be observed, that whereas on the E. the series commences with the lower and extends to the middle Oolites, on the W. it commences with the middle and is continued to the upper.

In the Boulonnais the Oolitic group is brought up against the old ridge here in question by a process of overlap, a circumstance which indicates contemporary subsidence. On the E. the upper Oolitic beds have been removed as they approach the ridge, and the surface thus produced is overlaid by the lowest beds of the Cretaceous series: or, confining ourselves for the present to the Belgic-French area, it is clear that the destruction of the Oolitic surface commenced on the E. before it did on the W.; thus showing a movement corresponding in order and results with what took place at a subsequent date with respect to the Cretaceous beds.

The original limitation of the Oolitic group, and the subsequent abrasion of some of its beds, were both dependent on a rise of old Palæozoic strata, of which the trend, for one part at least, was in conformity with the line of Artois; but this line, as we have seen, was not then the mere ridge that it is at present,—it became an axis by the subsidence of the tract which extended to the N., and this took place gradually, during the course of more than one subsequent geological period.

The line of the chalk axis of Artois can be prolonged westwards, by means of like phænomena of elevation and fracture, into the district of Bath and Frome: whether this line was throughout dependent on the same early physical features, is a question which must long continue matter of speculation: what is known is this, that the relations of the Oolitic beds to the Mendip anticlinal are just such as have been noticed in the Boulonnais; and further, that the Mendip anticlinal emerges from beneath, and is in continuation of, the great axis of Secondary strata of the South of England.

The littoral limits of the Oolitic series on the N. were dependent on the extent of that area of land-surface which, including portions of Belgium, Holland, and the southern extremity of the German Ocean, became narrower in its extension towards our own area; so that, if we trace an imaginary line which shall fall in with the anticlinal at Frome, it may possibly represent and complete the tract in question; inasmuch as we know that such line represents a zoological boundary—that on either side of which the Oolitic fauna puts on a change: N. of this line the facies is Germanic, to the S. it is Normanic*.

These considerations suggest the probability that the Oolitic series of depositions may be wanting over an area part of which is now

* Morris, Quart. Journ. Geol. Soc. vol. ix. p. 317.

represented by our S.E. counties, and along a line to the N. of the Wealden denudation.

To what extent the Oolitic group may exist beneath the Wealden and Cretaceous groups of Kent, Sussex, and Surrey, is a more difficult question; but, the continuity of the old ridge being granted, we may infer that, relatively as to its breadth, it exercised along our area a like influence to that it had along its continental course, and that, whilst the ascending members of the group were brought up against it by a process of successive overlap, as in the Boulonnais, so also they were abraded and denuded from above downwards, as has happened there. We shall see reasons for assuming that such a condition of surface existed, when noticing the composition of the Lower Cretaceous sand-group.

§ 3. *Wealden Series.*

I suggested in 1850* that the so-called Wealden strata would be found to be referable to two distinct geological periods of time,—the Oolitic and Cretaceous; and, apparently, from the movements which took place in the Western European area at those times, the secondary lacustrine series of the South of England corresponds with the Upper Oolitic and Lower Cretaceous or Neocomian group, whilst to the N. it may be the equivalent of older portions of the Oolitic series.

In the course of an excursion into Belgium in 1852, together with several members of this Society—the late Prof. E. Forbes, Mr. D. Sharpe, Mr. Prestwich, and Mr. Tylor,—we were shown by M. Dumont an old land-surface near Tournay, in an intermediate position between the Carboniferous Limestone and the lowest Cretaceous beds; again, near Mons, we were conducted by Mr. Lambert to a most striking instance of such conditions. Both these localities occur in that area which was dry land during the whole of the Permian, Triassic, and Oolitic periods. The evidence as to age from the contents of these beds has not as yet been worked out.

The lowest strata exposed in our S.E. counties belong to the Secondary lacustrine series; of this, the portion known as Weald clay may be seen on the W., as at Punfield, in Swanage Bay, to alternate with, and therefore be synchronous with, the marine Neocomian group†. No Neocomian beds occur anywhere W. of Punfield whilst Wealden strata do; and, as freshwater formations imply subordination to land-surface, it is clear that the direction in which it lay must have been W. and S. at the time when that subsidence was taking place which brought the Neocomian sea-group into the area of the Wealden lake.

Some beds in the Boulonnais which immediately overlie the Port-

* Quart. Journ. Geol. Soc. vol. vi. p. 467.

† The evidences of this were brought before the Geological Society in 1850, and I gave the fossils to the Jermyn Street Museum, it being the intention of my friend the late Prof. Edward Forbes to have described them in his account of the Purbeck and Wealden deposits.

land Oolite there, and which swarm with an obscure bivalve shell, belong to the Purbeck series, so that the limits of the lacustrine area are defined in this direction.

The occurrence of the Wealden *Unio* (*U. Martini*) through a considerable vertical thickness of the Lower Cretaceous group of the Department of the Haute-Marne points out the relative position of the land at that time; and earlier still there were the Purbeck-Wealden conditions, indicated by the fluvio-marine formation described by M. Cornuel*, and which are a continuation of those to be observed in the Boulonnais. Independently of this agreement between two localities somewhat distant, there is also this, that the deposits of iron-ore, which represent subaërial conditions, exactly agree as to position, so that it is on such considerations that the line of limitation of the Neocomian group has been drawn from the Boulonnais in a S.E. direction.

Some sections near Beauvais, which were particularly examined in 1852 by the Members of the Geological Society above named (p. 66), show an alternation of marine Neocomian with Wealden conditions, such as occurs at Punfield†. In this way the area of Wealden conditions becomes defined; being bounded on one side by the old ridge of the axis of Artois, and its extension to the S.E.; on the opposite side by a land-surface extending from our own western districts towards and across France (Seine Inférieure) in a line parallel with the Pays de Bray. Its northern limit would *à priori* have been defined by the extension of the old axis of Artois; and, if we may take the northern chalk-escarpment of our Wealden denudation to represent the N. limits of that axis, then the Wealden deposits cannot be expected much beyond that line: or the Wealden lake was defined on the N. by the extension of that old land which, as we have shown, existed from early times to the N. of Belgium and Holland. It was the same tract which in part supported the Secondary lacustrine deposits of Hanover.

The place and form of the Wealden Valley become defined, as does also the geological structure of the country around it; and it is thus that a peculiarity in the composition of its beds is satisfactorily explained,—all the Wealden sandstones and conglomerates point to their having been derived from the spoil of crystalline and metamorphic palæozoic strata; and of this character would be all the materials carried down by the streams from the old lands to the N., as well as from those of the Channel area.

The Wealden depression opened seawards on the S.W.

The foregoing observations have reference to the probable abrupt termination of the Wealden group on the N. Such a supposition may perhaps appear unreasonable to those who consider only the great dimensions of this series of depositions; but such, however, is the character of all the old lacustrine and many modern estuarine formations with which we are acquainted: should time suffice for

* Mém. de la Soc. Géol. de France, tom. iv. pp. 229–290.

† Topographie Géognostique du Dép. de l'Oise, par L. Graves; Lyell, Quart. Journ. Geol. Soc. vol. vii. p. lix.

the filling-up of the basin of the Lake of Geneva by the detritus brought down by the Rhone, that limited area would present accumulations which in places would be nearly 1000 feet in thickness.

It is very desirable with reference to the present inquiry that we should know what next underlies the Wealden group at some point near the Chalk-escarpment of Kent. Though the thickness of the Wealden group has been estimated at 1000 feet, such dimensions do not constitute any difficulty;—the elevation of the beds and the emergence of the lowest strata, together with the deep valley-sections of the Wealden area, are conditions which offer many favourable points for such researches.

§ 4. *Cretaceous Series.*

On the eastern end of the axis of Artois, near Bellignies, the Devonian or Eifelian series is overlaid directly by the Tourtia, an accumulation of mid-Cretaceous age, and the fauna of which has been fully described by M. d'Archiac*. This Tourtia everywhere underlies the Chalk along the axis of Artois, as may be seen at each of the small denudations or fractures which the ridge presents; it was found near Arras, and occurs over the whole line of the coal-basin of the Franco-Belgian frontier; it is well seen near Tournay, and was met with at Lille, as also N. of St. Omer. It is a conglomerate of old crystalline and palæozoic rocks, much water-worn, together with a basis which is either argillaceous, sandy, or calcareous, and, as such, is just such an accumulation as would be formed against a subsiding ridge. The peculiar character of its fauna was the consequence of such local conditions. The Neocomian group (Lower Greensand) is altogether wanting over the district here described; and this circumstance, taken in conjunction with the trend of the country towards the Department of the Haute-Marne, before this lower portion is met with, shows that it was an arrangement which was dependent on a physical barrier.

It is possible that some coarse quartzose sands, usually green, which underlie the true fossiliferous Gault clay of the Boulonnais may represent the Lower Greensand of our side of the Channel: the evidence of any included fossils is wanting, and from certain appearances of passage from one condition to the other, I at one time supposed that they were sands of the Gault. These sands thin away against the ridge of Palæozoic rocks, so that they are wanting in many sections, as at Blacourt, where the blue Gault clay fills the inequalities of the limestone surface. A calcareous grit, composed of the detritus of old rocks, underlies the Gault at Wissant; and M. d'Archiac has called attention to the agreement between the lowest Cretaceous beds of the Calais well with those of the Wissant section. If these represent the Lower Greensand, it is here reduced to a thickness of five yards.

The limit of the area of the "Lower Greensand" or Neocomian group is easily traced. It commences at Punfield on the W. in the

* Mém. de la Soc. Géol. de France, t. ii. p. 291.

form of a thin band of limestone, included in dark Wealden shales, with much vegetable matter, and containing a curious assemblage of marine, brackish, and freshwater shells. From this point there is no evidence of the presence of any beds of Lower Greensand along the base of the Chalk-escarpment of Dorsetshire, nor in the Vale of Wardour, nor yet at Warminster; and this arrangement is just what should take place, supposing that the axis of Frome should represent that of Artois, or any of the anticlinals which form part of the same system.

True littoral Lower Greensand shingle occurs near Devizes, and thence on to Calne. The precise age of these beds is that of M. d'Orbigny's Urgonian series, or upper division of the Neocomian group*. I am still of opinion that the weight and the worth of the evidence of the fossils are in favour of the Neocomian age of the Farringdon gravels, and that in their inquiries geologists must be guided by the forms which do not pass up into higher members of the series, rather than by those that do†: if so, the following species determine the question: *Terebratula Celtica, T. oblonga, T. prælonga, T. sella, T. tamarindus, Rhynchonella Gibbsiana, R. parvirostris, Salenia punctata, Goniopygus peltatus, Nucleolites Neocomiensis.* The beds containing these are situated on the N. of the Frome axis, so that it would seem that that line had caused an advancing ridge into the area of the lowest Cretaceous deposits, and produced an irregular boundary-line on the W. From Punfield (Dorset) a line may be drawn passing outside the Isle of Wight, and to the S.W. of the Pays de Bray, beyond which no Lower Greensand occurs. According to a recent discovery by M. Cornuel‡, freshwater shells have been washed into the Neocomian marine beds of Champagne, as has happened at Atherfield, indicating the proximity of land on either side; so that the Neocomian area of the N. of France and S.E. of England resolves itself into a channel, having a main direction at right angles to our present English Channel, and open only at its S.E. extremity, where it communicated with the great expanse of the ocean in which the earlier Neocomian groups of the S. of Europe were deposited. It will be thus seen that the two areas of the Anglo-Gallic Wealden and Neocomian groups are nearly co-terminous; in other words, an area of fresh water, bounded by ranges of land having a main direction of W. 31° N., was, by a process of gradual subsidence, converted into an arm of the great Southern-Europe ocean, and it was on such views that the lines drawn on the Map (pl. I.), were arrived at.

It remains that we should inquire as to the amount of evidence which can be arrived at as to a boundary-line in the North. As in all cases the materials of a detrital-sedimentary group have been derived from coast-line waste, an examination of these, particularly when of the character of coarse sands and conglomerates, will never fail to afford curious results.

* Quart. Journ. Geol. Soc. vol. vi. p. 469.

† See Sharpe, Quart. Journ. Geol. Soc. vol. x., p. 176; and Davidson, 'British Cretaceous Brachiopoda,' (Pal. Soc.) p. 106 *et seq.*

‡ Bull. Soc. Géol. de France, 2nd series, t. xi. p. 47.

The boundary-lines of the Neocomian group are now for the most part concealed: any good geological map will, however, show that it must have been defined in places by members of the Oolitic series, and that on the N.E. it passed transgressively over them. That this position was brought about by a process of overlap is clear from many considerations, the most satisfactory one being that the lowest or argillaceous portion is of limited extent compared with the higher or Urgonian division, and yet the whole of the fauna indicates depths of from seven to ten fathoms of water only. There are sections which show that in places the Lower Greensand of our S.E. counties has a thickness of 800 feet, as between Guildford and Dorking, and the whole of this consisting of quartzose sand or shingle.

The materials which compose the shingle-beds are identical with those of the Farringdon gravels, which have been already described, and I cannot do better therefore than borrow a few lines from that paper:—"The mineral character of the pebbles which compose this gravel suggests considerations of much interest in the history and source of origin of the materials which compose the secondary deposits of this country. The pebbles, as a mass, have been derived from altered sedimentary strata—such as shales converted into flinty slates or hornstone, and which must also have contained great subordinate veins of quartz-rock: water-worn crystals of felspar may also be detected, indicating the loose structure of the mass of felspathic granite, or porphyry, from which they were separated. The mineralogical character of the coast-line whence the materials of the Farringdon gravel were derived is thus clearly indicated, and is one which must necessarily, from the well-known distribution of masses of crystalline rocks, have existed at some considerable distance from the spot to which the gravel has been transported." (Quart. Journ. Geol. Soc. vol. vi. p. 458.) These accumulations rest on Kimmeridge clay and Coral rag; they could only have been produced on a coast-line, and they must have followed that line to their present positions.

If sections be taken at intervals within the Wealden area, as from Farnham to Maidstone, an insight will be got as to the change which the beds of the Lower Greensand undergo from S. to N., and it will then be seen that the subordinate shingle-bands become coarser northwards, so that at the latter place rounded blocks of granite have been met with nearly a foot in diameter. Such a fact as this is of itself sufficient to indicate the direction in which the coast-line of the Lower Greensand lay; and, coupling it with the evidence of its thinning-out and disappearance in the Boulonnais, we are enabled to carry on the line of the old axis of Artois, and to feel sure that, in its passage somewhere to the N. of our Wealden denudation, it presented at the period in question a like physical feature, and exercised the same influence there that it did along its continental course. The Farringdon shingle-beds followed this line of coast, from the old Palæozoic rocks on the E., from which all the materials could be derived.

It was on such considerations that I had defined the limits of the Lower Greensand group, when I received some information from

Mr. Prestwich which confirmed the view I had taken in a most remarkable manner. The boring at Kentish Town, after having been carried through the whole thickness of the Chalk and the Gault, passed to beds of red marl and sandstone, to the exclusion of any beds having the least resemblance to any portion of the Lower Greensand. Since this paper was originally read, the details of the Kentish Town well have been communicated to the Society*. The presence of a coarse conglomerate bed subordinate to the Gault, is a feature wholly at variance with the composition of that deposit round the whole circuit of the Wealden denudation; but that it belongs to the Gault is probable from the presence of a Belemnite very like *Belemnites Listeri*. Considering this conglomerate with reference to the size and mineral character of the rocks it contains, it is a good representative of the calcareous portions of the Tourtia of the Pas de Calais, and of Belgium, and its presence on our side of the Channel shows that the peculiar physical line which, as was shown long since by M. d'Archiac, both defined and caused that local accumulation was extended across into our area†.

The Tourtia conglomerate belongs to the northern slope of the old Palæozoic axis of Artois, and in this way the Kentish Town boring directly solves one of the most important points of this inquiry. Taking the narrow dimensions of the axis of Artois, when compared with the great expanse of the Wealden, with its high anticlinals, it might have been urged that some of these marked the course of the old line of disturbance, and hence the field over which the coal-band might be expected to occur would have been materially enlarged. We can now feel certain that the Kentish Town conglomerate has reference to the same northern slope; that the axis, therefore, passes beneath the range of the North Downs; and that the depression of the Thames Valley represents, and is physically a continuation of, that which, extending from Valenciennes by Douai, Bethune, Therouanne, and thence to Calais, includes the great coal-trough of those countries.

Whatever may have been the original range of the Oolitic group over the area now covered by the Wealden and Cretaceous formations of the S.E. of England, there is evidence that it has been reduced by the abrading action of the Lower Greensand sea along its coast-line. The shingle-beds of the Lower Greensand of Surrey and Kent contain, in addition to the materials already alluded to, a considerable number of extraneous fossils, such as the bones and teeth of Oolitic Saurians, *Ammonites Lamberti* and *A. crenatus* of the Oxford Clay, in great abundance, together with *Terebratula fimbria* and *Rhynchonella oolitica*.

Beds of this Oolitic age are brought up, as we have seen, against the S. slope of the French axis, and hence we see that the coast-line acted on during the Lower Greensand accumulations consisted partly of oolitic and partly of older rocks, and that for a given breadth the

* *Vide supra*, p. 6.

† For the composition of the conglomerate-band passed through by the Kentish Town well, I beg to refer to Mr. Prestwich's paper.

Oolite series is not likely to offer any serious impediment in the way of researches for coal, nor of enquiries as to the structure and arrangement of the rock-series underlying the district bordering on the Thames Valley.

§ 5. *Nummulitic group.*

The axis of Artois has hitherto been viewed (D'Archiac, *l. c.*) with reference to its influence on the characters of the Cretaceous and Nummulitic series, as these are presented both *along* and *on either side* of it; the influence being just such as would be exercised by a great physical limit, and which is indicated both by the composition of the beds as they overlap, and by the included marine fauna: but this influence is far more strongly marked in the Cretaceous series than it is in the Tertiary.

As a general rule, the members of the Nummulitic group thicken away on either side of this axis (to the north and south), thus showing that removal has taken place along the higher portions of the line, over *every* part of which it originally passed. The Chalk strata also thicken away in the same direction; so that, although from the Boulonnais to the province of Hainault the Nummulitic strata are found resting on chalk only, it is on the lower parts of that series and on reduced portions of it that it is seen along the central ridge,—indicating that precisely the same movements, attended by the same results, were repeated along the very same line at two very distinct periods of time;—1st, subsequently to the completion of the Cretaceous series; 2ndly, after the accumulation of the Lower Nummulitic group.

Chalk strata have been largely removed from off the surface of the province of Hainault, and this clearing must have taken place before the Nummulitic period, as beds of that age there overlie the truncated edges of the Chalk, and cover the old Palæozoic series. In the Boulonnais, to the W. of the axis of Artois, although Nummulitic beds come close to the edge of the chalk-escarpment, they are not found *within* that area. Here too the denudation has extended to the whole thickness of the Cretaceous series. This, therefore, has been effected subsequently to the Nummulitic period; although the two periods are so wide apart in time, the amount of removal over the Boulonnais during some post-Nummulitic period corresponds exactly with what was effected at the Belgic extremity of the axis, during the interval between the Cretaceous and Nummulitic groups.

There are many points on which I have not thought it proper to inquire in the preceding pages; of these perhaps the most important is that of the arrangements of the Palæozoic rocks from Therouanne to Calais. We have, however, evidence to warrant the following general inferences:—

1st. That the physical configuration of Western Europe at the close of the Palæozoic period is sufficiently clearly defined to admit of the restoration of the original surfaces which supported the coal-vegetation.

2ndly. That the Permian and Triassic groups indicate the earliest changes which the form of this area experienced.

3rdly. That at an early time a line of disturbed surface was produced, having a general E. and W. direction, and which, traversing a portion of the area of the coal-growths, has placed all the members of that series along its course either at or near the present surface.

4thly. That the physical and geological evidence derived from the S. of England concurs in showing that this area has followed these changes, and been a part of the zone along which all those movements have taken place which have tended to preserve the great Franco-Belgian coal-band and render it available.

The present communication must be considered only as a first attempt; but it is one which, from its economical importance, cannot fail to attract attention in proportion as the extension of productive coal-measures becomes proved from Therouanne eastwards: it will not be deemed too much to say, that we have strong *à-priori* reasons for supposing that *the course of a band of coal-measures coincides with, and may some day be reached, along the line of the valley of the Thames,* whilst some of the deeper-seated coal, as well as certain overlying and limited basins, may occur along and beneath some of the longitudinal folds of the Wealden denudation.

What is now above measure needed is, that we should obtain one single point of verification as to the depth at which any part of the Palæozoic group occurs beneath our S.E. area: the state of the question is such, that from this one single point, once ascertained, the rest of the investigation might be conducted, for practical purposes, with perfect certainty, and it is therefore of importance that the question and its possible results should not be lost sight of by all those who may be promoting deep sinkings at any places over the area which has been here indicated.

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Quetelet, A. Notices extraites de l'Annuaire de l'Observatoire Royal de Bruxelles pour 1855.

————. Sur la relation entre les Températures et la Durée de la Végétation des Plantes.

Renevier, E. Seconde Note sur la Géologie des Alpes Vaudoises.

Report to be presented by the Parliamentary Committee to the British Association, on the question, Whether any measures could be adopted by the Government that would improve the position of Science or its Cultivators in this country. *From the British Association.*

Ricca. Discorso sopra le opere del P. D. Ambrogio Soldani. *From the Accademia dei Fisiocritici di Siena.*

Sandberger, F. Ueber Anoplotheca, eine neue Brachiopoden-Gattung.

Suess, E. Notice sur l'Appareil Brachial des Thécidées. Traduite par M. le Comte de Marschall. Et Observations sur le même sujet, par *M. E. Deslongchamps.*

Tuomey, M., & F. S. Holmes. Fossils of South Carolina, 4°. parts 1 & 2.

Zeisczner, C. Geognostische Schilderung der Gangverhältnisse bei Kotterbach im Zipser Comität.

1048 Volumes of Books, 57 unbound Volumes, and Sundry Maps, Plates, and Pamphlets. *Bequeathed by the late G. B. Greenough, Esq.*

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 5, 1855.

Henry Conybeare, Esq., John Lubbock, Esq., and R. H. Jarvis, Esq., were elected Fellows.

The following Communications were read:—

1. *On the* Tilestones, *or* Downton Sandstones, *in the Neighbourhood of* Kington, *and their Contents.* By R. W. Banks, Esq.

(Communicated by Sir Roderick I. Murchison, V.P.G.S.)

[Plate II.]

On a reference to the Geological Maps of the Ordnance Survey of the Counties of Radnor and Hereford, it will be seen that the line of junction of the Old Red Sandstone with the Ludlow rocks proceeds in a north-easterly direction from the Painscastle Hills to Kington, and thence skirts the range of hills which run in the direction of Shobdon and Richards Castle, to Ludlow. The present notice will be mainly confined to an account of the junction-beds in the neighbourhood of Kington.

At Kington a tongue-like portion of red sandstone runs out northwardly from the general mass to Bradnor Hill. The extreme point of it is marked on the Geological Survey Map as Tilestone. The quarry from which the remains hereafter mentioned were obtained is situated on this spot, between Bradnor Farm and the Quarry House.

The lane which leads from Newton to Bradnor Hill in the direction of the quarry affords a good section of the beds which here immediately underlie the tilestone.

The lowest fossiliferous bed exposed in the lane is the equivalent of the Ludlow bone-bed, here a soft liver-coloured layer, varying from two to three inches in thickness, and containing, generally, *Orthoceras gregarium, O. politum* (M'Coy), *Goniophora cymbæformis, Orthonota amygdalina, Orbicula rugata, Holopella, Chonetes lata, Cornulites serpularius, Cucullella antiqua, Modiolopsis lævis, Rhynchonella nucula*, and *Bellerophon carinatus*, occasionally also the spines of *Leptocheles, Onchus tenuistriatus*, the shagreen of *Sphagodus*, and small shining black pipes and fluted plates which resemble figures 37 to 45, plate 4, of the "Silurian System," in illustration of the contents of the Ludlow bone-bed, and may perhaps be referred to *Serpulites*.

Above this layer, before the tilestone is reached, layers of *Orthonota amygdalina* and *Trochus helicites*, much flattened, occur. The uppermost beds are thin shaly beds of tilestone, containing a *Lingula* of a very small size (probably *Lingula minima*), grouped together in masses, and occasional traces of *Pterygotus*.

In the quarry the beds of stone dip to the east, at an angle of 15°; immediately under the surface-soil a few tilestones are obtained;—next three beds of a bluish-white stone* occur, about 12 feet in thickness, used for wall-stone. These beds of stone are very hard and close-grained, containing but little mica, except in the uppermost layers, and are unfossiliferous.

Between these upper beds and the underlying bed is a greyish layer, varying from three to six inches in thickness, occasionally of a blackish-grey colour, from the quantity of vegetable remains mixed up with it, and containing on the western side of the quarry the remains of Fish (*Pteraspis*) and of *Pterygotus* and other Crustaceans. This layer, when dry, is tough, and the remains are with difficulty removed from it; but, when placed in water, it separates easily, whereever the remains occur, and, if left in water, soon decomposes into mud. It appears to have been just such a muddy sediment, accompanied with sea-weeds, as was suited to Crustaceans. The organic remains in this layer retain their dermal covering, which is often glossy and in a more perfect state than in the underlying beds of Downton sandstone. Small round rusty nodules, sometimes irregular, occur in this layer in abundance, but no *Mollusca*†.

* Neither these, nor the blue portion of the Downton beds hereafter noticed, effervesce with sulphuric acid.

† The nodules appear to be due to vegetable remains. This layer is probably the same as the layer containing remains of carbonized vegetables at the bottom of the Old Red Sandstone of Clun Forest, in the sandy beds above the tilestone at Hagley Park and in the railway-cutting near Flaxley, noticed by Sir R. I. Murchison, "Siluria," pp. 139, 140, 237, 245.

The next bed, which is probably identical with the Downton sandstone, consists of a yellowish-white close-grained sandstone, on the east side of the quarry passing gradually into a blue and still harder stone, which contains occasional traces of *Pterygotus*, but more frequently *Lingula cornea*. The yellow portion of this bed contains throughout *Pterygotus* and Fish (*Pteraspis*) with an occasional *Trochus helicites*; but the remains are not so abundant as in the grey layers and underlying bed. This bed is from 3 to 4 feet thick.

This is followed by a grey layer, similar in composition and contents to the grey layer before noticed. The next, or bottom bed of the quarry is a yellow sandstone of still better quality, capable of being dressed to a very fine surface, and much used in building. It is about 4 feet in thickness. The lowest portion of it consists in many parts of the quarry of large flagstones, from a foot to eighteen inches thick, used for gravestones; these lie on the Ludlow rock, here a very hard unmanageable stone, termed by the quarrymen "greenstone." The *Pterygotus* and Fish-remains occur down to the very bottom; where first appear in considerable abundance the spines of *Leptocheles* *: *Trochus helicites*, much depressed, and the small *Lingula* before noticed, also occur in these lowest portions of the bed.

Before noticing the remains obtained from this quarry, other quarries in the neighbourhood will be referred to in order to show that the same remains occur there in a similar position and under like circumstances.

About a quarter of a mile lower down Bradnor Hill, at Ivy Chimney, is another sandstone quarry. Among the refuse stones of former workings the Fish-heads † (*Pteraspis*, Kner; *Cephalaspis*, Agassiz) occur. The recent workings exhibit micaceous unfossiliferous sandstone, and do not reach the Downton beds. The micaceous beds afford a confirmation of the course of the line of drift, noticed in the "Silurian System," p. 512. A large boulder about a yard in diameter, composed of red and white quartz-pebbles ‡, imbedded in a hard cement, has been excavated and lies in the quarry. Water-worn pebbles, at first sight like granite, of the syenite of Stanner Rocks, are abundant, and limestones, the surfaces of which retain traces of Corals and yet are so calcined as to crumble in the hand, exhibiting when broken the unaltered crystalline limestone of Old Radnor, are also imbedded. All these foreign materials were probably drifted here with the deposits which now form the sandstone beds. A little lower down the hill is another quarry, lying near the Iron-foundry; the bottom beds of yellow stone are exposed. Traces of the grey layer between the beds exist. In the few stones recently raised I found traces of *Pterygotus*, one-half of the head of a *Pteraspis*, and a *Lingula cornea*. Here the

* Imperfect casts of a small bivalved Crustacean also occur here, which Mr. Rupert Jones has recognized as a *Leperditia* and referred with doubt to *L. marginata*, Keyserl. sp. See Ann. N. Hist. for Feb. 1856, p. 95.

† The remains of Fish here referred to are those figured in Pl. II. figs. 1–3. See the appended descriptions of two species, *Pteraspis truncatus* and *P. Banksii*, p. 100.

‡ See the notice of this rock, "Silurian System," p. 314.

conglomerate of red and white quartz, imbedded in the sandstone, again occurs.

The yellow, or Downton beds, are worked in a quarry on the Lodge Farm, in the adjoining parish of Huntington, and contain traces of *Pterygotus* and *Pteraspis truncatus*.

A quarry, now abandoned, was some years since opened on New Barn Farm, Kington, on the sloping ground on the southern side of the Arrow. The surface-soil is not more than four feet above the Ludlow rock. Among the refuse stones I found a portion of *Pterygotus*, in a stone corresponding in composition with the lowest beds at Bradnor Quarry, and *Pteraspides* in a micaceous sandstone. The ground slopes abruptly from the quarry towards the river; and on the slope, some feet below the sandstone, the bone-bed, containing in addition to the *Mollusca* before named, *Theca Forbesii*, is exposed.

The similarity in appearance of the stone, of which the church and many of the houses in New Radnor and its neighbourhood are constructed, with the lowest Bradnor beds, induced me to examine the quarry from which it was obtained. The road to this quarry proceeds from New Radnor to Harley, and then up a narrow valley by the side of one of the streams which run from the Forest of Radnor to the blue flag- or slate-quarry; a steep road here skirts and gradually ascends the hill on the opposite side of the valley. In the last steep ascent, stones containing *Chonetes lata*, *Orthoceras bullatum*, and other common forms of the Upper Ludlow rock, occur on the surface. The sandstone-quarry is situated at a very considerable height, not far from, and to the north-east of, the Trigonometrical Station. It is a mere outlying patch of sandstone, reposing on the Ludlow rocks. The yellow bed of sandstone alone occurs,—from 8 to 9 feet thick, almost free from mica*, and with the surface of the beds coated over with small crystals of quartz. The quarry has not been worked for some years. In the refuse stone, *Pterygotus* and the small *Lingula* occur.

Between Shobdon and Mortimer's Cross on the side of the turnpike-road is a quarry, the lowest beds of which are Downton sandstone, similar in composition with, but rather more of a yellow tint than, the same beds on Radnor Forest and Bradnor Hill. *Lingula cornea* occurs in abundance, with occasional traces of *Pterygotus* in the refuse stone of the Downton beds, the lowest bed of which was not exposed when I visited the quarry. The layer of carbonized vegetables is also present.

At the bottom of the old red sandstones on the right bank of the Teme, near Ludford, and opposite to the Paper Mills, is a thin layer containing carbonized vegetables, lying immediately underneath the old red sandstone and on a bed of bluish-white marl. In this layer Mr. Lightbody and myself found spines of *Leptocheles* and a Fish-bone†, about three inches in length and a quarter of an inch in

* The grains of mica are very minute and apparently enter but little into the composition of these beds.

† Prof. Huxley has examined this, and believes it to be either the jaw or tooth of a Chimæroid ? Fish.

width. The lithological composition of the bed overlying this layer is that of the old red sandstone,—a coarse-grained micaceous grey stone, altogether unlike the tilestone-beds. Above the bone-bed at Ludford we noticed in the tilestone-beds near the surface *Lingula cornea.*

The range of the *Pterygotus* has been shown to extend low in the Ludlow Rocks*. I have met with only one trace of it below the tilestones,—in the shales on the side of the descent of Knill Garraway, which contain *Cardiola interrupta, Graptolithus Ludensis,* and *Orthoceras primævum.* This specimen, viewed with the naked eye, appears nothing more than a black marking of an inch in length; with the aid of the microscope scales of *Pterygotus* appear; but there is nothing to indicate to what part of the animal it belonged. The specimens in my possession prove that the *Pterygotus* was more abundant in the Tilestones than in any of the underlying strata.

The *Pterygotus* of the Tilestones is probably identical with the *Pterygotus* so graphically described by Mr. H. Miller in the eighth chapter of his 'Old Red Sandstone.' It was a lobster-like animal with a flexible tail, composed of several segments and probably terminated by natatory fins. Mr. Miller considers that the terminal flap of the tail was entire; but it is possible that he may have considered as the terminal flap one of the curiously edged segments presenting on the upper and under side a convex surface covered with scale-like markings.

The *Pterygotus* possessed two most distinctive features, which are wanting in *Limulus*: a flexible tail, composed of segments, and a series of regular jaw-feet; while the only species of *Limulus*† known have, as a caudal appendage, a straight pointed stylet without joints, and, in common with many of the *Pœcilopoda*‡, have, as a substitute for jaw-feet, spiny appendages at the base or haunches of the first six pairs of feet.

In the specimens of the joints, which formed the base of the feet of *Pterygotus,* there is no vestige of any such appendage. I think I may therefore venture to differ from the generally received opinion that *Pterygotus* was one of the *Pœcilopoda,* allied to *Limulus* of the Indian Seas.

The illustrations§ accompanying the present notice contain three distinct jaw-feet, with some of their appendages,—joints of some of the first pairs of feet,—fingers of the forceps,—portions of the carapace,—and a few segments of the tail, with the natatory appendages.

* "Siluria," p. 142, 237, 346; Strickland and Salter, Quart. Journ. Geol. Soc. vol. viii. p. 386; Symonds, Edin. New Philos. Journ. April 1855.

† See Cuvier, Le Règne Animal; Les Crustacés, par M. Milne-Edwards; p. 249 *et seq.* and plate 76.

‡ "Mais c'est surtout par l'absence de mandibules et de machoires ordinaires qu'ils (*Pœcilopoda*) s'éloignent de tous les autres Crustacés;" *ibid.* p. 247.

§ Mr. Banks's beautiful drawings of the several portions of *Pterygoti* contained in his collection are not reproduced with this memoir, but have been at his request transferred to the Museum of Practical Geology for the illustration of the description of *Pterygotus* which is intended to be published in the Memoirs of that Institution.—Ed. Q. J.

The remains of ***Pteraspides*** before referred to are, I believe, undescribed. There are two species, differing essentially in form, although nearly allied in structure. Both possess under the outer dermal covering the granular texture, on the existence of which M. Agassiz * laid so much stress in pronouncing his opinion on the head of *Cephalaspis Lloydii*; but instead of granules, resting on laminæ, the lower end of each of the granules fits into an irregular hexagon (Pl. II. fig. 2 *c*). In addition, the bony enamel of the Old Red fish is wholly wanting. Both had a dermal covering, marked with very distinct longitudinal striæ †, which in most of the specimens has wholly or partially disappeared.

Many of the specimens from the Tilestone are in a state of disintegration ; the granules lie separated on the surface, and the hexagons, thus exposed, are visible to the naked eye. To use Mr. Miller's description in reference to *Cheiracanthus* and *Diplacanthus*,—"The cranium seems to have been covered, as in the Shark family, by skin, and the skin by minute shagreen-like scales; and all of the interior cerebral framework which appears underneath exists simply as faint impressions of an undivided body, covered by what seems to be osseous points,—bony molecules, it is probable, which were encrusted in the cartilage ‡."

The most prominent features of the species illustrated by Pl. II. fig. 2. are a round snout, followed by a sharp projection on either side, with horns attached to the sides of the posterior part of the head. The striæ of the horns are almost regularly parallel and so continue, though with less regularity, over the sharp projections and round the snout. On the upper, or raised portion of the head, the striæ proceed from the ridge in somewhat curved longitudinal lines, every fourth one of which is larger and more prominent than the others, until they meet in the centre above the snout. On the underside of the sharp projections before referred to are protuberances which seem to be projecting horny eyes, similar to those of crustaceans.

The other species (Pl. II. fig. 1) has an almost square, slightly incurved snout, without lateral horns, or trace of eyes; the striæ are less regular, and there is an indication of an upper jaw. For other details I must refer to the drawings and the specimens, which accompany this notice.

These fossils occur in places in considerable abundance. Like the ***Pterygotus***, with which they are often found in juxtaposition, they appear to have congregated in masses and to have frequented the same haunts.

Of another specimen, which occupies a doubtful place between the Crustaceans and Fish, I must defer an account until I can furnish an accurate illustration of it. The portion I have found is

* See 'The Silurian System,' p. 595.

† Such longitudinal striæ are visible on the head of *Cephalaspis Lloydii* in the Museum at Ludlow.

‡ Footprints of the Creator, p. 43.

about two or three inches in length. The surface appears to be covered with shagreen, with an underlayer of minute closely-set circular hollows, which traverse the surface with the greatest regularity.

A specimen of a Crustacean, probably a species of *Eurypterus*, was found in the grey layer before noticed (see Pl. II. fig. 4); it is very imperfect; the trace of the dermal covering is slight, and the posterior segments, which would throw a greater light on its proper position, are wanting. The posterior portion of the head, at the junction with the thorax, is bounded by an almost straight line, of an equal width with the bands, which are entire from side to side and without any longitudinal depression. Mr. Salter proposes to name it *E. pygmæus*. One specimen which I lately found had a distinct swimming-foot on the left side, resembling those figured by various authors who have written on the genus.

I have figured also some specimens of the Crustacean named *Himantopterus Banksii* by Mr. Salter*. The species is not uncommon in the Kington beds, and is represented by detached heads (Pl. II. figs. 5 *a*, 5 *b*, 5 *c*), body-rings (figs. 5 *d*, 5 *e*), and spines (fig. 6), which are very possibly the caudal spines.

It is very probable that traces of the same remains will be found to exist wherever the Downton sandstone (or tilestones) occurs and is regularly quarried, but the continued working of the Bradnor Quarry has afforded unusual means of investigation. In a quarry abandoned, or where the strata are merely exposed, there is necessarily but little opportunity of learning the contents of the beds; for in many portions of the tilestone beds an occasional slight marking is the only indication of the existence of these remains, while in other portions they occur congregated together in great abundance.

Adopting the test made use of by M. Alcide d'Orbigny † in order to ascertain whether these beds belong to the Old Red Sandstone, as was originally considered by Sir R. Murchison, or to the Ludlow Rocks,—the absence of the Mollusca of the Ludlow Rocks and the presence of Fishes and Crustaceans, which have never been found in the Ludlow Rock, and the greater development of *Pterygotus*, which occurs in Scotland in the middle beds of the Old Red Sandstone ‡, lead to the conclusion that these Downton, or Tilestone beds, should be considered as separate from the beds in which the Molluscs of the Upper Ludlow rock occur, and be classed as the bottom beds of the Old Red Sandstone.

Doubtful as it is whether the buckler-like fossil remains above referred to belonged to Fishes or to Crustaceans, it is certain that

* Quart. Journ. Geol. Soc. No. 45. p. 32.

† Cours élémentaire de Paléontologie, vol. ii. pp. 245, 256. Caractères stratigraphiques négatifs, § 1598. Car. strat. positifs, § 1598. Des exceptions aux limites des faunes géologiques, §§ 1605—1609.

‡ See Miller's 'Old Red Sandstone,' 5th edit. p. 177–179.

they are closely allied to *Cephalaspis Lloydii* and *C. Lewisii*. This fact will probably be sufficient to remove all doubt that the beds in which they occur form part of the Old Red Sandstone.

Traces of these remains have been recently found in the tilestone beds at Northfield, Shobdon, by the Rev. J. F. Crouch, President of the Woolhope Field Club.

Appendix.

Prof. Huxley and Mr. Salter have carefully examined the cephalic bucklers referred to above, and have compared them with the remains of previously described species; and Prof. Huxley is now minutely examining their structure in order to determine their true relationship, either to Crustaceans or to Fishes. In the meantime, and until we may hope for a complete account of these fossils, I have been favoured by the above gentlemen with short descriptions of the two figured species, which are easily distinguishable from those found in the Cornstones of the Old Red Sandstone.

"Pteraspis, Kner*, 1847.

As it is evident,—whether these shields be eventually referred to Fish, as suggested by Agassiz, or to Crustaceans, to which opinion some naturalists incline,—that they must be separated generically from the broad cornuted heads of *Cephalaspis Lyellii*, we cannot do better than adopt the name suggested by Dr. R. Kner.

The characters of the two new species may stand as follows:—

Pteraspis truncatus, Huxley and Salter.

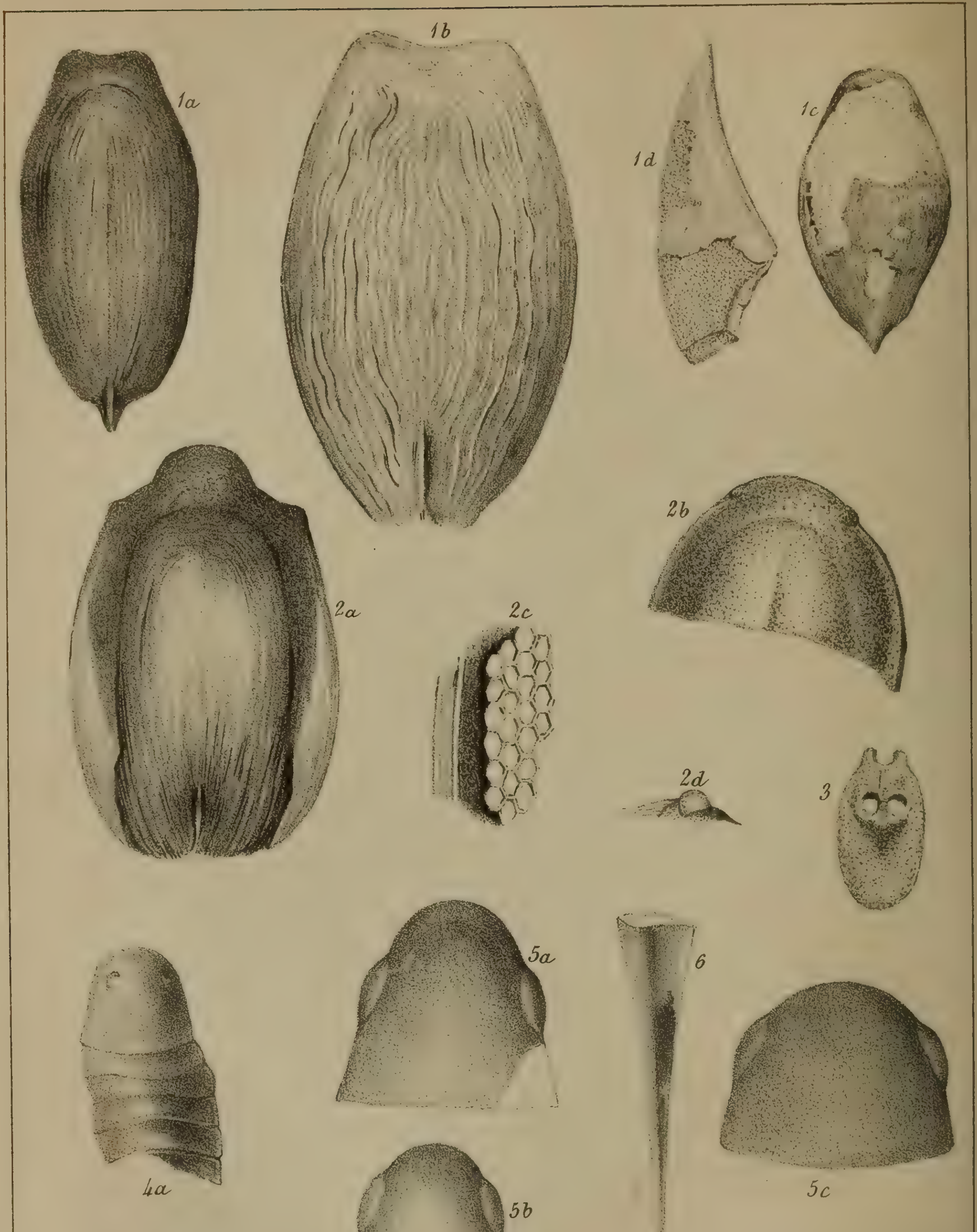
P. capite elongato, ovato, regulariter convexo, anticè truncato vel emarginato, posticè contracto, gibbo, carinato, brevispinoso: superficie lineis undosis longitudinalibus distinctis tenuissimè interstriatis.

Pteraspis Banksii, Huxley and Salter.

P. capite latè elliptico subdepresso, posticè truncato carinato brevispinoso, anticè contracto, et utroque tuberculo marginali; lateribus planis et quasi alatis: superficie striis tenuissimis costulisque ornatâ, et ante medium capitis tuberculis 9–11 clavatis è lineâ medianâ radiantibus.

There is another species, very like the *P. truncatus*, in the Upper Ludlow Rock, lately discovered by the geologists at Ludlow. It will be described hereafter."

* Ueber die beiden Arten Cephalaspis Lloydii und Lewisii, Agassiz, und einige diesen zunächst stehenden Schalenreste: Haidinger's Naturw. Abhandl. vol. i. p. 159, pl. 5.



R.W.B. del. C.R.Bone, lith.

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FOSSILS FROM THE TILESTONES
of Kington.

EXPLANATION OF PLATE II.

Fig. 1. *Pteraspis truncatus*, Huxley and Salter.

1 *a*. Cephalic buckler, or head, showing the upper surface; natural size.

1 *b*. Cephalic buckler, or head, showing the upper surface; enlarged one-half, to show the striæ.

1 *c*. Cephalic buckler of another specimen (natural size); the greater part of the surface has been destroyed; the striæ remaining in parts, and elsewhere the granular layer visible.

1 *d*. Profile of part of a head: the granular layer is seen, and in parts the striated dermal covering also.

Fig. 2. *Pteraspis Banksii*, Huxley and Salter.

2 *a*. Natural cast of the interior of a cephalic buckler; natural size.

2 *b*. Portion of the anterior part of a cephalic buckler; natural size: the upper striated layer has been worn away.

2 *c*. Fragment of buckler, highly magnified; showing the constituent layers.

2 *d*. Eye-like marginal protuberance,—one of these is situated on each side of the anterior projection of the buckler.

Fig. 3. Portion of a head, similar in structure to the others, but imperfect; natural size. Only one specimen has been found. From the grey layer.

Fig. 4. *Eurypterus pygmæus*, Salter.

4 *a*. The head and five of the body-rings (Mus. Banks).

4 *b*. The head of another specimen (Mus. Geol. Survey).

Figs. 5 & 6. *Himantopterus Banksii*, Salter (Mus. Banks and Geol. Survey).

5 *a*, 5 *b*, 5 *c*. Heads of different individuals.

5 *d*, 5 *e*. Body-rings of different individuals.

6. Probably a caudal spine of an individual belonging to this species.

2. *On the* Last Elevation *of the* Alps; *with* Notices *of the* Heights *at which the* Sea *has left* Traces *of its* Action *on their* Sides. By Daniel Sharpe, Esq., F.R.S., F.G.S. &c.

[Contents.]

Introduction.—In the following pages I have attempted to show, that, after the Alps had assumed their present form, and when they already stood as much above the surrounding lowlands as at present, they must have been nearly submerged below the sea, out of which their rise must have been, by a series of steps or starts of unequal amount, separated by long intervals of time. The evidence on which these views rest is derived from three sources; 1st, from the traces of erosion on the sides of the mountains, ending upwards in lines of uniform level; 2ndly, from the levels to which the valleys have been excavated; 3rdly, from the elevation of the terraces of alluvium in the valleys; and lastly, from the harmony of the results obtained from these three sets of observations, when compared together*.

Traces of Erosion on the Sides of the Mountains.

In reading Prof. James Forbes's interesting description of Norway, I was much struck with his remarks on the frequent occurrence of rugged and precipitous mountain-ranges rising, at the same elevation, from a comparative level of gentle undulations destitute of angular prominences, where this change of form cannot be due to different powers of resistance in the rocks, which are of the same character both above and below the changes. Prof. Forbes states that, "as a general rule, the surfaces of erosion (whether produced by glaciers or otherwise) have a tolerably definite superior limit, as in the Alps, only here [in Norway] at somewhere about 1500 to 2000 feet above the

* Mr. R. Chambers has brought forward evidence, in some respects similar, to prove that Great Britain was submerged beneath the sea during the Pleistocene period; 'Ancient Sea Margins,' 1848.

sea, instead of 7000 or 8000, as in Switzerland." After referring to an observation of M. Agassiz, that "the limit of the surfaces of friction coincide with the levels of ancient glaciers, above which only the peaks of the higher mountains stood forth bare, or merely snow-covered, but free from the abrading influence of moving ice," and adding some remarks too long to quote, the author concludes,—"adopting hypothetically, then, the theory of glaciers to account for the singular configuration of the Norwegian rocks, it fits so far well in its different parts as to explain plausibly the phænomena; and whether correct or not, the analogy, on a great scale, of the line of demarcation of the rugged summits and the abraded slopes of the Norwegian and Swiss Alps, inclines us strongly to adopt a common theory in explaining both*."

In rambling over the Swiss Alps with Prof. Forbes's remarks in my mind, one of the subjects to which my attention was directed was the much-disputed question of the extent to which glaciers had formerly reached; and it was with this object in view that I first paid attention to the upper limit of the erosion of the mountains; but, as all my observations led me to limit the action of ancient glaciers to a degree which did not allow of considering them as the agents which had produced the surfaces of erosion described, I was driven to look elsewhere for an explanation. The traces of ancient glaciers seemed to me to be confined to the valleys, and only to reach between 1000 and 3000 feet below the present glaciers†; but the traces of erosion, up to a definite line, are seen not only on the higher snow-capped mountains, but on detached hills in advance of the great chain, such as the Mythen of Schwytz, and the hills which enclose the Lake of Thun, which have their flanks rounded up to the height of 4700 or 4800 feet above the sea. For glaciers to reach to those heights would require a sheet of ice 3000 feet thick descending from the whole extent of the Alps, and covering to nearly that height the plain between the Alps and the Jura; a supposition once thrown out by M. Agassiz ('Etudes, &c.,' p. 304), but which found so little favour that it is not now worth combating.

Moreover, though moving ice rounds away the projections on the sides of the rocks with which it comes in contact, it is nowhere seen to scoop out hollows in their sides. As soon as the surface of the rocks has become polished, the ice can produce very little farther effect upon them; its action tends to produce a uniform surface, not an indented one.

The action of water next suggested itself as the cause of the phænomena in question: if the sea had stood for a long period at the

* 'Norway and its Glaciers visited in 1851, by James D. Forbes,' pp. 58 & 59; and plate 2, which represents the mountains near the Folden Fiord, in illustration of the above remarks.

† Many of the Swiss geologists are disposed to extend the ancient glaciers much farther; but they build their conclusions on the evidence of erratic blocks, which belong to another set of operations of a period preceding that of the ancient moraines.

level of the upper limit of the erosion, it would have produced a marked indentation round the mountains, such as was under consideration; and as the mountains gradually rose out of the waters, they would have had their flanks worn into rounded slopes; and occasionally again indented by another line of erosion, whenever their elevation was arrested and the waves continued to beat for a long period against their flanks at another level*.

I had already observed several such lines of erosion in the Alps at different levels, and I soon met with a complete confirmation of their marking the levels of the ocean at their respective periods, in finding that they corresponded in height with the levels of the action of water shown in the excavation of many valleys. The inquiry now assumed a new interest, and I regretted that, not having seen its full importance at the outset, I had let slip many opportunities of making observations which would have been valuable. For, if by such observations we can mark the successive stages at which the mountains rested on their rising out of the ocean, we may hope to throw light on some most difficult problems of geological inquiry connected with the elevation of mountain chains: we shall see how far that elevation was sudden or gradual; whether the mountains of one chain were raised up together, or separately; and whether the different parts of the chains were equally elevated. I am far from undertaking to answer all these inquiries at present: I shall be satisfied if, in calling attention to a field of inquiry applicable to other countries as well as to the Alps, I have illustrated the subject sufficiently to lead to a due appreciation of its importance†.

* See R. Chambers, 'Ancient Sea Margins,' pp. 183–189, describing the Lines of Erosion on the Eildon Hills.

† The views of M. Agassiz on this subject will be found in his notes "On the Glacial Theory and its recent progress," in the Edinburgh New Phil. Journ. vol. xxxiii. pp. 232, 233; they have also been published by M. Desor in the 'Bibliothèque Univ. de Genève' for March and April 1841, under the title "Sur le niveau des Roches polies et sur les conséquences qu'on peut en tirer;" and again at p. 15 of an account of an ascent of the Shreckhorn in the 'Revue Suisse' for June 1843. M. Agassiz states in the first-mentioned paper that "in Switzerland there exists a limit at about 9000 French feet (9589 English feet) above which the summits are no longer polished, but where the rugged peaks present a very striking contrast to the lower surfaces, which are polished or at least *moutonnés*. In the exterior chains of the Alps, the polishing does not reach to a greater height than 6000 or 7000 feet (6393 or 7460 English feet). It cannot be doubted that this limit, which is so well marked, indicates the level of the bed of ice at the epoch of its greatest thickness."

M. Desor informs us that on the sides of the Seidelhorn the rocks are polished to the height of nearly 8000 feet (8524 English feet), being about 200 feet above the present level of the Glacier of the Finsteraar; from which he concludes that the upper limit of the polished rocks indicates also the upper ancient limit of the glacier. On the sides of the Schreckhorn the polished rocks rise, as you ascend the valley, until they are lost under the snow at an elevation of nearly 9000 feet (9589 English feet), which he regards as the highest limit of polished rocks.

M. Desor's remarks appear to apply entirely to the polishing of the surface of rocks by the friction of glaciers; with which subject I have nothing to do at present. But M. Agassiz appears to confound together the superficial polishing by glaciers and the deep erosion which has altered the forms of the mountains and

The contrast between the rounded and the rugged portions of the mountains is best seen in the gneiss, where its foliation dips at a high angle. Among the stratified rocks, there is often a difficulty of distinguishing the flat surfaces of the beds from those produced by subsequent abrasion.

The accompanying woodcuts (figs. 1 and 2), taken from drawings which Mr. Ruskin has had the kindness to lend me, will illustrate this feature in the form of the Swiss mountains better than any description; and they show us also that it attracts the notice of the artist as well as of the geologist. The first drawing (fig. 1) is a view

Fig. 1.—*The Chain of Mont Blanc, as seen from the Valley of Chamounix.*

E, E, indicate the line of erosion.

of the Chain of Mont Blanc looking up the valley of Chamounix. In this view the definite level at which the rugged peaks all rise from the lower rounded shoulders of the chain is well seen, that level being at about 9000 feet above the sea. The second (fig. 2) is a drawing of the Matterhorn, or Mont Cervin, taken from the Riffelberg, in which the same contrast is most strongly marked. I have not ascertained the exact height of the base of the Matterhorn, which is above

worn away large portions of their sides. Prof. Forbes, on the contrary, though alluding hypothetically to glaciers, really describes the erosion which I ascribe to the waves of the sea.

It will be remarked that M. Agassiz notices two lines of erosion at different levels in different parts of the Alps.

The contrast between the rugged peaks of the Alpine mountains and the rounded shoulders from which they rise, had previously attracted the attention of M. Hugi, who accounts for it by dividing granite into two mineral classes,—1st, *true granite*, which forms rounded masses; and 2ndly, *halb-granit*, which forms rugged peaks ('Alpenreise,' p. 55); but he gives no mineralogical distinction between the rocks, and no subsequent observers have been able to detect a difference between them. The change of outline between the upper and lower parts of the same mountains is shown in Hugi's plates 8, 9, 12, and 13.

Fig. 2.—*The Matterhorn, as seen from the Riffelberg.*

E, E, indicate the line of erosion.

9000 feet; there is a thick covering of snow round it, which conceals the line of erosion and makes it appear to be higher than it really is.

There is no distinct lower limit to the abraded or rounded portion of the mountains, but the upper limit of the abrasion is usually well marked by a change in the outline of the hill-sides from a moderate to a steeper slope, similar to the indentation produced on a coast by the waves beating against a cliff*. The nearly uniform height of this re-entering angle produces a tolerably level line round the mountains, which I shall speak of as the *line of erosion*. It is best seen when the observer is at a distance, or, if near, is only a few hundred feet below it, when a horizontal line may often be traced by the eye round every one of the mountain-tops within its reach; this is nowhere more remarkable than in the view from the top of the Splugen Pass. When standing on the level of the line of erosion, it is often more difficult for the eye to follow it; slight inequalities in the ground which are near at hand concealing or interfering with the view. This makes it difficult to measure the height of the erosion within 100 or 200 feet, even under favourable circumstances. But there are spots free from this difficulty: whoever has ascended from Zermatt to the Riffelberg must remember the distinctness with which the conical Riffelhorn rises from the flat at the top of the rounded Riffelberg: the line of erosion is there as well marked as at the foot of a sea-cliff, being (by my aneroid) between 9000 and 9100 feet above the sea.

When the observer is more than 1000 feet below the line, it will require a practised eye to estimate its height within 500 feet; and the result will be merely a rough guess, which will usually prove to be below the truth. In the following statements I have pointed out those measurements which are most to be relied on; but in general,

* Some excellent profiles of cliffs and beaches have been given by Mr. Godwin-Austen, Quart. Journ. Geol. Soc., vol. vii. pp. 118, 120, and 124.

I feel that my best observations may, with one or two exceptions, be 100 or perhaps 200 feet wrong, while the worst can, I think, never have an error exceeding 500 feet. The admission of the probability of such errors may stagger the faith of my readers, but the want of absolute accuracy will be found to be compensated by the number of observations which harmonize sufficiently to restore confidence in them.

There are many mountains in the Alps on which I failed to trace any distinct line of erosion: but, when we recollect how long a period has elapsed since the ocean reached to the flanks of the Alps, during which time the surface of the rocks has been crumbling away from the action of the atmosphere, I think it more remarkable that the sea-levels are still to be traced at all on their sides, than that these traces should have been frequently obliterated.

In pointing out the various lines of erosion which I was able to trace on the sides of the Alps, I will begin with the highest, and describe them in order from above downwards. The heights are all reduced to English feet.

First Line of Erosion, 9000 *to* 9300 *feet above the sea.*—In taking a general view of Mont Blanc from the Croix de Flegère, I estimated the line of erosion to be above 9000 feet. From the Col de Balme, I estimated it at somewhat above 9000 feet; and from the Col de la Seigne, which, being higher, brought me within a distance in which the eye may be trusted, I placed it between 8900 and 9400 feet. The average between these observations is about 9000 feet.

On the Riffelberg, a good observation already mentioned, p. 106, fixed the line of erosion at between 9000 and 9100 feet.

The top of the Stilvio Pass, 2814 metres above the sea, is about 200 feet above the upper limit of erosion, which gives us 9000 feet for the height of the line of erosion: this measure may be trusted, as in ascending to above the line I had a good opportunity of noting it with tolerable accuracy. The rocks are limestone and dolomite, belonging to the triassic series.

In all the three districts mentioned above, the effects of the erosion are very strongly marked on the sides of the mountains, producing a deeply indented line round them; this indentation represents the amount of rock which has been removed by the waves, and proves to us the great length of time that the sea must have stood at the level in question.

A second and less-strongly marked line of erosion may be traced round the lower shoulders of the Mont Blanc Range, a little above the Col de Balme: I did not find it sufficiently well defined to note its altitude accurately; but it probably coincides with the Second Line which I am about to mention.

Second Line of Erosion, about 7500 *feet above the sea.*—This line may be traced over a great part of the centre of Switzerland, as strongly marked on the mountain sides as the First Line, and indicating an equally long period of the action of the waves at its level. It attracted the attention of Professor J. Forbes, and led to his remark, already quoted, that the upper limit of erosion in the Alps was between 7000 and 8000 feet above the sea. The following are the places where I noted it.

On crossing both the Scheideck and the Wängen Alp, the line of erosion is well seen at about 7500 ; in both these cases this line may be observed on the nummulitic, as well as on the older rocks.

In the ranges of the Hochwang and the Casanna, between Chur and Klosters, which consist entirely of flysch, a rough estimate gave me about the same height of 7500 feet for the line of erosion; and in the Klausen Pass, between Linththal and Altdorf, I noticed the line at about the same height on the jurassic, nummulitic, and flysch rocks.

From the top of the Splugen the line may be very well traced round all the neighbouring mountains; it is about 500 feet above the Pass, or 7500 feet above the sea: it nearly corresponds to the upper limit of the stratified slate-rocks of the neighbourhood, the geological age of which is undetermined.

In the Lukmanier Pass (6338 feet) and in the Pass of the Oberalp from Andermatt to the head of the Rhine (6580 feet), the erosion reached to so great a height above the Pass, that I could not estimate its upper limit accurately: in both instances the line was somewhat above the highest jurassic rocks.

On the sides of the upper and middle parts of the Lake of Como only a few tips of the highest hills of gneiss rise above the line of erosion: as the highest hardly reach 8000 feet, the line must be about 7500 feet high.

Third Line of Erosion, about 4800 *feet above the sea.*—The two Mythen behind the town of Schwyz, consisting of cretaceous limestone, afford an excellent example of the contrast between the rough steep peaks above the erosion and the rounded shoulders below: the pass between the two hills is 4726 feet above the sea, and is a little below the line of erosion, which may be taken at about 4800 feet.

On the sides of the Rigi (nagelfluh) and Mount Pilatus (cretaceous), the erosion ends at about the same height: but I did not get any accurate measurements.

The hills on both sides of the Lake of Thun rise above a line of erosion, which, judging from their height, must nearly correspond with that on the Mythen.

Many of the limestone hills round the foot of the Lake of Como have their highest points a little above a line of erosion; as only a few of them rise a little above 5000 feet, so this line must here nearly correspond with that on the north flank of the Alps at 4800 feet above the sea.

General results of the preceding observations.—I have thus pointed out three equally distinct and level lines of erosion to be traced on the sides of the Alps at about 9000, 7500, and 4800 English feet above the sea, marking three long periods of rest in the elevation of this great group of mountains, at each of which only so much of the mountains as rises above this respective line then stood out of the waters: at the earliest of these periods the Alps formed merely a cluster of small islands, with nearly precipitous sides dipping at once into very deep water, and surrounded by an open ocean, the highest being 6750 feet above the sea. At the second period there were a few large islands, rising to above 7000 and 8000 feet, separated by narrow channels, with deeply indented shores, surrounded by a deep sea, and forming a group somewhat resembling the Hebrides. At the third period the group would have more resembled the north of Scotland, forming a long narrow island, indented with deep friths, but with its highest peaks 10,000 and 11,000 feet above the sea, and therefore probably capped with snow.

It is probable that a closer examination would find other lines of erosion, intermediate between the three here noted; but, if they exist, they are far less marked, and consequently less important than the three lines here described. They may also perhaps be found below my lowest line; but it will require great care in tracing them; for, as we descend below that level, the vegetation interferes more and more with our observations, and cultivation often modifies the ground; besides which, the lower heights lie principally among stratified rocks, whose forms are as much due to the horizontality or inclination of their strata as to subsequent erosion.

As the two lower lines of erosion have been traced equally across the eocene and all the older formations, I think it is evident that these erosions took place at a late period,—probably after all the strata of Switzerland (except the drift) lay in their present positions relatively to one another: and there are no circumstances connected with the uppermost line to lead us to place it before the same period: the change indicated by these observations is the elevation of the whole country out of the sea, as has been going on for several centuries in Sweden and Norway.

This elevation seems to have been very uniform over the whole of Switzerland; or, if it has been greater at one end of the country than the other, the difference must be very trifling; my observations give a uniform level to the lines of erosion for about ninety miles from N. to S., and a very near approach to uniformity from E. to W. for nearly 200 miles. And, as stated at starting, I think that the error in their general results cannot amount to 200 feet.

The amount of degradation which the Alps have undergone during the periods here referred to seems to correspond with the enormous accumulation of rolled detritus collected on their flanks. The area of the great valley of Switzerland between the Alps and the Jura is not very different in extent from the area of that portion of the Alps of which the detritus would be carried northwards. I do not know whether any one has made an estimate of the average thickness of the deposit of rolled detritus throughout that valley, which I should estimate at several hundred feet. This therefore shows the abstraction of the same thickness of matter from the whole of the Alps, or of a much greater thickness from the more limited area exposed to the reach of the waves during their elevation.

In the higher valleys, both in Switzerland and in the mountainous parts of Great Britain, I have often been struck with the great accumulations of rounded blocks and pebbles in places where there were no torrents which could be supposed to have rounded them or brought them to their present position. I particularly noticed a very large collection of such blocks near the top of the Splugen on ascending from the north, where there were no lateral valleys down which they could have been brought: they lay very thick at the elevation of about 6000 to 6500 feet, reaching nearly to the top of the Pass, covering the sides and filling up the bottom of the valley in irregular hillocks, without forming any regular terrace, such as we see at lower levels. These accumulations are doubtlessly formed out of the destruction of the beaches of these early oceans, which, owing to the steepness of the sides of the mountains, have been carried by the slipping of the snow and by the gradual action of the weather to the first resting-place below the level at which they were formed.

Lines of Water-level traceable in the Excavation of Valleys.

In ascending any alpine valley, we usually find the ascent tolerably gradual until, on reaching the head of the valley, the ascent suddenly becomes steep, and we have to climb some winding or fatiguing path for a considerable height; after this we often find ourselves in another upper valley, which, like the lower one, is but moderately inclined until we reach its head, where a second steep ascent must be climbed on to another higher level. The valley of the Engadin is an example of such a structure; from Martinsbruck we ascend the Inn gradually to Zernetz, situated at the head of the lower Engadin, 4910 feet above the sea; we then ascend rapidly about 250 feet on to the level of the upper Engadin; then for nearly thirty miles the ascent is so slight as to be imperceptible to the eye, until above the lake of Sils, at an elevation of 5900 feet, we again find a steep ascent to the Pass of Maloggia.

More frequently we find lateral valleys at a different level from the main valley, into which they empty themselves by a cascade: thus the valley of Linththal rises very gently to and ends abruptly at an elevation of 2500 feet; but, if we climb a steep zigzag path by the side of the falls of the Fätschbach, we come about 2000 feet above the Linth to the level valley of Urnerboden, which ends, at a height of 4700 feet, at the precipitous ascent to the Klausen Pass.

A more familiar illustration may be found in the Valley of Chamounix, which rises gently to the village of Le Tour, 4274 feet above the sea; a little above this commences the ascent to the Col de Balme. But the lateral valley of the Mer de Glâce ends some 1700 feet higher than the Valley of Chamounix; the glacier then rises moderately; from its termination below the Montanvert there is a gradual ascent to a height of above 9000 feet at the head of the branch called the Glacier de Lechaud *. The head of the Glacier

* These heights are taken from Prof. Forbes's 'Travels,' &c., chap. i. 6.

de Talèfre, in which the Jardin stands, is also more than 9000 feet above the sea. But the ice prevents our ascertaining with any accuracy the exact height at which the change in the steepness of the rocks takes place.

These deep indentations at the heads of valleys are not due to the streams which flow down them, for their action tends to equalize the slope of their beds: they must owe their origin to the action of waves beating for a long period against the rock. To ascertain whether the waters producing such effects were those of lakes or of the sea, we have only to compare the levels to which they reached in different valleys: if the same levels were only found in lateral valleys connected with one main valley, we might attribute their production to the waters of a lake: but when the same levels are found in valleys which have no connexion with one another, or which lie on the opposite sides of mountain-chains, we must refer their excavation to the waves of the sea.

The latter is the case with the valleys of the Alps: the head of the valley of Urnerboden, which is connected by the Linth with the Rhine, is 4730 feet above the sea: Haudères at the head of the Valley of Herens stands at 4763 feet, and Ayer at the head of the Valley of Annivier at 4776 feet; these two latter valleys drain into the Rhone: the Valley of Visp on the north side of Monte Rosa ends at Zermatt, at 5410 feet; that of Gressonay on the south of Monte Rosa ends near La Trinité at 5455 feet above the sea. From these and other instances, which will be given in a Table, we learn with certainty that the final excavation of these alpine valleys to their present levels was done by the sea. It is not at present necessary to consider what causes produced the cracks which enabled the sea to penetrate so deeply into the flanks of the mountains, nor what was their condition in the earlier geological periods, as I am only treating of those later agencies to which the valleys owe their present forms.

Coupling the conclusion, that the sea was the agent of excavation of the alpine valleys, with the sudden changes of level previously mentioned at p. 110, and with the different elevations above the sea at which we find the valleys terminate, we learn a similar result to that which we have already obtained from observing the lines of erosion on the mountain sides,—that the elevation of the Alps out of the sea has taken place by numerous steps or comparative starts, after each of which was a period of rest long enough to allow the waves to leave a permanent record of their action; and that throughout Switzerland the whole chain was equally elevated, or as nearly so as this method of observation will allow us to judge of.

The measurements on which my comparisons are founded are principally derived either from the "Hypsométrie de la Suisse" of my friend M. Ziegler, or from the figures on the Map of Switzerland published by the Federal Government, under the direction of General Dufour; a few are reduced from my own observations by the aneroid †. The two former do not give me the heights of the heads of the valleys, but only those of the village nearest to its head, and this is usually rather below the level of the head of the valley. Another source of error arises from the valleys being always more or less choked up at their upper ends by detritus brought down from the mountains by the torrents, and of which we cannot see the depth. Judging from what I could observe of such deposits, I think it likely that they do not often exceed 200 or 300 feet in such situations. Fortunately these two errors are in opposite directions, and therefore tend to neutralize one another. From these and other causes I consider that the altitudes here given can never be relied on within 100 feet; but they probably are all within 200 feet of the truth.

The highest valleys which contain glaciers do not admit of so near an approach to accuracy: we have no means of knowing the depth of the ice of the glacier, and can therefore only form a rough guess of the level to which the head of the valley has been excavated.

The Table No. I. (p. 123) exhibits the heights above the sea of the heads of a few valleys which I measured, and of a number of villages which stand close to the heads of their respective valleys or just below a spot where the valley exhibits a sudden change of level. Where several names occur on one line, those places are on the same line of drainage: where the village stands considerably below the head of the valley, it is marked thus *, to show that the height there given is below that of the head of the valley. All the measures are reduced to English feet.

The following levels may be reduced from the Table No. I. by throwing together those heights which approximate most closely.

As I have no accurate measurements of the heads of the highest valleys, owing to their being filled with ice, they are not inserted in the Table; but I may repeat that the branches of the Mer de Glâce end at above 9000 feet, and probably correspond at their highest level with the highest line of erosion observed.

1. The Piedmontese Val Ferret ends at 7660 feet: I have not the exact height of the head of the Allée Blanche, but have reason to believe it to be about the same. This height nearly corresponds to that of the "second line of erosion," noted at 7500 feet.

† The aneroid barometer is a treacherous guide, owing to the frequency with which the hand is displaced by a jolt, and it cannot be trusted alone: but it will answer all the purposes of a geologist in a tour where he has frequent opportunities of comparing it with a mercury barometer, or of checking the accuracy of its index in passing spots of which the heights are known. As there is hardly a hill or a village in Switzerland of which the height above the sea is not published, these opportunities are offered to the tourist several times every day; and, if he finds that no displacement of the hand has taken place, he may rely on his intermediate observations to within 10 feet. The contemporary changes of the atmospheric pressure may be traced from the meteorological observations at Geneva and at the Great Saint Bernard, which are published monthly in the "Bibliothèque Universelle de Genève," and from the recorded observations of Prof. Wolf of Berne, which, though not published, are, through that gentleman's kindness, equally accessible.

2. Prérayean at the head of the Valtelline, which I did not visit, stands at 6593 feet.

3. The valleys of the Rhone, the Engadine, and Oberhalbstein end between 5750 and 5900 feet.

4. Many valleys end between 5300 and 5450 feet.

5. The lower Engadine ends abruptly at Zernetz at 4910 feet; and several others between 4750 and 4900 feet: these nearly correspond to the lower line of erosion, placed at 4800 feet.

6. Between 3800 and 4400 feet there are so many heights noted, that it is difficult to throw them into groups; but the most distinct are at about 3900, 4100, and 4400 feet.

7. In Oberhalbstein there is a termination of the lower valley at 3600 feet.

8. Val Blegno ends above Olivone at about 2900 feet.

9. Linththal and Muottathal end between 2500 and 2600 feet.

Thus it appears that the earlier elevation of the Alps, represented by the higher water-levels, was in great starts of 1000 feet or more at once; that these gradually became less and less violent, until, after rising above the well-marked line of 4800 feet, the later elevations were so gradual that the rough process by which it is here attempted to measure them is hardly sufficient to distinguish one of the lower levels from another.

The valleys above mentioned are excavated in rocks of every age from the nagelfluh to the gneiss; therefore the operations here described were all posterior to the eocene period. I am unable to say whether they are prior or posterior to the formation of the molasse; but I think it probable that they were posterior, and that the only deposit which was formed during the last elevation of the Alps was the drift.

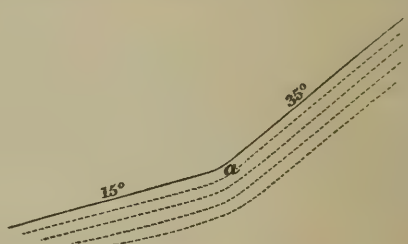
Terraces of Alluvium in the Alpine Valleys.

The valleys of the Alps offer innumerable instances of terraces of alluvial matter projecting from their sides and cut through, often to a great depth, by the present streams. These occur in places where it is impossible to account for their existence without going back to causes operating under different circumstances from those which now exist; for the forces now at work are destroying and carrying them away. Such terraces are common in all mountainous regions, and they have everywhere nearly the same character, form, and constitution: their materials consist of sand and gravel, of various degrees of coarseness, mixed up with slightly worn fragments of rock, all or nearly all belonging to the rocks to be found in the same valley, and arranged with an irregular approach to stratification, which slopes both down the valley and from the sides towards the middle of the valley at angles varying from 2° to 15°, in planes usually parallel to the surface of the terrace.

The nature of these deposits is so precisely similar to those formed immediately below the surface of the water wherever a mountain-stream enters a lake or a quiet arm of the sea, that this explanation of their origin is, I believe, universally admitted: but it has been so clearly stated by Mr. Darwin, that I will quote his words; in case of "a river delivering during a long period detritus into a lake, the level of which was gradually sinking from the wearing down of its mouth, a gently sloping surface would be formed at its head. But as the barrier was cut deeper and deeper, and the lake sank, the stream in the part where it was once checked by meeting with the still water would gain velocity, and hence would cut through the beds which it had originally deposited; *" and again, at p. 55,—"the waterworn materials appear to have been transported by the present rivers, and yet they are so deposited as could not have happened without some intervening cause. The only obvious solution is that the valley had been occupied by an expanse of gradually subsiding water, either of a lake or of an arm of the sea."

Besides the matter brought down by the rivers, the terraces in the Swiss valleys have in many instances received large additions of materials from the falling of fragments of rock down the steep sides of the mountains; and the outlines of these accumulations give a strong confirmation to the above views; under ordinary circumstances the fragments which roll down the sides of a precipice form themselves, as is well known, into a slope at an angle of about 35°, which has been named in consequence "the angle of repose:" but in the lower parts of the Swiss valleys it is very common to observe that the slope suddenly changes from 35° in the upper part of the talus to about 15° in the lower part, as at *a* in the annexed diagram (fig. 3); and this change of angle takes place at a uniform height for a considerable distance.

Fig. 3.—*Diagram to show the arrangement of the materials in the Terraces.*



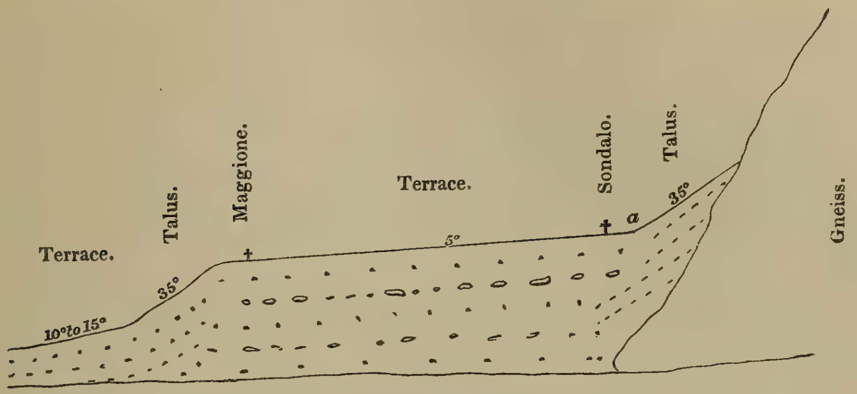
This is well seen on the south side of the valley of the Rhone near Sierre, where the level at *a* is 1800 or 2000 feet above the sea, and the lower slope spreads out into a series of flat hillocks more than 200 feet above the Rhone. The change of angle of the slope of the debris, and the uniformity of level at which the change takes place, are strong proofs that water stood at this time up to the level at *a*, and that this water had sufficient motion, either from currents or tides, to alter the angle of subsidence of the falling debris †.

The diagram, fig. 4, gives the outline of two terraces in the Valtelline, above Grosio; the angles are drawn correctly, but the distance between the two ends of the upper terrace at Sandalo and Maggione

* Darwin, "On the Parallel Roads of Glen Roy:" Phil. Trans. 1839, p. 51.

† In Nov. 1830 Mr. James Yates communicated a paper to this Society "On the Formation of Alluvial Deposits," of which a short abstract is given in our Proceedings, vol. i. p. 237: it will be found at length in the Edinburgh New Phil. Journ. for 1831, vol. xi. p. 1. The manner in which terraces are formed in lakes from the materials brought down by the streams is well explained, pp. 30–39. See also R. Chambers, 'Ancient Sea Margins,' p. 51.

Fig. 4.—*Section of two Terraces of Alluvium in the Valtelline, cut through by the River Adda.*



Bed of the Adda.

ought to be greater; the River Adda has cut through the rubble forming the terraces for about 300 feet, down to the rock below. We learn from this that a body of water stood for a very long period at the level of *a*, where Sandalo now stands, 2940 feet above the sea; and that it stood at a later time, and for a shorter period, about 200 feet lower, at the level of *b*.

The terraces are so uniform in their principal features that it is useless to give other representations of them.

I noted the heights of the principal terraces in many of the valleys, with the view of comparing them together to determine whether we ought to refer them to lakes or to the sea. There is usually a village on the broader terraces, of which the height above the sea is published; where this is not the case my aneroid gave me a tolerably accurate measure of their elevation. But there is an inevitable source of error caused by the slope of the terraces themselves, which often amounts to 100 feet; and thus, if we happen to compare the upper end of a terrace in one valley with the lower end of one in another valley, we may think the one 100 feet higher than the other, when they are really at the same altitude: nor can this be obviated by limiting our observations to the upper end of each terrace, as frequently that has been washed away, and its traces only remain on the sides of the valleys. I think, however, that 100 feet may be taken as the limit of the errors in my statements of altitude.

In tolerably level valleys, instead of terraces we find long sloping meadows, in which we cannot separate the deposits which may have been formed under ancient waters from those now forming by the action of the present rivers and of the weather. I have therefore taken no account of these, and only mention them to show that our not finding terraces in such valleys is no proof that waters may not have stood in them to the same height as in those valleys in which terraces are most frequent.

Terraces are also less evident in broad than in narrow valleys; perhaps because a given amount of materials would make less show when spread out in a wide valley, than when confined in a narrow one.

In many valleys my attention was so much fixed on other objects that I omitted to note the occurrence of terraces, or only noted the more striking and important ones: in every instance I omitted many of minor importance, or of which the real character may be doubtful; thus the following list is very incomplete, and no negative argument can be drawn from its omissions.

Valleys of the Rhone and its Tributaries.—Valley of the Rhône: there are great irregular terraces above Sierre, at above 1800 feet elevation, which appear to have been altered and cut up by subsequent causes.

In the valley of Evolena there is an extensive terrace at La Loet, 3316 feet, which may be traced down the valley for nearly two miles.

Below Vex, at 2821 feet elevation, is an extensive terrace, on a portion of which stands a ruined castle.

In the valley of Visp I noted a terrace above S. Nicholas at 3815 feet, another below Stalden, at 2490 feet, which is seen again below Neubruck at 2470 feet.

In Entremont, descending from the Great St. Bernard, I observed a sloping terrace a little above Liddes at 4782 feet, and a succession of considerable terraces between Liddes and Orsières, at about 4350, 4150, 4000, and 3770 feet.

Valleys of the Rhine and its Tributaries.—On the Vorder Rhine the highest terrace is seen at St. Jacob and Tavesch at 3825 feet; it is very extensive, but irregular. Dissentis stands on a large terrace at 3805 feet, which must be a continuation of the same. In Medelserthal the highest terrace is at S. Rocco at about 4720 feet; there is also one at Platta at 4658 feet, which is probably part of the same. There is a very distinct terrace at Medels, 4422 feet.

Valley of Vals: on the descent from Vals to Ilanz, I observed several terraces; one at Fuors at about 3300 feet, another between Fuors and Peiden at about 3175 feet, and a third below Peiden at about 2930 feet; and some smaller terraces above Ilanz, which stands at 2323 feet elevation.

The Hinter Rhine: on the descent from the Splugen towards Coire the terraces are numerous and well defined; the following were noted.—The highest terrace is at the village of Splugen at 4780 feet; others at Sufers at 4343 feet, Ander and Dormat at 3113 feet, Zillis at 2930 feet, between Zillis and Tussis at 2770 feet, at Tussis at 2350 feet, at Rhazuns at 2200 feet, and at Bonaduz at 2145 feet.

In Oberhalbstein there are some traces of a terrace below Muotta at 6110 feet: a terrace at Tinzen, 4230 feet, and a very large terrace above Am Stein, at about 3300 feet elevation. I was much interested to find an ancient moraine resting on this last-mentioned terrace; both the moraine and the terrace have been cut through by the stream, affording a section in which the position of the moraine on the terrace of alluvium was clearly seen. Higher up the same valley there is a large moraine above Marmels, which also appears to rest on a bank of alluvial detritus; but there is no section seen, and the superposition is not certain*.

Terraces are numerous in the valley of Prätigau; but I have only the elevations of one at Mezza Selva, 3444 feet, and another at Saas, 3254 feet.

In Davos there is a long terrace at Wiesen at 4770 feet: there are others higher up the valley of which I have not the elevations.

On the lower part of the Rhine, between Ilanz, 2323 feet, and Coire, 1968 feet, there is a succession of terraces at short intervals.

Valleys of the Inn and its Tributaries.—The upper Engadine is a remarkable valley, its bottom forming a uniform alluvial plain which only falls 750 feet in 30 miles, from the Lake of Sils to its sudden termination above Zernetz; the upper end of this deposit is 5900 feet above the sea. Terraces are numerous in the Lower Engadine: at Boscia, 5464 feet, and Fettan, 5404 feet, there is a terrace on the side of the hills more than 1000 feet above the river; at Tarasp, 4597 feet, is a terrace which occurs also on the opposite side of the river at Upper Schuls; another at Lower Schuls, 3970 feet, extends down the valley nearly to Sus; below Sus is a terrace on the sides of the hill at 4060 feet elevation. Others occur lower down the valley at 3567 feet, at Strada, 3465 feet and at 3415 feet, these last two being distinct.

On the north side of the Bernina Pass there is a long terrace at 6190 feet elevation, between Pontresina and Bernina, which is the highest terrace which I observed in Switzerland; another occurs at Pontresina, 5930 feet.

On the descent from the Stilvio into the Tyrol, the highest terrace is about 950 feet below Trefiu at about 4230 feet elevation; and there is another about 500 feet lower.

Valleys on the South of the Alps.—The Valtelline: Ceppina stands at 3865 feet on a terrace of some extent; at Morignone is a well-marked terrace at 3770 feet; another at Mondalizza, 3120 feet; at Sandalo is a very extensive terrace at 2940 feet, 300 feet above the Adda, of which a sketch is given at p. 115; and about 100 feet below is another of less extent: an important one is seen at Tiolo, 2690 feet, and another equally important above Grosio at 2330 feet, and at Sernio at 1700 feet. Below this I did not follow the valley, having entered it at Tiranno from the Bernina.

On the south side of the Bernina the highest terrace is at about 5650 feet, some way below La Rosa; and there are several others, of which I have not the elevations, between this and Posciavo, which stands at 3323 feet.

In Val Bregaglia there is a small terrace at Carrel at about 5200 feet, and another equally small a little above Casaccia at about 5000 feet.

* M. Studer informed me that a moraine near Berne rests on a high terrace of worn debris; and M. Rozet states that, throughout the French Alps, the ancient moraines rest on the diluvial deposits (Bull. Soc. Géol. France, 2 série, vol. xii. p. 246); therefore there can be no doubt that these terraces were formed before the period of the great extension of the glaciers.

On the south side of the Splugen I could find no terrace whatever; but all round the Lake of Como there are the remains of a terrace of coarse gravel, some 200 or 300 feet above the lake; and therefore between 900 and 1000 feet above the sea.

In descending from the S. Gotthard to Bellinzona, the highest terrace observed was at Giornico, 1234 feet; but in Val Blegno there is a terrace a little above Olivone at 3100 feet, and another at Agoa Rossa at about 2100 feet; and in the branch valley of Misocco there are several terraces above Misocco, between 2500 and 3500 feet in elevation. Near Bellinzona there are several large alluvial flats at 30 feet, 100 feet, 160 feet, 190 feet, and 230 feet above the Lago Maggiore, which may perhaps be due to a gradual lowering of the waters of the lake, and not belong to the class of terraces under consideration; but between Locarno and Bellinzona there is a well-marked terrace at 981 feet elevation,—that is, 300 feet above the lake.

In Val Onsernone, which ends at the Lago Maggiore, there is a large terrace at Intragna at 1300 feet, another some 300 or 400 feet higher, and another about 300 feet below Intragna; of the last two I have not the exact altitudes, but the last probably corresponds to the terrace observed between Locarno and Bellinzona at 981 feet.

In Val Isone, which drains into the Lake of Lugano, the highest terrace observed was at an elevation of above 2000 feet; but, having no known height near it as a point of comparison, I could not fix its altitude accurately.

Round the Lake of Lugano there is a well-marked terrace a few hundred feet above the lake, of which I did not measure the elevation; here we may doubt whether to attribute this to a lowering of the water of the lake or to a more general cause.

For more convenient comparison I have thrown these observations together in a tabular form, see Table, No. II. p. 123.

General Results from the foregoing Observations on Terraces.—The first point to which I wish to call attention is that there are terraces at the same elevation in valleys which have no connexion with one another; thus, in valleys opening both on the Rhine and the Rhone there are terraces between 4770 and 4780 feet, between 4340 and 4350 feet, and between 3815 and 3825 feet. Both in the Valtelline and in the valley of Entremont, which falls into the Rhone, there are terraces at 3770 feet. In the Valtelline and the valleys connected with the Rhine there are terraces at between 3110 and 3120 feet, between 2930 and 2940 feet, and between 2330 and 2350 feet.

I think these are conclusive proofs that the terraces were formed by the sea which surrounded the Alps at these periods and entered into all the valleys: for it is incredible that there should have been so close an agreement of level in a number of independent lakes, such as would be formed by closing the valleys of the Rhine, the Rhone, and the Adda by glaciers or any other barriers.

The numerous correspondences of level in terraces which occur in valleys connected by a common outlet, as well as those just mentioned, afford a satisfactory confirmation of the general accuracy of my altitudes. These coincidences of levels in such distant localities also confirm the remark already made, that the elevation of the Alps must have been uniform from Savoy to the Tyrol, no such difference appearing in the levels as would occur if one part of the chain had been more elevated than the rest.

In Table No. III. p. 123, will be found a general comparison of the elevation of the various water-levels, deduced from the previous observations on the Lines of Erosion, the Heads of Valleys, and the Terraces, which harmonize in numerous points. There are no terraces so high as the two upper lines of erosion, but the lower line, noted at about 4800 feet, nearly corresponds with the heights of the heads of several valleys and of four terraces observed in different parts of the Alps. And the close coincidences in the elevation of the heads of many valleys with that of terraces elsewhere are very numerous.

The conclusion which I draw from all these observations is the same;—that they show the levels at which the surface of the sea beat for long periods against the Alps as they rose out of the ocean; the effects produced at each level giving a sort of relative measure of the length of time that the land remained stationary at that elevation, and the distances between them marking the steps in the progress of the elevation of the mountains. These steps appear to have been greatest at the commencement of the elevation, and to have gradually lessened as the mountains approached the height at which we now find them. The periods of longest rest were undoubtedly those marked by the lines of erosion at 9000, 7500, and 4800 feet elevation.

There are, however, some peculiarities in the unequal distribution of terraces in different parts of the Alpine Chain which may be thought to favour the hypothesis that they were formed in lakes; I will state these fully, that both sides of the argument may be fairly seen. The terraces are far more numerous in the upper valleys of the Rhone above Sion, of the Rhine above Coire, of the Inn, and of the Valtelline, and in all the lateral valleys which fall into these, than they are either in the valleys on the north of the Alps, which open on to the great central valley of Switzerland, or in those which run southward to the plains of Lombardy. Thus, while there are numerous well-marked terraces on the north side of the Splugen, I observed none on the south side more than 1000 feet above the sea, at about which height there is a terrace around the Lake of Como some 300 feet above the lake; and on the descent from the S. Gotthard towards Bellinzona I noted no terrace above Giornico, where there is a large one 1234 feet above the sea, though in the branch valley of Misocco they occur above Misocco at more than 2500 feet elevation.

Some stanch glacialist will probably offer to explain this difference by the greater facility of forming lakes in the inner valleys by glaciers choking their mouths. But, as I know of no evidence that such glaciers ever existed, I must look elsewhere for an explanation; and that which occurs to me is, that such deposits would be best preserved in valleys occupied by still water. In a rough sea of which the level was gradually falling, the waves would undermine and wash away such loose deposits, and spread them over the base of the valley, in a less regular form. If this view be correct, it will agree with the fact that the sheltered inner valleys of the Alps have terraces up to very high elevations; while the outer valleys, into which the seas on the north and south of the chain must have beaten with violence, have terraces only in their lower and more sheltered portions; and that some valleys on the south of the Alps, of which the east and west direction would be a cause of shelter, are also studded with terraces, as the Valtelline, Val Insernone, Val Isone, Val Misocco, &c.

Whether this explanation be accepted or not, I still think the uniformity of level observed in valleys on the opposite sides of the mountains must outweigh all other considerations, in favour of the conclusion that such terraces were formed in the same sea.

Another difficulty will doubtless be found in our not having discovered any organic remains in the terraces of alluvium. But this meets us equally if we suppose the terraces to have been formed in lakes. The almost entire absence of organic remains in the drift-deposits of Europe is a most remarkable fact, which has not yet received a plausible explanation; it is so general, that we must look for a wide-spread cause, and, until that is discovered, the fact itself must not be allowed to weigh against conclusions which can be safely derived from evidence of another nature*.

* After this memoir was read to the Society I received the following note from Mr. James Smith, of Jordan Hill, which leads me to hope that marine shells may be found in the alluvial deposits of Switzerland:—

Athenæum, Dec. 14, 1855.

My Dear Sir,—A summer's examination of the superficial beds of gravel in Switzerland led me to the conclusion that some of them must have been deposited under the sea, for the following reasons:—

1. They are stratified and exhibit no appearance of disturbances, hence the configuration of the country must have been the same as at present.

2. They are at an elevation which does not admit the supposition that they are lacustrine.

I did not discover marine remains *in situ*, but the following indications of the existence of pleistocene shells may perhaps lead to their discovery and set an important question at rest.

In the Museum at Geneva I found in a drawer marked "Swiss fossils" *Mya Udevallensis*, a most characteristic and abundant species in the Clyde beds.

In the Museum at Berne I observed several shells with the locality "Court" attached to them: they had all the appearance of pleistocene shells; I inquired for the curator of the Museum, but as it was during the vacation of the University he was absent. It is ten years since, and at this distance of time I do not recollect whether I could identify any of the species.

Yours truly,
James Smith.

Daniel Sharpe, Esq.

Theoretical Conclusions.—It would be very interesting to fix the period at which the elevation of the Alps out of the waters took place, of which the traces of water-levels here described are the records. To accomplish this we must find the latest formation in which we can observe levels corresponding to those which I have established. As the objects of my visits to the Alps confined me principally to the higher mountains, I could not extend my observations in the Tertiary Lowlands of Switzerland; and thus I can only say with certainty that the elevation included the Eocene Rocks and the elder Nagelfluh which rest on them. But I have little doubt that the elevation took place at a much later period, after the deposit of all the Tertiary Formations. I arrived at that conclusion by looking at the subject from a different point of view. Every elevation of mountains on a large scale must have left its record in an accumulation of debris round their base. If we look backwards in the history of the Swiss Alps, we find the earliest accumulation of this kind to be the *Verrucano*, a coarse conglomerate marking the first elevation of the Swiss Alps through the then crust of the earth. Towards the close of the Jurassic period we again find conglomerates, some calcareous, others sandstones (which have sometimes been confounded with the earlier Verrucano), marking another period of great elevation. At the end of the Eocene period, the older Nagelfluh, the enormous thickness of which is seen at the Rigi and neighbouring mountains, points out the period of that great elevation when, the central masses of the Alps being thrust upwards for the last time through the crust of the earth, the mountains received their present form, and the Secondary Rocks on their flanks were thrown into the distorted position which they now occupy. The alternations of the beds of gravel with the marine and fresh water deposits of the Molasse point to a long epoch of alternate elevation, depression, and elevation, which are probably contemporaneous with violent movements below the great central valley of Switzerland, on a line parallel to the axis of the Alps, to which the Molasse and the old Nagelfluh owe their disturbed position and their dip towards the Alps for so great a distance.

After that period the whole country must have again sunk below the sea, and the elevation to which this present communication refers followed at a still later period, raising the whole region up uniformly *en masse* out of the ocean without disturbing the relative positions of its parts; and to this movement we may naturally attribute the deposits of gravel and boulders spread irregularly over the Lowlands of Switzerland, and thus place this movement after the conclusion of the Tertiary period.

I have already pointed out (p. 116) that the moraines which mark the greater extension of glaciers at a former period sometimes rest on terraces of alluvium in the valleys and on the so-called diluvium of the plains, showing us that the extension of the glaciers followed the accumulation of those deposits which I suppose to have been formed during the elevation of the Alps out of the ocean. An increase of altitude of the Alps of between 1500 and 2000 feet would give an extension of the glaciers sufficient to account for all the moraines and polished and striated rocks in Switzerland. After tracing the upward progress of the Alps during their rise of 9000 feet from their position at the first observed water-level to their present heights, it requires but a slight stretch of the imagination to suppose a farther elevation of 1500 or 2000 feet to account for the earlier glaciers, followed by a subsequent sinking of the land to its present level. But so many other causes may have produced a change of climate, and the proofs of a glacial period in other countries are so numerous, that it seems better to look for a general cause of a colder climate throughout Europe at the period in question, than to limit our views to a local movement peculiar to the Alps.

Erratic Blocks.—The subjects of this paper approach too nearly to the much-debated question of Erratic Blocks for me to leave them entirely unmentioned. A large proportion of the rounded boulders and gravel may have been distributed over the Lowlands of Switzerland during the elevation of the Alps; for, as this elevation went forward, every portion of the country must in its turn have been part of the coast, and consequently acted on by the waves. This may account for the distribution of the smaller rounded blocks at all the lower levels.

But, if that explanation be admitted for the rounded erratics, we have still to account for the great accumulations of large blocks, often angular, which lie scattered here and there throughout Switzerland above the deposits of gravel, and the presence of which on the Jura and on the sides of the hills that enclose the valley of the Rhone has led to so much discussion. On the Jura these blocks reach, according to M. Charpentier, to the height of 4250 feet above the sea *. The blocks of Monthey, so eloquently described by Prof. J. Forbes, are stated to be at least 500 feet above the plain †, or above 1700 feet above the sea.

It will be seen by Table III. that the sea has stood for some time round the Alps near each of these levels; thus we have the existence of a sea demonstrated, on which ice-rafts carrying such blocks may have floated: and it only requires a climate capable of producing floating ice, to furnish an agent for transporting blocks of any size, of stranding them in lines along the coast, or dropping them here and there at the bottom of the sea ‡. The extension of the glaciers, caused probably by a climate colder than the present, followed soon after the period when the sea stood at the heights mentioned, and thus the conjectural explanations of the two succeeding phænomena, referring both to a colder climate, harmonize together, and save us from the necessity of the gratuitous creations of a "Glacier of the Rhone" ending on the side of the Jura nearly 3000 feet above the

* If, as it is probable, these are French feet, they are equal to 4528 English feet; if Swiss feet are intended, they are equal to 4182 English feet. Not having Charpentier's work at hand, I quote from the abstract of it in Edinb. New Phil. Journ. vol. xxxiii.

† 'Travels in the Alps,' p. 51.

‡ See Sir C. Lyell's account of the transport of blocks by the breaking up of coast-ice now going on in the Bay of Fundy.

TABLE I.—*Altitudes of the Heads of Swiss Valleys in English Feet*: *e p.* 116.

VALLEY.					to ft.	above 5000ft.
Trient	....	Trient 4316 *				
Arve............	....	Le Tour 4274	....	Nant Bourrant 52		
Val Ferret ...	....	....	....	....		
Saanen.........	....	Gsteig 3936			'82	
Kander.........	....	Kandersteg 3828				
Ormont	....	Les Plans 3822				
Laubach	....	Lauenen 4100			20	
Rhone	....	....	....	....		
Herens.........	....	Heremenence 4152 ...	Haudères 4763		30	
Annivier	....	....	Ayer 4776			
Visp	....	....	Täsch 4877	Zermatt 5410	....	6110
Saas	....	....	....	Saas 5257 *		
Dala............	....	....	Baths of Leuk 4642 *		70	
Valpelline......	....	....	....	Biona 5315		
Gressoney ...	....	....	....	Trinité 5455	30	
Anzasga	....	Macugnaga 4305 *				
Formazza	....	Formazza 4143				
Simplon	....	....	Simpeln 4626 *		97	5464 5900
Reuss	....	....	Andermatt 4642 *			5930
Levantina ...	....	Airollo 3867			....	6190
Blegno.........	Olivone 2905	Campo 3985				
Misocco	....	....	....	S. Bernardino 53		
Rhine	....	....	....	Hinter Rhein 53	....	5650 ?
Oberhalbstein	Am Stein 3597	Schweiningen 4058	....	....	00 ?	5200 ?
Landquart ...	....	Klösters 3953	....	Sardasca 5365		
Engadine	....	....	Zernetz 4910	Sils 5895		
Münster	....	Sta. Maria 3954				
Valtelline......	....	Bormio 4117				
Weisstannen	....	head 4100				
Linth	head 2500 ...	....	Head of Urnerboden 4730			
Schachen......	....	head 4400				
Muotta.........	head 2600 ?...					
Alp Bach	....	Gspaa 4240				

The altitudes marked * are below the head of their respective valley

Lake of Neufchatel, for which there is no other evidence than that of the existence at this height of erratic blocks †.

Table III.—*General Comparison of the preceding observations.*

Lines of Erosions.	Heads of Valleys.	Terraces.
English feet.		
9000		
7500......	7660	
	6593....................................	6100, 6190
	5756, 5835, 5895	5900, 5930
		5650 ?
	5410, 5455	5464
	5280*, 5257*, 5315*, 5315, 5365, 5370	5200 ?
	4877, 4910	5000 ?
4800......	4626*, 4642, 4642*, 4730, 4763, 4776	4720, 4770, 4780, 4782
		4597
	4400....................................	4422
	4305*, 4316*	4343, 4343, 4350
	4240, 4274	4230, 4233
	4100, 4100, 4117, 4143, 4152 ...	4150
	4058....................................	4060
	3936, 3953, 3954, 3985	3970, 4000 ?
	3822, 3828, 3867	3730, 3770, 3770, 3815, 3825, 3865
	3597....................................	3567
		3415, 3444, 3465
		3254, 3300, 3300, 3316
		3100, 3113, 3113, 3120, 3175
	2905....................................	2930, 2930, 2930, 2940
		2770, 2770, 2821, 2840
	2600 ?	2690
	2500....................................	2490
		2330, 2350, 2350
		2200, 2200
		2100 ? 2145, 2145
		1650 ? 1700
		1234, 1300
		981, 1000 ?

The numbers marked ? rest on doubtful measurements.
The numbers marked * are below the truth.
The altitudes placed on the same line are supposed to belong to one water-level.

† In corroboration of my statement of the limited extension of the real proofs of the existence of ancient glaciers, I cannot quote a better witness than M. Agassiz, who, after saying "On ne rencontre des traces de moraines terminales que dans les vallées comprises dans l'intérieur des chaînes des Alpes," proceeds to account for their disappearance beyond. ('Etudes sur les Glaciers,' p. 63.) The moraine of the Glacier of the Aar, near Berne, lately discovered (see *ante*, p. 117), is, I believe, the only exception to the accuracy of this statement of M. Agassiz. The only evidence in favour of a farther extension of glaciers is built upon the distribution of gravel and erratic blocks, to which category, I believe, that we must refer most of the *Blockwälle* of M. Escher's Map of the "Verbreitungsweise der Alpen-Fündlinge."

Table I.—*Altitudes of the Heads of Swiss Valleys in English Feet:* *see p.* 112.

Valley.					
Trient		Trient 4316 *			
Arve		Le Tour 4274		Nant Bourrant 5280*	
Val Ferret					head 7660
Saanen		Gsteig 3936			
Kander		Kandersteg 3828			
Ormont		Les Plans 3822			
Laubach		Lauenen 4100			
Rhone					Foot of Glacier du Rhone 5756
Herens		Heremenence 4152	Haudères 4763		
Annivier			Ayer 4776		
Visp			Täsch 4877	Zermatt 5410	
Saas				Saas 5257 *	
Dala			Baths of Leuk 4642 *		
Valpelline				Biona 5315	Prérayean 6593
Gressoney				Trinité 5455	
Anzasga		Macugnaga 4305 *			
Formazza		Formazza 4143			
Simplon			Simpeln 4626 *		
Reuss			Andermatt 4642 *		
Levantina		Airollo 3867			
Blegno	Olivone 2905	Campo 3985			
Misocco				S. Bernardino 5370	
Rhine				Hinter Rhein 5315 *	
Oberhalbstein	Am Stein 3597	Schweiningen 4058			Stalla 5835
Landquart		Klösters 3953		Sardasca 5365	
Engadine			Zernetz 4910	Sils 5895	
Münster		Sta. Maria 3954			
Valtelline		Bormio 4117			
Weisstannen		head 4100			
Linth	head 2500		Head of Urnerboden 4730		
Schachen		head 4400			
Muotta	head 2600 ?				
Alp Bach		Gspaa 4240			

The altitudes marked * are below the head of their respective valleys.

Table II.—*Altitudes of Terraces in the Swiss Valleys in English Feet:* *see p.* 116.

Valley.	Below 1000 ft.	1000 to 1500 ft.	1500 to 2000 ft.	2000 to 2500 ft.	2500 to 3000 ft.	3000 to 3500 ft.	3500 to 4000 ft.	4000 to 4500 ft.	4500 to 5000 ft.	above 5000 ft.
Rhone			above 1800							
Evolena					2821	3316				
Visp				2490			3815			
Entremont							3770, 4000 ?	4350, 4150	4782	
Vorder Rhein			many				3825			
Medelserthal								4422	4720	
Valserthal				above 2323	2930	3175, 3300				
Hinter Rhein				2145, 2200, 2350	2770, 2930	3113		4343	4780	
Oberhalbstein						3300		4230		6110
Prätigau						3254, 3444				
Davos									4770	
North of Splugen				2145, 2200, 2350	2770, 2930	3113		4343	4780	
Valley of Trafoi							3730	4233		
Engadine						3415, 3465	3567, 3970	4060	4597	5464, 5900
North of Bernina										5930, 6190
Valtelline			1700	2330	2690, 2840, 2940	3120	3700, 3865			
South of Bernina										5650 ?
Val Bregaglia									5000 ?	5200 ?
Val Levantina		1234								
Val Blegno				2100 ?		3100				
Lago Maggiore	981									
Val Onsernone	1000 ?	1300	1650 ?							

December 19, 1855.

The following Communications were read:—

1. *Description of a* Fossil Cranium *of the* Musk-Buffalo [Bubalus moschatus, *Owen*; Bos moschatus (*Zimm. & Gmel.*), *Pallas*; Bos Pallasii, *De Kay*; Ovibos Pallasii, *H. Smith & Bl.*] *from the* "Lower-level Drift" *at* Maidenhead, Berkshire. By Professor Owen, F.R.S., F.G.S. &c.

The subject of this description was discovered by the Rev. Mr. Kingsley and John Lubbock, Esq., in a gravel-pit close to the engine-house at the Maidenhead Railway Station: the deposit appears to be that called "the lower-level drift." The specimen was submitted to my inspection by Mr. Lubbock in July 1855, and proved to be the first example of the Buffalo-tribe (*Bubalus*) which had come under my observation from a British locality, and I most heartily welcomed so interesting an accession to the catalogue of British fossil mammals.

The specimen consisted of the cranial part of the skull, from which one condyle of the occiput, and the tip of the left horn-core were broken away; but the characteristic very broad, depressed, approximated, rugged bases of the horns, covering the whole upper surface of the cranium save a narrow median channel, and a portion of the much extended telescopoid orbit at once showed the subgenus to which the fossil belonged.

The bovine ruminants present, as is well known, three main modifications of their horns and horn-cores; in one the horn is subcylindrical at the base, which springs from the posterior angle of the frontal; in another the base of the horn, of similar shape, springs from the frontal in advance of the post-posterior angle; in a third the base of the horn is more or less depressed and expanded in breadth, so as to spring (in the adult males) from the whole or a large proportion of the lateral part of the frontal, and in some to encroach upon its upper surface. To the bovine animals with the first modification the generic name *Bos* has been restricted; to those with the second modification that of *Bison* is given, and the term *Bubalus* is applied to the third*. The common appellations of "Oxen," "Bisons," and "Buffaloes" answer to the Latin generic terms above cited, and the Musk-buffalo seems to have been subgenerically separated without due grounds from the other *Bubali*, and especially from the Cape Buffalo (*Bubalus caffer*), under the misguiding term *Ovibos*; its peculiar affinities amongst the Ox-tribe to the Sheep being by no means obvious: for the woolly covering beneath the coarser hair of the Musk-buffalo is a purely adaptive modification

* I do not here pledge myself to the soundness or strict uniformity with nature of the threefold division of the *Bovidæ*, above cited. Intermediate modifications have been pointed out in Indian species of Wild oxen, under the terms *Bibos* and *Gavæus*, by the acute observer Mr. B. H. Hodgson (Illustrations of the Genera of the Bovinæ, 8vo. 1841); but the three main modifications of the horns, at least as regards their bases and origins, are those that it seems to me are chiefly of moment in reference to the fossil skull in question.

for an arctic climate, like that which the extinct northern Elephant and Rhinoceros presented.

Not long after Jeremie* and Dobbs had made known the existence of the Musk-buffalo in North America, Pallas† described a fossil skull, which he referred to the same species. This skull was found in the arctic circle on the banks of the Ob : a second cranium, referred to the same species, was discovered in a marsh or moor still further north. A third fossil skull from the mouth of the Yana, between the Lena and Indigirska, was afterwards described and figured by M. Ozeretskowsky‡.

The short account by Cuvier§ of the fossil remains of the Musk-buffalo is based upon the memoirs of the Petersburg Academicians; the figures given by Pallas being reproduced in the 'Ossemens Fossiles' on a reduced scale in pl. xii. figs. 9 & 10, and those of Ozeretskowsky in pl. xi. figs. 6 & 7 (with the horny sheaths of the horn-cores). Cuvier leaves the question of the specific relations of these Siberian fossils undetermined, and concludes his notice by remarking that, as they were obtained from no great depth, nothing hinders but that they might have come, as Pallas believed, from America across the polar ice; since the Musk-ox has been, in that way, seen in Greenland‖.

Sir John Richardson, in his excellent account of the fossil bones from Eschscholtz Bay, justly remarks that "a greater accumulation of fossil materials is needed to determine the question" which Pallas and Cuvier had left undecided: and Sir John gives a description and figure of the skeleton of a young Musk-bull, and figures of the skulls and some other bones of the male, female and young of the same recent species, in order to facilitate future comparisons. An extinct species is, however, founded by the same author on a fossil *vertebra dentata* under the name of *Ovibos maximus*.

The materials for contributing towards the solution of the question as to the specific relations of the fossil and recent Musk-buffalo, at present at my command, are the fossil cranium discovered at Maidenhead,—a corresponding part of the skull of the fossil *Ovibos* from Siberia, which formed part of the Museum of the late Joshua Brookes, without the record of any more special locality,—the plaster cast of a similar fossil, also from Siberia, brought by Sir Roderick Murchison from Russia,—and the recent skull of an old Musk-buffalo brought from the Arctic regions, in which the occipital region and the right horn-core are partially mutilated, and the entire horn is preserved on the left side.

In the form of the occipital region, in the form, proportions, and direction of the horn-cores, especially in the extent of the rough, flattened, horizontal tract at the upper surface of their base, the

* In Charlevoix's 'Nouvelle France,' vol. iii. p. 131, "Bœuf musqué."

† Novi Comment. Acad. Scient. Imp. Petropolit. tom. xvii. tab. xvii. figs. 1–3, 1772.

‡ Mémoires de l'Acad. de Pétersb. t. iii. p. 215. pl. 6, 1809.

§ Ossemens Fossiles, 4to. tom. iv. p. 155.

‖ Fossil Mammals, Zoology of H.M.S. Herald, 4to. 1852.

three fossils closely agree with each other, as they do likewise with the figure of the Siberian fossil cranium given by Pallas, and reproduced by Cuvier in pl. xii. figs. 10 & 11 of the 'Ossemens Fossiles*.'

The first difference between the fossils and the recent skull is the somewhat greater extent, in the latter, of the vertical plate of bone between the superoccipital ridge and the back part of the bases of the horn-cores. In the English fossil the still persistent lambdoidal or superoccipital suture crosses transversely the corresponding tract. In the Siberian fossil and the recent cranium that suture is obliterated; they are both from older individuals; but the tract in the recent skull is smoother and more convex, as well as more extensive. The value, however, of this character is diminished by the fact that, in the cranium of the recent Musk-buffalo, a bull of between four and five years old, figured from behind, of the natural size, in the "Fossil Mammals of the Herald," pl. iii., the tract between the superoccipital ridge and the horn-cores is not greater than in the English fossil, and it is equally traversed by the lambdoidal suture, showing that that suture is retained until the animal has acquired its full size, and up to the fifth year. Sir John Richardson gives no other view of that recent skull, of the natural size, with the horn-cores exposed. Comparing, therefore, the fossil crania with the cranium of the old Musk-bull from Melville Island, the bases of the horn-cores, though similar in size and rugosity, slope down at their upper surface, as they extend from the median fossa outwards, more directly and gradually, and the interval between their inferior surface and the side of the cranium is narrower and more angular in the recent skull, but is wider and more arched in the fossil: in this respect, however, there appears to be a difference between the skull of the old Musk-bull and that of the younger Musk-bull figured by Sir J. Richardson, in which the curve of the basal part of the horn-cores rather more resembles that in the fossil skulls.

The cranium from Maidenhead is the only one of these that has an entire horn-core; the right one, at least, wants only a small part of the tip.

Comparing the recent (fig. 6) and fossil (fig. 3) crania in a side view, the horn-core in the recent is less vertically deflected, and is bent in a slight degree more outwards and forwards at the tip. This character, however, is not so strongly marked in the figure of the young Musk-bull above cited, as in the old Musk-bull before me.

The deep and narrow longitudinal groove, extending along the middle of the upper surface of the cranium, and dividing the broad bases of the horn-cores, is similar in, and equally characteristic of, the fossil (fig. 2) and recent (fig. 5) crania compared. The lower surface of the base of the horn-core is continued more directly from the side-wall of the cranium, outwards and downwards, in the recent cranium: in the fossil crania that part of the base of the horn-core rises before it curves outwards, and thus the space between the zygomatic arch and the horn-core is greater in the fossil (fig. 1) than in the recent (fig. 4) skull. The outer surface of the horn-core is divided from

* Tom. iv. 4to. 1823.

the anterior surface by a ridge, that surface forming a right angle with the outer one : in the recent Musk-bull the anterior part of the horn-core is convex, the outer passing insensibly into the anterior surface, at least in the old Bull under comparison.

Figs. 1–6.—*Fossil and Recent Crania of the Musk-Buffalo.*

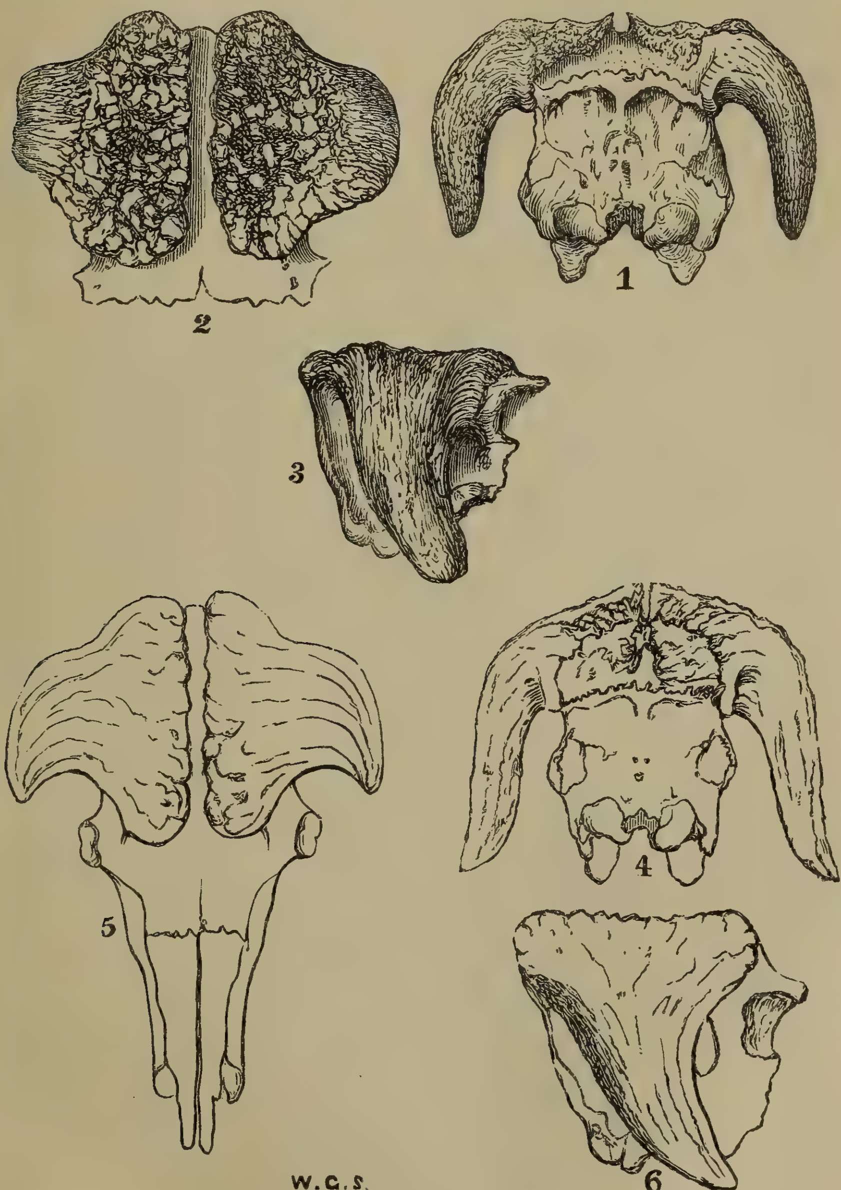


Fig. 1. / Fig. 4.	Back view of the skull of the	fossil / recent	*Bubalus moschatus.*
Fig. 2. / Fig. 5.	Top view of the skull of the	fossil / recent	
Fig. 3. / Fig. 6.	Side view of the skull of the	fossil / recent	

So far as the rest of the cranial structure can be compared, there is no notable difference between the recent and fossil crania.

The question remains, whether the degree of difference observable in the horn-cores is to be interpreted as specific. On this point it may be remarked that the difference in the size and proportions of the horn-cores is much greater between the male and female of the existing Musk-buffalo, than between the recent and fossil skulls of the male sex. It seems unreasonable, therefore, to involve a distinct primordial origin, or specific act of creation, to account for differences that are so much smaller than those that depend on mere sexual modification of one and the same species.

The horns are superadded appendages to the mammalian type; they are not common to all *Ruminantia*; in many of that order they are restricted to the male sex. Like all peripheral superadditions to typical structure, they are subject to great variety. The influence of restricted range in space and of relative number of individuals to a given extent of feeding-ground affects the proportions of the horns in wild species, or those that in all other respects continue to live in a state of nature. This fact is exemplified in the Red-deer of the Highlands of Scotland. No examples of that noble crowned antler which characterized the "Hart of tyne" within the historical period are now to be seen, or have been obtained for some years back, in the Scottish deer forests. But the typical luxuriance of antler-development is still to be met with in the red-deer existing under more favourable circumstances and with a wider range of pasturage, in parts of central and southern Europe and in Asia Minor*. When to restricted range is added the more direct interference of man, as in the domestic races of ruminants, the horns are amongst the first parts to attest the influence of those modifications relating to food, to exercise, to exposure to the elements, and to defence from natural enemies, resulting from domestication.

We might fairly infer, therefore, *à priori*, that the progressive limitation of a bovine species, to a more restricted area and more northern latitudes, would first manifest its influence in some modification of the horns. The observed differences, however, between the fossil and recent Musk-buffaloes in this respect are far inferior to those which domestication has effected in the condition of the same appendages of the same unquestionable species of Ox and Sheep.

By the analogy of such facts, therefore, and guided by the above train of reasoning, we are led to conclude that the ascertained differences between the fossil and recent Musk-buffaloes are not of specific value; and that the *Bubalus moschatus*—with a range at present restricted to a southern limit, defined "by a line running from the entrance of the Welcome River into Hudson's Bay, about the 60th parallel of latitude in a westward and northward direction to the 66th parallel at the north-east corner of Great Bear Lake, and from thence in nearly the same direction to Cape Bathurst in the 71st

* Since this paper was read, Dr. Sandwith has shown me the antler of a Red-deer (*Cervus elaphus*) from the Crimea, which equals in size, number of snags, and expanse of summit, any fossil specimen I have seen.—Feb. 1856.—R. O.

parallel*," from which line it roams in summer northwards to the islands beyond Barrow's Strait,—is the slightly modified descendant of the old bubaline companion of the Mammoth and the Tichorhine Rhinoceros; the Musk-Buffalo then enjoying a much wider range, both in latitude and longitude, over lands that now form three divisions or continents of the northern hemisphere of the globe. There appears to have been no degeneration in general bulk in the existing Musk-buffaloes, and the close wool and coarser hair which clothe them were doubtless the defensive covering of the pleistocene individuals, as of the co-existing Elephants and Rhinoceroses.

I should wish to be understood, however, whilst offering this interpretation of the facts and comparisons based on Messrs. Kingsley and Lubbock's British fossil, not to be pronouncing absolutely as to the specific identity of the fossil and the recent Musk-buffalo. I am submitting merely the conclusion which, in the actual state of zoological philosophy, seems to me to be deducible from the premises at command. It is only since the publication of the illustrations of the "Zoology of the Herald," in 1852, that naturalists were made acquainted with the forms and proportions of the skeleton of the recent Musk-buffalo†. No entire skull of the pleistocene or fossil species has yet been obtained; the bones of the face are unfortunately broken away in the specimen, No. 24,591, IB, in the British Museum, from the beach in Eschscholtz Bay, which, from the retention of the horny case of the horns, Dr. Buckland could not consider as fossil‡. Of the forms and proportions of the bones of the extremities in the fossil Musk-buffalo we as yet know nothing. I do not, however, deem it probable that the parts of the skeleton less liable to variation than the horns will be found to manifest a greater amount of modification than those parts have presented in the specimens of recent and fossil skulls hitherto compared. And the extent and kind of variety observed in the horn-cores of the recent and fossil Musk-buffalo by no means lend support to the hypothesis that would derive all the forms of bovine animals from one specific stock. For no influences have been yet observed so to modify the horns of the Ox proper (*Bos*) as to diminish the interval between them and the Bison's (*Bison*); the horns of the Oxen may wholly disappear in certain breeds, but their place of origin, or relative position to the frontal bone, never varies. Moreover, the three leading types of *Bovidæ,—Bos, Bison,* and *Bubalus,*—were coeval in geological time, and were represented in Europe, Britain inclusive, by the *Bos primigenius, Bison priscus,* and *Bubalus moschatus* seu *Pallasii.*

In regard to the question of the extinction of some of these bovine species and contemporary *Herbivora*; although the argument for the fact of a diluvial cataclysm, at a recent date in geological time, which Cuvier deduced from the discovery of the carcass of an elephant preserved with its soft parts entire in frozen soil on the

* Sir J. Richardson, *loc. cit.* p. 23. † Fossil Mammals, pp. 66–87, pl. ii.

‡ See, however, the judicious remarks of Sir John Richardson on the conservative property of frost and frozen soil in regard to this specimen. *Op. cit.* p. 22.

coast of Siberia, and which argument Sir Charles Lyell was, I believe, the first to invalidate, has for some years lost all its weight, and the phænomena are now known to be explicable without any such reference to a diluvial or other cataclysm, it may not be without its use in diffusing true ideas of the conditions of the former existence of Elephants and Rhinoceroses in northern latitudes, to bring that argument face to face with the facts above stated relative to the *Bubalus moschatus*.

Supposing that the Musk-buffalo, like the Mammoth and Tichorhine Rhinoceros, had been known only as a fossil, the deductions from the habits and habitat of the nearest allied buffaloes, as to its unfitness for an Arctic clime, would have been as reasonable or plausible as was Cuvier's in regard to the Siberian elephant. The entire division of the bovine race, subgenerically separated as Buffaloes (*Bubalus*) from the Bisons (*Bison*) and Oxen (*Bos*), inhabit, it would have been urged, the warmer or tropical latitudes. The species which, in the form, proportions, and direction of its horns, makes the nearest approach to the Siberian fossil Buffalo is the *Bubalus caffer* of South Africa. What speculations might not have been indulged in as to the changes that had taken place, in the climate of the Ob, the Lena, and the Indigirska, since the period when the Buffaloes, whose fossil remains Pallas discovered in these inclement parts of Siberia, lived and ranged along the banks of those rivers! What temptations to elude the difficulties of explaining such changes of temperature, by invoking, with Cuvier, the vast and sudden diluvial wave that might have borne along the carcases of Buffaloes as well as Elephants and Rhinoceroses, from fertile regions to the land of lasting frost!

In the Musk-buffalo encountered by our enterprising and much-enduring Arctic explorers in Melville Island and Baring's Island, we have the living exemplification of the slight and superficial modifications which enable one species to find its appropriate theatre of existence in a far different latitude from the rest of its congeners. Ought we to have been much more surprised if some individuals—some lingering remnants of the species—of the two-horned woolly Rhinoceros, or even of the equally warmly-clad Mammoth, had been met with in the same rarely visited regions of Arctic America, deriving their subsistence from the thick forests near the Mackenzie, or resorting to the scattered clumps of spruce-fir that skirt the barren grounds between the 60th and 66th parallels of north latitude?

The conclusion from present evidence seems to be that the circumstances which have brought about the extinction, probably gradual, of the northern Rhinoceros and Elephant have not yet effected that of the contemporary species of Arctic Buffalo.

TABLE OF ADMEASUREMENTS.

	Fossil.							
	Pallas.			Lubbock.			Recent old male.	
	in.	lin.		in.	lin.		in.	lin.
Breadth of the cranium between the orbital borders	11	4	...	11	0	...	11	6
Greatest transverse diameter of the occiput	8	6	...	7	6	...	8	3
Vertical diameter of the occiput from the middle of the super-occipital section to the upper border of the foramen magnum	4	0	...	3	6	...	4	0
From the outer border of one occipital condyle to that of the other	6	0	...	5	0	...	6	0
Antero-posterior diameter of the base of the horn-core	9	0	...	7	0	...	10	0
Length of the horn-core (following outer nerve)	0	0	...	11	0	...	12	6
Depth of the intercornual groove	0	11	...	0	8	...	0	11
Breadth of the intercornual groove	0	6	...	0	6	...	0	7

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2. *Note on the* GRAVEL *near* MAIDENHEAD, *in which the* SKULL *of the* MUSK BUFFALO *was found.* By J. PRESTWICH, Esq., F.R.S., F.G.S.

THE Valley of the Thames, broad and open in the tertiary area as far as Maidenhead, there contracts into the comparatively narrow and circuitous gorge through which the river traverses the chalk hills by Henley, Reading, and Pangbourne. To this point also extends an extensive mass of ochreous gravel, stretching in a continuous and uninterrupted sheet from the sea to Maidenhead, a distance of 50 miles, from 2 or 3 miles to 8 or 9 miles wide, and with a thickness of from 5 to 15 feet*.

The great bulk of this gravel is composed of subangular chalk-flints, derived, it may be presumed, from the destruction of portions of the adjacent chalk-surface; whilst, as subordinate materials, we find a considerable number of perfectly rolled and round flint-pebbles, derived directly, not from the chalk, but from the lower tertiary strata and from the Bagshot sands; also a not inconsiderable number of hard quartzose sandstone-pebbles, pebbles of white quartz, slate, and other older rocks,—all perfectly rounded,—and these again derived, not directly from the rocks to which they originally belonged, but, as far as I can judge, all, without exception, from the conglomerates of the new red sandstone of Worcestershire and Warwickshire. A singular feature of this gravel is, that although the transport of this debris of the new red sandstone must have passed over the wide band of the oolites of the midland counties, yet but extremely few traces of these rocks are to be found. Of the Lower Greensand and sand of the Portland series a number of the small black pebbles belonging to

* It ranges much further westward, but forms narrower bands, or else detached masses, and loses its distinctiveness.

those beds are met with, but rolled oolitic fragments are very scarce. They do, however, occur, and one considerable block of coral rag was found last summer by Sir C. Lyell and myself in a gravel-pit near the Thames between Twyford and Henley. When this gravel reposes on the chalk it is generally mixed at its base with a large proportion of chalk-rubble, which sometimes is concreted and forms a thin solid base or pan to the gravel.

At various places in this gravel of the Thames Valley there have been found from time to time numerous organic remains consisting of land shells and bones of land animals. These it is not now my object to allude to further, except to state that they are not found constantly, but, on the contrary, only at distant intervals. Mr. Trimmer long since discovered them at Brentford, and last summer elephant remains were found in the gravel near Kingston. Mr. Blackwell has also found them far up the Valley of the Thames, or rather the branch Valley of the Kennet, at Aldermaston near Newbury. But although it was apparent that the same gravel extended over the greater part of the intermediate area, yet no organic remains had hitherto been noticed in the central district of Windsor and Maidenhead.

On the right-hand side of the Great Western Railway, just before reaching the Maidenhead station, there is a large gravel-pit which I had formerly visited, and which has of late been extensively worked for ballast. I had never found any bones in this pit; still the locality appeared very favourable for further research. Therefore, when, last summer, Mr. Lubbock informed me of his intention to spend a few days at Maidenhead, I pointed out this spot to him, and expressed a hope that he would examine it carefully. This he kindly undertook to do, and, to my great gratification, returned in a few days with the remarkable specimen of which Prof. Owen has given so able and interesting a description. Besides the skull of this Buffalo, Mr. Lubbock procured a few Elephant and other bones*, but in a very imperfect state. They were all found low down in the gravel—at the point where it becomes mixed with chalk-rubble, or on the top of the chalk itself. I only hope that he will return there again and follow up an investigation so well begun.

The bones, as usual in such situations, although very friable, are tolerably entire, or if broken are not worn. Nor does the gravel itself afford any evidence of long-continued movement or of much wear. If we eliminate from it the flint-pebbles derived from the tertiary beds and the pebbles of the older rocks derived from the new red sandstone, we have a residue of subangular flints which exhibit extremely little wear—nothing like that which would result from long-continued river or shore action,—and it is necessarily this residue which gives us the true measure of wear and tear which the mass has undergone. To this I wish merely to allude in passing, as it is a point

* I have since visited this pit and obtained part of a tooth of the Elephant. The workmen informed me that a considerable quantity of bones were found some time since at the other (west) end of the pit. At the east end, where they are now digging, they have found but very few bones.

which has been too frequently overlooked; it is of essential importance in considering the drift phænomena, but its fuller discussion I must reserve for a future occasion.

With regard to the age of this gravel, it belongs doubtlessly to the same period as the Kingston, Brentford, Kew, and London beds, which I am inclined to consider as amongst the most recent of our drift deposits, and as posterior to the period of the great Boulder Clay of Norfolk and Suffolk; but the exact relation of these deposits is nowhere clearly seen, and this question of relative age depends upon a variety of collateral evidence which I hope to lay before the Society at a future period.

In the meantime I may mention that although the boulder clay does not approach within twenty miles* of Maidenhead, yet there is another gravel in that district, distinct from the mammaliferous gravel, and showing that distinctive position tolerably clearly, although not so well as it is seen further westward.

Section of part of the Valley of the Thames, showing the relation of the high-level and the low-level gravels.

a. High-level gravel .... 5 to 10 feet.
b. Valley-gravel, with mammalian remains .... 5 to 20 „
c. Mottled clays (lower tertiary).
d. Chalk.

Thus immediately from this plain of gravel there rises near the Maidenhead station the chalk hill on which Taplow stands. This hill forms a ridge connected with the hills at Beaconsfield and above Wycombe. Over these hills and extending as far as Taplow is another gravel very similar in many respects to that in the valley, but always on a higher level, and without organic remains. It is an older gravel. In the same way the hills of Bagshot and Windsor Forest to the southward of the Thames Valley are capped by older gravel. Both these possess some peculiar and interesting features, but the description of them I will reserve until I can bring the subject before you in a more complete form. My object on this occasion is merely to point out the position and general relation of the gravel in which the very remarkable fossil, the subject of this evening's important communication by Prof. Owen, was found, and not at present to occupy your time by any independent inquiry on the physical phænomena considered apart.

* The nearest places to which I have yet traced it are on the Finchley Hills; and it extends probably as far as Hendon Hill.

3. *On some Geological Features of the Country between the* South Downs *and the* Sussex Coast. By P. J. Martin, Esq., F.G.S.

The object of this paper is not so much to give a minute description of the district I am about to review, as to promote a discussion amongst the members of the Society here present on some of its phænomena, which seem to be singularly illustrative of the superficial changes that have been effected in the south of England by dynamic forces of comparatively modern date.

The district is to be found in the ninth section of the Ordnance Map, and extends from near Portsmouth to Shoreham, or that flat country which is to be seen from any part of the tops of the South Downs from Portsdown Hill eastward to the Shoreham River.

If time serve, we may perhaps be induced to extend our views as far as Brighton. The cliffs of Brighton and its raised beach have been so often described, have given rise to so much discussion, and so little new can be said about them, that I have in my own mind set them down, and the beach in particular, as amongst those *specialties* (like terrestrial surfaces, patches of modern, or recent, or post-pliocene deposits with correspondent fossils) which cannot be ignored, but which I hope some day to see brought into harmony with the simpler actions of consentaneous elevation and denudation, which I, and much abler geologists than myself, have endeavoured to expound.

The first remarkable feature of this tract of country which I propose for your notice, and which brings it into the same category with all the disturbed districts of the south-eastern part of our island, is an anticlinal line of chalk-elevation, extending from Portsdown Hill into the sea at or near Worthing. Portsdown is on its northern slope; its ridge, or line of culmination, runs by Emsworth and West Thorney to Donnington and Hunston, south of Chichester (here much obscured by drift), and then less obscurely by Climping and Ford to the Arun. From thence it passes between Leominster and the hamlet of Wick, and rises suddenly on its northern slope, like Portsdown, in another, but smaller, eminence called High Down*. From thence, I believe, it goes out to sea and is lost, unless it approximates to the South Downs east of the Ouse, and produces the synclinal tertiaries of Newhaven and Seaford.

This anticlinal brings up at Hunston and elsewhere along its range, a portion of the white chalk, characterized by *Marsupites*, which I regard as higher in stratigraphical position than the so-called "upper chalk" of the south-eastern counties of England. This uppermost chalk is soft and marly, and without flints; it is called "free-chalk" or "marl"; and is dug for manure at Stoke and Lavant. It appears also along the base of the chalk-escarpment at Halnaker and a few other places in West Sussex, but does not occur on the Downs, which have lost this upper member of the chalk-series by denudation.

North and south of this chalk-elevation are two synclinals or

* These eminences were described as "outliers by protrusion" in Mr. Martin's 'Geological Memoir on a part of West Sussex,' 1828.

troughs of tertiary deposits. Eastward from the Forest of Bere the tertiaries of the northern synclinal have been much denuded, and are mixed up with an enormous quantity of drift, to be hereafter described. They emerge again from this drift, and appear in considerable force in the high grounds between Chichester and Arundel, in Eastergate, Walburton, and Binsted. East of the Arun, again, they expand into the woody districts of Angmering, Clapham, and Castle Goring in the rear of High Down, where a great mass of eocene gravel has long been worked out for economical purposes. The southern synclinal is occupied by the well-known Bognor beds and the Bracklesham eocene; and these and the London Clay, or its equivalent, form the basis of all the flat country south of Chichester, called the Manhood. I do not think that the Bracklesham beds have any inland outcrop; but the London Clay is extensively exposed in Siddlesham, Birdham, and the north part of West Wittiring. Wells in the last-mentioned parish have furnished me with the geodes or septaria of the London Clay; but I have not been able to pick up any fossils from the same. The cement-stone is also dredged up in the adjoining part of Chichester Harbour. Wells and excavations in the southern part of Birdham and in Earnly furnish a fawn-coloured micaceous sand—perhaps the Thanet Sands.

This will suffice to prove that the basis of all the plain south of Chichester is the stratified beds which assimilate to those which occupy the valley of the Thames. A great deal of drift reigns paramount over all; and the most interesting part of this material is the deposit to be found south of Siddlesham,—consisting of loam or brick-earth, extensive beds both of rounded gravel and angular flints, the former much predominating, with large boulders of granite and other crystalline rocks; the whole exhibiting much of the heterogeneous and tumultuary character of the boulder-drifts of the eastern counties.

The high grounds of Selsey are entirely composed of these deposits. Extensive shingle-beds spread in all directions through the eminence on which the village of Selsey stands, which eminence rises 25 or 30 feet above the sea; and they are carried on eastward about the church, and on into the flat called the Harbour, a branch of Pagham Harbour, producing there a remarkable phænomenon called the "Hushing Pool," described by the county historians as amongst the most remarkable natural curiosities of this district*. The boulder-drift dies out as we come north from Selsey, though there is good reason to believe that it was once spread over all the district, for large masses lie here and there over the parishes of Birdham, Siddlesham, and Hunston, or are occasionally brought to light by the plough†.

North of Hunston and Donnington, and of all the chalk-anti-

* It is simply the bubbling and hissing produced by the disengagement of the air from the gravel before the incoming tide.

† The font of Yapton Church is of granite, which, if not found on the spot, was most probably not brought from any great distance, as the fonts of this country are mostly of Purbeck marble.

clinal before spoken of, extensive beds of angular gravel prevail, containing sometimes eocene pebbles, and, more especially as we approach the Downs, forming the "supracretaceous" zone of drift I have elsewhere described as mantling round the nucleus of the Weald.

These drifts have been so well described by Sir R. Murchison in his paper* on the flint-drift of Sussex, that I need not enter into further detail respecting them. The great occasional mixture of these angular gravels with the shingle-beds of the eocene has escaped the notice of Sir Roderick. This mixture is very remarkable about Boxgrove and Crocker Hill on the Chichester road, and at Halnaker, and indeed is common to all districts where relics of the lowest tertiaries are to be found.

Much stress has been laid on the colour and general appearance of these gravels, the white being considered as of the newest order. The flints that are found mixed up with chalk-rubble have a white coat, and the angular gravel that is mixed up with ferruginous sand or brick-earth is brown.

I consider these as accidental circumstances; and, although the gravel arising from the earliest chalk-denudations may exhibit a browner colour and greater marks of antiquity, whilst that which was last produced, when the denuding forces were in operation, appears to be more recent, yet there seems to be no ground for the belief that they belong to distinct eras or other agencies than are common to both.

[The above notice of the geology of part of Western Sussex comprised the written portion of the communication made by Mr. Martin, and was preliminary to the verbal exposition of the author's views on the relations of the boulder-deposits of Bracklesham and the neighbourhood with the older tertiary and cretaceous strata, on the one hand, and with the superficial gravels and brick-earth on the other; a subject closely connected with the author's previous researches in the geological history of Sussex and the Wealden district†.

A paper by Mr. Martin, illustrative of this subject, was unfortunately mislaid after having been read before the Geological Society in 1840, and not found again until about 1848. The author was subsequently enabled to publish it in the 'Philosophical Magazine' (see Mr. Martin's "Memoir on the Anticlinal Line," &c. 1851) with additional observations; and, at the request of the President, who took advantage of the opportunity to express the Society's regret for the temporary loss of Mr. Martin's memoir above referred to, Mr. Martin favoured the Meeting with a general exposition of his views on the Wealden denudation, as far as time allowed, on the occasion of his reading the paper now printed.

In this communication the author assigned the boulder-drift lately

* Quart. Journ. Geol. Soc. vol. vii. p. 347.

† See Mr. P. J. Martin's Memoir on the Anticlinal Line of the London and Hampshire Basins (8vo, 1851) and Supplement, 1854; in which also his previous writings on the subject are referred to.

brought to light by Mr. Godwin-Austen to an outer zone of Wealden drift, in addition to those which he had already described as mantling round the nucleus of the Weald; the corresponding parts of this zone, he thinks, are to be found in the valley of the Thames, and perhaps yet to be discovered amongst the Greywethers and other relics of the Tertiaries found on the chalk-country of Hampshire and Wilts. The above-mentioned zone is regarded by the author as the remains of the boulder-deposit which is spread over the tertiary countries of this and the adjoining parts of the North of Europe, before their continuity was disturbed by the upheaval of the great anticlinal of the South of England.

The country immediately under review, Mr. Martin regards as a sectional part of this great anticlinal, and not to be considered apart from the wide geological area to which it belongs. He considers that its phænomena of arrangement and drift belong to the epoch of that upheaval, and betoken the agencies of powerful diluvial currents, set in motion and contemporaneously assisted by the dislocations known to abound in this part of our island; and without the aid of which no satisfactory conclusion, in the author's opinion, can be deduced respecting the drifts and the other phænomena of the denudations and surface-changes here exhibited.]

January 9, 1856.

H. P. Hakewill, Esq., was elected a Fellow.

The following Communications were read:—

1. *On the* Physical Geography *of the* Tertiary Estuary *of the* Isle of Wight. By H. C. Sorby, Esq., F.G.S.

[This Paper has been withdrawn by permission of the Council.]

(Abstract.)

In this paper were first described the currents due to the action of the tide and stranding surface-waves in an estuary, and the relations between them and the physical geography of the limiting shores. These are such, that, if the direction and character of the currents were known, the physical geography of the area might be inferred within certain limits. After this were explained the various structures produced by currents in strata formed under their influence, from which the direction, velocity, character, and depth of the currents can be ascertained. This was followed by an account of the directions and other peculiarities of the currents indicated in the various sandy and other strata of the tertiary formations at numerous localities in the district under consideration. From thence the author obtains data from which many peculiarities in the physical geography of the coast-lines of the tertiary land and sea in the area now occupied by Hampshire and the Isle of Wight can be deduced. The chief of these characters are

that during the tertiary period there was formed a wide estuary of a large river, running from the west towards the east; that the land from which the river came must have been to the north, the west, and south-west, whilst the estuary opened into a tidal sea towards the east; and that at the western part of the Isle of Wight area there existed a considerable shoal. This explains why the section of the tertiary deposits at Alum Bay is so very different to that at Whitecliff; where there was no shoal, but a tidal channel too deep to be affected by the action of the waves of the surface.

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2. *On the* PERMIAN CHARACTER *of some of the* RED SANDSTONES *and* BRECCIAS *of the* SOUTH *of* SCOTLAND. By E. W. BINNEY, Esq., F.G.S. In a letter to Sir C. LYELL, V.P.G.S.

AT the conclusion of the paper on the Permian beds, printed in our Manchester Memoirs this last summer, I gave the following as the greatest thicknesses of the different beds in the descending order:—

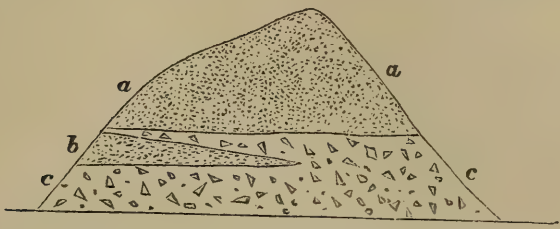
	feet.
1. Red and variegated marls, with gypsum in the north, and thin beds and nodules of limestone in the south of the district	300
2. Magnesian limestone, resembling the Yorkshire deposit	10
3. Conglomerate	350
4. Lower New Red Sandstone, of a soft crumbling character; some of the beds flaggy; the lower beds passing into red laminated marls at Westhouse	500
	1160

Below these occur the red and variegated sandstone of Whitehaven, which at present I do not include as Permian. In my paper I state that I am convinced that the conglomerate, or rather breccia, at Craigs and in the Cleuden near Dumfries are of the same geological age as the sandstones and conglomerates of Belah, Brough, Westhouse, and Humphrey Head, and I quote Professor Harkness on the thickness of some of those deposits.

Since the time you were in Manchester I have been down into the South-west of Scotland, and, after looking at the country, I have come to the conclusion that the red sandstone of Canobie on the Esk, Lockerbie, Corncockle Muir, Dumfries Thornhill, near Sanquhar, and Mauchline, as well as those of the West of Scotland generally, with the exception of the Annan beds containing tracks of the *Labyrinthodon*, will have to be classed as Permian, instead of Trias as they appear on most geological maps.

At Ballochmoyle Bridge is a fine section of the Upper Permian sandstone of Dumfries and of a purple-coloured conglomerate, or breccia, resembling the same deposit near Dumfries, except that the fragments and pebbles imbedded in the cement consist of trap-rocks instead of slates and Silurian rocks. The escarpment near the old bridge shows the following section:—

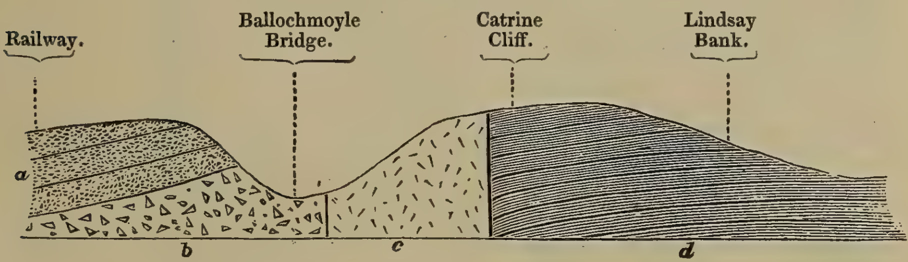
Fig. 1.—*Section near Ballochmoyle Bridge.*



a. Red-coloured sandstone, false-bedded; 60 to 70 feet.
b. Red sandstone.
c. Breccia; 30 feet.

Further up the river, a mass of amygdaloidal trap cuts off the breccia-beds on their rise, and thus prevents their lower portions from being seen; but about half a mile further up the stream towards Catrine, red marls and red and purplish sandstones, of great thickness, make their appearance, dipping slightly to the west. In some of the latter there are slight traces of fossil plants and beds of ripple-marked sandstones.

Fig. 2.—*Section from the Glasgow and South-western Railway to beyond Catrine.*



a. Red sandstone.
b. Breccia, dipping W. at an angle of 8°.
c. Dyke of amygdaloidal trap; running N.W.—S.E.
d. Red, purple, and variegated marls and sandstone; dipping W.

The breccia near Ballochmoyle Bridge dips due west at an angle of 8°. Some of the pieces of trap are rounded and others quite angular. The beds are divided by thin veins of sparry matter. The cementing paste has much the appearance of felspathic ash. After the trap-dyke is passed, and its breadth must be near a third of a mile, the sandstones and marls of Catrine Cliff occur. They dip very slightly to the west. As you pass through Catrine to Lindsay Bank you come to a great thickness of red and variegated marls and sandstones, some of the latter being ripple-marked flags, which near Lindsay Bank dip due west at an angle of 30°. I did not go up the river so far as Sorn; but, from the large fragments of breccia seen in the Water of Ayr, in the river above Lindsay Bank, I suspect that the Ballochmoyle Bridge deposit may again occur further up the river. All the beds about Catrine appeared to me to be very like Permian strata. The red sandstone at Ballochmoyle lies in wedge-shaped masses in the conglomerate (fig. 1), like the same deposits at Belah, Westhouse, and Flookborough (Humphrey Head).

The conglomerate and breccia, whether seen at Flookborough in Furness, Westhouse in Yorkshire, Belah Bridge and other places in Westmoreland, near Dumfries, at the foot of Criffel near the mouth of the Nith, or at Ballochmoyle in Ayrshire, present the same kind of paste or cement, resembling decomposed felspar, but the imbedded rocks vary as the rocks of the respective districts do; thus at Flookborough, Westhouse, Belah, and Brough, we have limestone fragments,—at Craigs and in the Cleuden, slates and Silurian rocks,—near Criffel, granite,—and at Ballochmoyle, trap; clearly showing that such rocks have been derived from the beds of the neighbouring districts, and not brought from a distance.

The circumstance of the large tract of the South-west of Scotland, hitherto coloured as Trias, proving to be Permian, must be of great importance to the ironstone and coal districts lying near it, and will in some instances no doubt allow such deposits to be followed under it. In addition to this economical advantage, the change cannot but prove highly interesting to the palæontologist, as it will enable him to remove all the tracks of animals found in the Corncockle Muir, Locker Bridge, Craigs, and Greenbank quarries from the Trias and place them in the Permian fauna,—a position where they will better fit, when compared with the continental deposits, than in their old place in the Trias.

January 23, 1856.

Richard S. Roper, Esq., and the Rev. S. Lucas were elected Fellows.

The following Communications were read:—

1. *On the* Cryolite *of* Evigtok, Greenland. By J. W. Tayler, Esq.

[Communicated by J. Tennant, Esq., F.G.S.]

The few remarks which I am about to offer relate to the mineral Cryolite*, and the nature of the district in which it occurs; and I propose to lay before the Society some observations which the exploration of a rich lead-vein situated in the Cryolite has afforded me the opportunity of making.

Evigtok (which signifies in the Esquimaux language "a place where there is plenty") is distant about twelve miles from the Danish settlement of Arksut, and forms a small bay in the Fiord of Arksut;

* See Thomson's 'Outlines of Mineralogy,' vol. i. p. 251; and Giesecke's article "Greenland," in the Edinburgh Encyclopædia, 1816.

it is a semicircular space of rather low irregular ground, surrounded by a ridge of mountains, rising abruptly to the height of about 2000 feet; making the enclosed space appear the half of a deep basin about two miles in diameter. Evigtok is noted in Greenland for its abundance of fish in the summer season; shoals of capelins blacken the small bays, whilst thousands of codfish swim close to the shore in pursuit of them, both of which are taken by the natives in large quantities. At the foot of the mountains and on their sides are to be found many grouse, hares, and arctic foxes. In the winter season immense flocks of eider ducks and other water-fowl resort to this part of the Fiord. Vegetation, such as it is in Greenland, also prospers here: a miniature forest of *Salix Arctica*, about 4 feet high, covers about a square mile, and the *Angelica, Rumex, Taraxacum, Potentilla,* and other plants are met with more abundantly than is general in Greenland; the spot appearing like a garden amidst the general barrenness of a land buried deep in snow nine months out of the twelve. But Evigtok is more remarkable as being the only place in the world in which the mineral cryolite has hitherto been found.

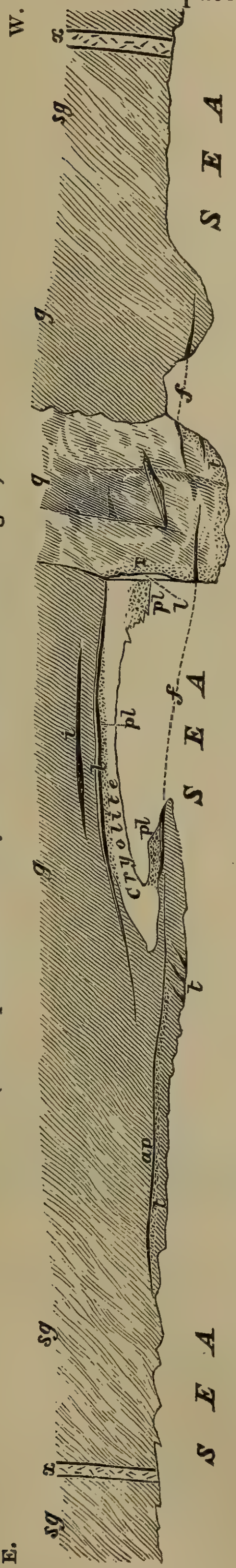


Fig. 1.—*Horizontal Section or Ground-plan of the Cryolite at Evigtok.*

(The exposure of the Cryolite is about 300 feet in length.)

g, g. Granitic gneiss, with quartz-veins.
sg, sg. Schistose gneiss and hornblende-schist.
x, x. Trap-dykes.
q. Quartz-rock, with felspar, cryolite, and ores of iron, tin, lead, zinc, &c.

f, f. Fluor-spar.
i. Sparry iron-ore.
ap. Arsenical pyrites, and tin.
pl, pl. Iron- and copper-pyrites, galena, and blende.

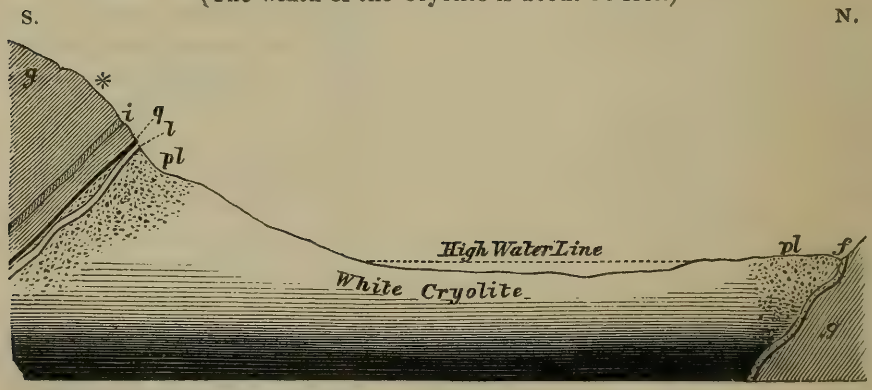
l, l. Galena.
t, t. Tin-stone.
T. Tantalite.

By reference to the horizontal section (fig. 1), two trap-veins will be seen bounding a space containing the cryolite and the minerals accompanying it. To this space I shall confine my remarks. The section is not drawn accurately to a scale, but it is about $\frac{1}{24}$ inch to the fathom.

Starting from the western trap-vein, which is situated in schistose gneiss and hornblende-schist, we find the gneiss gradually losing its slaty structure, until in the neighbourhood of the cryolite it becomes granitic, and now contains numerous metallic traces; before arriving at the cryolite, we find a wide vein of white quartz and felspar, running about S.W.; the quartz and felspar are in very large masses and crystals, some crystals of quartz measuring a foot in thickness. This rock is traversed in several directions by small veins and masses of cryolite, isolated from the larger body of that mineral, in which, as well as in the rock, are to be found numerous crystals of a variety of tantalite, oxide of tin, blende, molybdenum, much galena, copper-pyrites, arsenical and iron-pyrites, and sparry iron-ore. In this rock are many small caverns, arising from the decomposition of the felspar, and probably also from the decomposition of the cryolite, which is here porphyritic, containing crystals of felspar and quartz. The floors of these caverns are covered with loose crystals and fragments of felspar, and in some places kaolin, crystals of tinstone, and carbonate of iron. In one of these cavities is a large vein of arsenical pyrites and purple fluor-spar; also a large vein of black cryolite, containing copper- and iron-pyrites, and red felspar. Smaller cavities are found when blasting, the sides of which are completely covered with crystals of the tantalite, resembling on a large scale

Fig. 2.—*Transverse Section of the Cryolite at Evigtok.*

(The width of the Cryolite is about 80 feet.)



g, g. Gneiss.
i. Sparry iron-ore.
q. Quartz-vein.
l. Argentiferous galena.
f. Purple fluor-spar.
pl, pl. Galena, copper-pyrites, blende, iron-pyrites, and carbonate of iron scattered in cryolite.
* Fragment of cryolite was found imbedded at this spot.

the crystalline cavities in amygdaloidal traps. In this quartz- and felspar-rock there is a remarkable vein, containing soft ferruginous clay and rolled pebbles, sparry iron-ore, and copper-pyrites. The copper lies over the sparry iron, and runs in fine threads between the folia of the partly decomposed iron-ore, appearing as if it had run into it in a state of solution. To this quartz- and felspar-rock succeeds more granitic gneiss, in which the cryolite occurs; this gneiss gradually loses its granitic character as it approaches the eastern trap-vein, where it again takes on the same slaty appearance as at the western trap-vein.

We will now refer to the transverse section of the cryolite (fig. 2). The cryolite forms a bed or vein parallel to the strata, and is about 80 feet thick and 300 feet long; it dips to the south, at an angle of nearly 45°, and runs nearly E. and W. In the upper wall of gneiss, about 2 feet above its junction with the cryolite, runs a vein of sparry iron, with the same dip as the cryolite; and a layer of opake quartz-crystals lines the under side of the gneiss, between the iron-ore and the cryolite: sometimes sinking several feet into the cryolite, but never rising into the gneiss, is a vein of argentiferous galena, containing $83\frac{1}{2}$ per cent. of lead, and 45 ounces of silver in the ton of ore; this was worked during the year 1854–5, and some good ore was extracted. The cryolite below this vein is impregnated for a few feet with galena, copper-pyrites, and sparry iron-ore; but beyond, until within a few feet from the under wall of gneiss, it is quite pure and white; within 10 feet, however, of this under-gneiss, it again contains the same minerals disseminated, but is here separated from the gneiss by a vein of dark purple fluor-spar. The gneiss on both sides of the cryolite contains much fluor-spar disseminated.

The upper part of the cryolite at its junction with the gneiss is much decomposed, leaving many cavities, which contain loose crystals of sparry iron. At a depth of about 10 feet from the surface, the cryolite, although free from foreign matter, assumes a darker colour; and at 15 feet it is nearly black, and more translucent and compact; and, as the deeper we sunk we found the cryolite become darker, there is reason to believe that below this depth the mineral will be found to be wholly black. As the white cryolite is only found at the surface, and bears evidence of partial disintegration by having lost some of its compactness and translucency, it is reasonable to suppose that the cryolite was originally wholly dark-coloured or black.

When the black cryolite is heated to redness, it loses about 1 per cent. (moisture and acid), the whole of its colour, and part of its translucency, becoming perfectly white, like the cryolite at the surface. And from this fact we may conclude that the white colour of the cryolite at the surface has been produced by a similar cause. I consider it probable that the trap now found at each end of the cryolite has formerly overlain it, heating it superficially, and rendering it white; there are at present no remains of overlying trap between these two veins, but in this country the trap and allied rocks disintegrate most rapidly from the effects of frost. The cryolite itself has considerably decreased, from this and other causes; for I found a piece of it imbedded in the upper gneiss, more than 8 feet above the highest part of the cryolite, proving that it formerly stood at that height.

In working the lead-vein, we sunk about 30 feet on the dip of the cryolite; it probably extends to a great depth, and exists in great quantity.

The fact of its solitary occurrence in this spot induces speculation in regard to its origin. The number of minerals, mostly crystallized, which accompany it, indicate some powerful and long-continued agency to have operated in a limited space. The few facts I have stated may suggest some opinions which may elucidate the as yet ill-understood subject of mineral veins. The cryolite has been hitherto applied to few purposes. The Greenlanders were the first to turn it to account, which they did in a curious manner, viz. the manufacture of snuff. They grind the tobacco-leaf between two pieces of cryolite, and the snuff so prepared contains about half its weight of cryolite powder. This snuff they prefer to any other. In Europe cryolite has been employed to a limited extent; but the recent discovery of the mode of preparing aluminium will probably render it a valuable ore of that metal.

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2. *Description of Remarkable* Mineral Veins.
By Prof. D. T. Ansted, M.A., F.R.S., F.G.S.

[This Memoir was preceded by an introduction, in which the author, after certain definitions, stated the class of facts which he considered it desirable should be recorded by mining engineers in investigating mineral veins, in order that their observations might be available for scientific purposes.]

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1. *The Cobre* (*Copper*) *Lode of Santiago de Cuba.*

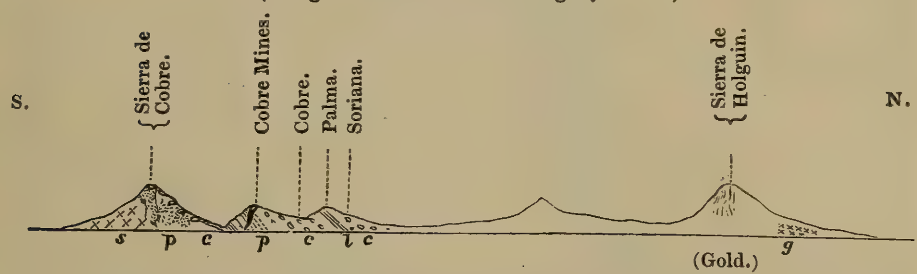
As being a very exceptional and remarkable vein, and one which possesses a remarkable geological interest, I have selected for this memoir the great Cobre lode, and I propose to describe and, as far as possible, explain the conditions of this vast deposit of mineral wealth. I select it with the greater readiness, as it has not hitherto, I believe, been the subject of scientific investigation, although known for twenty years as the richest copper lode which has within that period been the object of continuous mining operations in any part of the world.

Position of the Lode.—This deposit of copper ore, opened in a hill near the small town of El Cobre, is about eight miles W.N.W. of the town and magnificent harbour of Santiago de Cuba, the mines being directly connected with the harbour by a railway, which takes advantage of the valley of the Cobre River to reach the mining district. There is a fall of about 300 feet from the plateau on which the town is built to the sea, and the hill on which the principal crop of the lode takes place is about 300 feet above the level of the railway. The line of railway running nearly parallel to the principal direction of the sierras, both along the coast and in the interior, gives some little insight into the structure of the country, and to the facts observed in the cuttings I shall have occasion to allude presently.

Structure of the Country.—Commencing with the plateau on which the town is built, we find towards the south a considerable mountain-chain, consisting of highly calcareous porphyritic rocks, passing into and associated with basalts and a peculiar conglomerate, while to the north, at some distance, are hard beds of limestone. I submit a general section (diagram fig. 1) through the eastern part of the island of Cuba, crossing the mining district, which will give a sufficient idea as to the allocation of the beds. It will there be seen that the beds of greenstone and porphyry appear to overlie the conglomerates, green grits, and hard limestones, and these in turn are overlaid by newer tertiary limestones developed near the coast. For this section I am partly indebted to M. Quintana (Government Inspector of Mines of the district), who had crossed the island as far as Holguin in the central plains. My own observations were confined to the mining district and the north and south coasts.

Fig. 1.—*General Section across the Eastern End of the Island of Cuba.*

(Length of Section about eighty miles.)



c. Conglomerate. *l.* Limestone. *p.* Porphyry. *s.* Syenite. *g.* Granite.

The mineral veins occur in the large-grained porphyry already alluded to, near its contact with a coarse conglomerate, both conglomerate and porphyry being extremely calcareous. The general direction of the mountain-ridges and watershed, the strike of the porphyries and conglomerates, and also the strike of the lodes, are all approximately east and west, this being also the direction of the south-eastern coast of the island of Cuba.

The dip of the lodes is to the south, and that of the bedded rocks to the north, but the former are much more nearly vertical than the latter. Towards the east the coast range is syenite, and it is not unlikely that this syenite extends to or is repeated in the west side of the harbour, south of the mines. Of this, however, I have no positive proof. It is worthy of notice that the whole of the mountain-tract forming the south-eastern extremity of Cuba, is remarkably subject to earthquake action, two months rarely elapsing without a shock, while towards the centre of the island and to the west no shocks are ever felt.

The surface of the ground, both in the neighbourhood of the mines and elsewhere in this part of Cuba, is so covered with tropical vegetation, and the ground for the most part so impracticable, that any continuous survey is impossible, so that many observations, elsewhere matters of course, are here of necessity reduced to mere inferences.

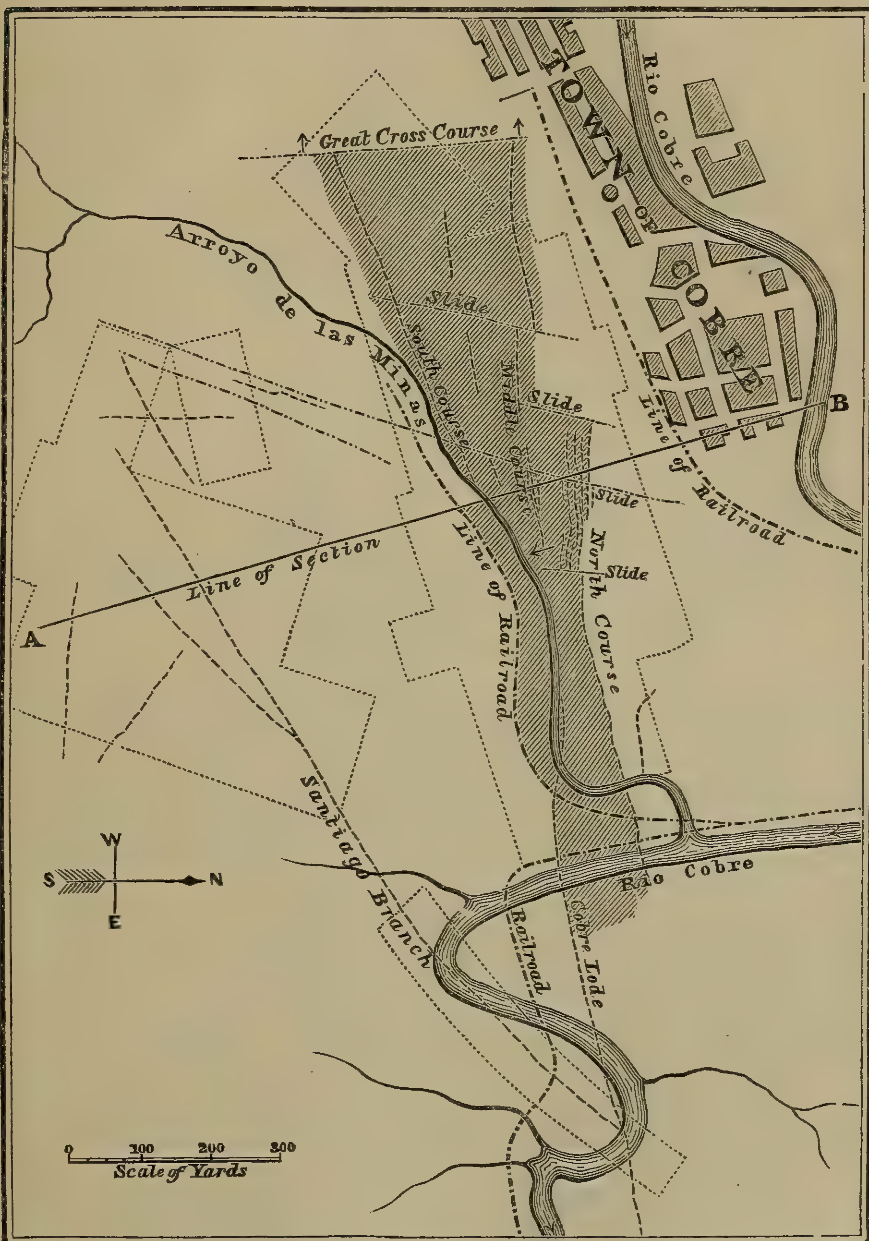
Dimensions of the Lode.—The Cobre lode, as at present known, is limited in its crop to a distance of about a mile, but it probably ranges further to the east. Near the eastern extremity a branch is given off, making an angle of about 30°, and proceeding south-west. At the bifurcation, which is well seen on the steep banks of the Cobre River, both lode and branch are nearly vertical, and the latter is large; but as it proceeds it becomes irregular, and is broken up and intersected by numerous threads and strings. The main lode is cut off to the west by a cross course, after being heaved by several slides of small amount. See fig. 3.

Fig. 2.—*General Map of the Country around Cobre.*

(The arrows mark the dips.)

Although the whole extent of the lode, as known by the crop, extends to 1800 yards or thereabouts, it is but a small part of this that can be regarded as valuable. The whole workings on the principal vein are limited to a linear extension of 800 yards, and the

Fig. 3.—*Map of the Mineral Field of Cobre, Island of Cuba.*



Limits of Concessions.

Lodes and courses of ore.

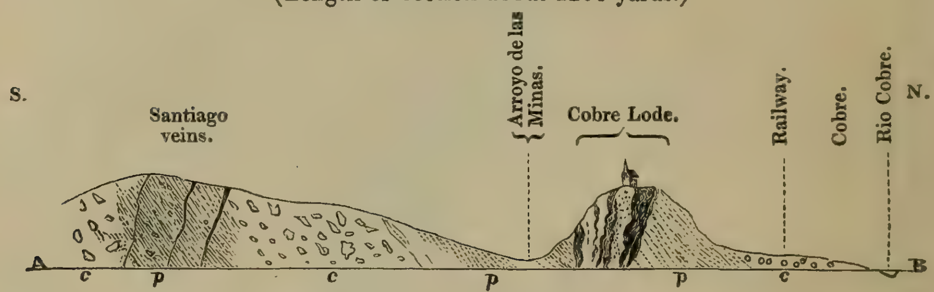
Heaves and cross-courses.

The breadth of orey ground in the great lode, approximately marked.

extreme breadth of the ground, including all the parallel rich branches, is less than 200 yards; so that within a narrow space of about thirty acres are crowded the whole of the "plant" and buildings of two extensive mines, and part of a third, with dressing-floors and ore-heaps on a scale rarely seen*, as it seldom happens that so much ore has been raised from a single group of lodes of such small extent. The diagram fig. 3 marks the limits of the concessions, and thus shows the small extent of surface; but it gives no idea of the crowding that has necessarily resulted from the form of the ground, which is extremely broken, and in many parts precipitous. The section fig. 4 will, however, assist in giving an idea of these peculiarities.

Fig. 4.—*Section across the Mineral Field of Cobre.*

(Length of Section about 1200 yards.)



c. Conglomerate. *p.* Porphyry.
A.B. Line of Section on the Map, fig. 3.

Contents of the Lode.—The rich part of the lode is for the most part contained in the precipitous hill on which the old and now ruined church stands, and the ground here, at one time the source of litigation amongst three companies, is now entirely undermined. The enclosing "country," of which the shell of this hill is composed—the contents consisting almost entirely of veinstone, formerly largely mixed with red ore (of which nearly a million tons have been removed),—is a confused mass of material scarcely distinguishable from a coarse breccia of the adjacent porphyries, with the exception of some more schistose portions, and of grits met with in descending. This material, identical with that which formed the hill now fissured, has no doubt fallen into the cavity or rent formed by some subterranean elevatory force. The whole group of lodes may be described as a multitude of yawning cavities, connected with innumerable smaller crevices, having, for the most part, an east and west extension, but crossed by other crevices of the nature of small faults or heaves, all more or less nearly at right angles, and terminated towards the west by one such cross-course, beyond which no ore has yet been found.

Towards the east, the crevices or veins become gradually of less importance, and pass into a vein containing but little valuable ore, though clearly traceable for some distance at the surface. (See map, fig. 3.)

The whole outcrop of the great lode on this hill has been so much

* At the time of my visit there were not less than 5000 tons of dressed ore ready for shipment belonging to the Cobre mine alone.

disturbed, and there remains so little of the original gossan to examine, that the real characteristics of the gossan and crop can only be made out by close investigation. It would seem, however, beyond a doubt, that the appearances must originally have been very remarkable, consisting of an enormous breadth of ferruginous earthy mineral, much of it of a bright vermilion colour, very soft and easily removed, and containing, at various depths, down to sixteen or seventeen fathoms, so large a per-centage of black oxide of copper in a powdery state, that this mineral alone, for a long time, was obtained by simple digging, and sold at a low price to the original proprietors of the Cobre mine. With the black oxide, there was, however, a considerable quantity of red oxide, and of blue and green carbonates, crystals of great beauty having been frequently obtained; whilst, in any hollow space that might exist, or be left after superficial workings, large stalactitic masses of sulphate of copper accumulated. As a specimen lode, however, the Cobre has long ceased to exist, though singularly large and perfect crystals of iron pyrites are still not unfrequently met with, and sulphates might be found in abundance in neglected workings.

The whole of the ground to the depth above stated (sixteen fathoms) appears to have been largely impregnated with copper; but down to that level, sulphurets of the ordinary kind were either not found or were partly decomposed. This at least appears to be the recollection of those who saw the mine in its early stages, and it is well known that the yield of the ore was then very high, and the supply chiefly oxide.

Below sixteen fathoms, however, the gossan appears to have terminated, passing down at once into valuable and solid sulphurets, occupying a large breadth of some part or other of the wide space of orey ground which was still traceable, and which ranged between what were called the north and south lodes. A section across this part of the lode shows it to consist of three courses of ore, the northernmost of large size, though variable in width, underlying to the south, and especially rich at moderate depth; the middle less regular and less valuable, and diminishing as it goes down, though generally traceable; and the southernmost, smaller and less regular than the northern, but still a steady course of ore, rather improving in depth, and nearly vertical. Between these, not only is the ground generally mineralized, but pockets and bunches of rich ore have been so often met with, that every part of the space is worth exploring, while many bunches of ore have been found outside the walls both of the north and south courses of ore.

Heaves and Cross Courses.—The north course of ore has been affected by several small heaves, some of which have not reached the south course. The north course also, about the middle of the rich ground, has apparently possessed the largest and richest branch of ore yet found. All the heaves and cross courses dip west, ranging a little east of north and west of south; and the great north course of ore dipping south, while the south course is vertical, there would thus appear to be a tendency in the orey parts of the lode to unite at a certain depth. Everything seems to show that the various deposits occupy the gaping mouths of a fissure which is of moderate dimensions below, although expanding, and containing much rich ore near the surface.

Breadth of orey ground.—The magnitude of the deposits of ore is often so large, that a breadth of ground amounting to from twenty to forty feet required to be removed, leaving only very small and insufficient arches.

Timbering on the grandest scale has therefore been resorted to, to prevent accidents; and it is not unusual to see pairs of spars, consisting of trees hewn square and having a section eighteen inches square lashed together, placed to meet at an obtuse angle midway, and strengthened with diagonal bracings, forming a solid construction, like the vaulted roof of a cathedral. Those only who are conversant with the difficulty of introducing such spars into the small shafts of a mine, and handling them underground so as effectually to serve for the purpose intended, and preserve the mine for years without danger or accident, can do justice to the science and engineering that have been brought to bear on this part of the mining operations of the Cobre Company, and it is only a just tribute to the skill and activity of the successive managers (all, I believe, of Cornish experience) to allude to so important a part of the œconomy of these remarkable mines.

Mundic.—Within the various parts of the lode are found at intervals, and at all depths, large quantities of mundic, or iron pyrites, often highly crystalline. Much of this occurs between the north and south deposits of ore; and, in addition to the masses, and detached crystals, the copper pyrites are not unfrequently so completely coated with this worthless mineral as to render it impossible to estimate their value by the eye. This is the case more in the upper than in the lower levels.

Veinstone.—The Cobre mine is open at present to the 160-fathom level below adit; and, although a fair proportion of reserves exists in the lower levels, it will be readily understood by those accustomed to mining in rich veins, that only a few arches of ground have been allowed to remain in the upper part of the mine. The communications between the different courses of ore at the different depths, and the cross cuts out of the lode to north and south, at various points, as well as the appearance of the lode, where now being removed, are all extremely interesting and instructive. The enclosing country, and the ground between the courses of ore, appear to become more compact and regular in descending, and are occasionally very hard. At the 140-fathom level the lode becomes gypseous, considerable quantities of white alabaster appearing without sensibly affecting the value of the ore; but the veinstone a little below becomes very hard, and in some parts of the lode the ore ceases altogether in the vicinity of the gypsum.

At the lower levels, the heaves and cross courses appear to have rather more influence than near the surface, at least with regard to the quantity of ore.

Temperature.—The temperature of the lode in the upper levels is about 90° Fahr., both in the levels themselves, and wherever I could place a thermometer in the rock. At ninety fathoms I noted in one place a temperature of 96°, and in a small neglected working on the south course of ore an exceptional temperature of 101°. At this point, which was not without ventilation, being close to a shaft, the heat was very sensible, but the air did not appear to be tainted with any disagreeable odour. I noticed, however, much iron pyrites thereabouts. Lower down, the air becomes much cooler, and in the 130-fathom level I observed the thermometer to stand at 86° in a small sump near a slide, and at 88° in a hole opened in the rock, not in the orey part of the vein. In many parts of the mine, both men and boys work entirely naked, and although, while underground, I did not notice much difference in the temperature, as compared with deep mines in other countries, the subsequent exhaustion was far greater than is usual in temperate climates. The mines and district are by no means unhealthy, although there has often been considerable mortality amongst the white (Cornish) hands, owing to the want of prudence and caution whilst above ground. I was pleased to find a cage provided in the Cobre mine to lift the miners after their work was concluded.

Recapitulation.—I may now sum up as follows the principal results of my observations on the western or productive part of the Cobre lode.

1. It includes three courses of ore regarded as distinct, nearly parallel to each other in strike, but gradually approaching as they go down, two of them unusually large and rich, and the third (the middle) of smallest importance, the northernmost (on the foot-wall) being chiefly affected by certain small heaves; but all the orey ground terminated by a cross course to the west. The intervals between the three courses of ore are occupied by a conglomerate or breccia, consisting of fragments of decomposing porphyries and greenstone, abounding with lime, passing into a compact whitish green porphyry. Associated with the courses of ore, the veinstone, and the country, are large quantities of iron pyrites, and at a certain considerable depth the veinstone contains gypsum.

2. Regarding the three courses of ore together as parts of one great lode, nearly 200 yards wide at its crop, this lode may be described as dipping moderately to the south, as shown in fig. 4, p. 148, the orey portions being chiefly near the hanging-wall and the foot-wall, but extending occasionally and irregularly not only into bunches and strings in the intervening veinstone, but also into the country, both north and south of the lode. The whole of the adjacent rock is also highly mineralized.

3. Not only the lode, but each of the principal courses of ore appears to be well indicated at the surface by a distinct gossan, consisting of spongy quartz and iron oxide of the usual kind, and highly coloured clays and marls, immediately beneath or amongst which have been oxides, carbonates, and sulphurets of copper. At greater depth, the yellow ore (a sulphuret of copper and iron) en-

tirely replaces the other metalliferous minerals, the proportion of iron gradually preponderating on going down.

4. The *horses*, or areas of unproductive ground occurring within the lode and between courses of ore, consist for the most part of porphyry, identical in appearance with the rock outside the lode, but generally mineralized with iron and copper pyrites.

5. The metalliferous deposit, obeying the form of the ground, terminates abruptly to the west, where the hill is precipitous, and dies away towards the east. The heaves and cross courses do not carry ore.

The Santiago Lode.—Following the main lode from its chief development towards the east, its outcrop may be traced at intervals until we reach a point where a contra lode or main branch forms a junction with it. This junction is well seen in a natural section formed by the river-banks, and beyond it, towards the east, the outcrop continues remarkably strong, and possesses many points of interest. The contra lode or branch makes an angle of 30° with the main lode, and goes away to the south-west. It is seen at various points, and after about half a mile bifurcates, and is crossed by several small strings and subsidiary lodes, traceable in various directions, and not yet proved to be connected with each other in any important sense. Some of these strings and lodes are of considerable size (measuring underground from three to seven feet) and have shown, either at the surface or at some depth, very good coppery indications, consisting of oxides, carbonates, and rich sulphurets of copper. The gossans of such lodes have generally led down to bunches of unusually rich sulphuret, but no steady and continuous deposit has yet been proved to exist, resembling that found in the Cobre concessions. The country also is here less metamorphosed, calcareous green conglomerates replacing the porphyries, while elvans of porphyry occur amongst the lodes. Generally speaking, in this part of the mineral field the appearance of the lodes when cut underground has not been so satisfactory as might have been expected from the character of the gossans, and whilst the ore obtained has been of the finest quality, the quantity has been too small, and the supply too irregular, to secure a profit on the mining operations carried on.

Besides the group of lodes cropping out to the south of the Cobre, and connected with the Santiago lode, trials have been made on small gossany outcrops in the valley of the Cobre, to the north of the lode, and also in the ground to the west. Bunches of ore exist under these crops, but no valuable deposit of copper has been found.

Metamorphism of the enclosing rock.—Having thus described the circumstances of the Cobre lode, and its principal contra lode, it remains for me to allude to one very important fact regarding the enclosing and associated rocks. I have already described these as consisting of grits and conglomerates, passing into metamorphic rocks, which include porphyritic conglomerates, greenstone, and even basalt. The circumstances under which these changes take place are too remarkable to be passed over.

In passing along the railway from the harbour towards the mines, the first thing seen is a bedded greenstone-porphyry, and as the road tends to the north of west (intersecting the strike of the beds, which dip northwards), we come successively on newer beds. These include, first, shales and alternating beds of basalt, partly columnar and partly in concentric blocks of various dimensions. To these succeed bands of grit, and rotten altered rock, after which come in nodular sandstones and greenish grits with calcareous lumps, distinctly passing into greenstone and porphyritic conglomerate. This is the general sequence; but there is a special example near the bifurcation of the Cobre lode, which is also deserving of notice.

At this point the rock on the south side of the main lode and contra lode, as seen in actual contact with the vein, of which it forms the hanging-wall, is a fine-grained porphyry, compact and hard, and of crystalline appearance. At the distance of a few yards, this porphyry is succeeded by, or passes into, a conglomerate, made up of angular fragments, some of them of large size and of extremely irregular composition. At no great distance, but still to the south, and in a cutting close to the right bank of the Cobre river, a gritstone is seen, covered by conglomerate; and a little further off, in the direction of the branch, the porphyries altogether replace the grits and conglomerates.

Lastly, In a quarry close to the hanging wall of the great lode, and near its richest part, the green porphyritic rock is quarried for road material; while close by, to the south, and near the branch, the conglomerate takes its place. It is almost impossible to represent in a diagram the near approximation and complete intermixture of the crystalline rock with the bedded conglomerate, while the chemical characteristics of the two are sufficiently similar to justify the conclusion that one is only a modification of the other.

There are few or no marks of direct igneous action, in the ordinary sense of the term, with the exception of the bedded basalts, and other rocks of this kind.

Conclusion.—The Cobre lode is thus remarkable for its great magnitude and complication, its extraordinary richness, the high degree of mineralization of the surrounding "country," the nature of its enclosing rock, and the combination of metamorphic and mechanically formed rocks, in close contact, and frequent alternation. It possesses the ordinary characteristics of veins only in some respects, and is in others very anomalous. It is situated in a district not much resembling in any point those in which copper is usually found, and the general geology of the surrounding country would hardly indicate so rich and remarkable a deposit as that which has been proved to exist. The study both of the phenomena of the lode and of the surrounding rocks, would well repay a longer time than I was able to afford; and I shall be happy if my remarks, by attracting attention, may serve to the further elucidation of the exceptional appearances I have referred to.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

February 6, 1856.

The Rev. Thomas Wiltshire was elected a Fellow.

The following communications were read:—

1. *Notice of some* Raised Beaches *in* Argyllshire. By Commander E. J. Bedford, R.N.

[In Letters to Admiral Sir F. Beaufort, communicated by Sir R. I. Murchison, V.P.G.S.*]

Surveying Service, Lochgilphead,
August 21st, 1851.

Since my last report of progress I have made a more minute examination of the "raised beaches" which I therein alluded to. I have directed my observations to two in the locality of Lunga Island, a sketch † of each of which I enclose. "No. 1" is at the head of a deep bay in Lunga proper; "No. 2" is situated about the centre of the north isle of the group, or North Fullah. Guided by your

* This portion of the Communication was read before the Society on June 13, 1855; and an abstract of it was published in the Quart. Journ. Geol. Soc. vol. xi. p. 549.

† These sketches and others afterwards referred to are deposited in the Society's Library.

suggestions, I carefully levelled each for ascertaining their present altitude above high water mark, and for determining their horizontal position. The former gave respectively 40 feet 11 inches and 40 feet 4 inches; but, allowing for some little difference in the high water mark, I have given the mean as the altitude of each. The latter (No. 2) I found to be a plane, *perfectly horizontal*. The deposit is composed entirely of water-worn stones, of various sizes, from ½ cwt. to a pebble, and of the same character as the solid neighbouring rocks, without fossils, shells, or wood; which, however, is not surprising, as few shells are to be found on the shore; and they, exposed to a heavy sea, would become pulverized and difficult to trace; and wood is seldom met with. The shingle of No. 1 is covered by about 6 inches of a mossy soil; that of No. 2 is nearly exposed, and in places as clean as the daily-washed beach; and, whereas the first is but a short distance from and parallel to the present shore, exposed to the same direction of swell and exhibiting the same effects, that of the latter alone has the general character of a beach, as the present margin of the isle in the direction of the longest fetch is now low, broken, and rocky.

Lochgilphead.
August 29th, 1851.

Having been detained in Kerrera Sound, I was led by information to search for a deposit with fossils, which I was fortunate in finding; and, on levelling it, found it to be within 1 inch of the same height as the raised beaches before referred to. The base of the deposit being 39 feet 10 inches, the band about 1 foot in thickness=40 feet 10 inches;—40 feet 11 inches being the elevation given (or rather found) of the beach on Lunga.

The deposit contains fossils having the same appearance as shells now to be constantly seen thrown up by the sea and lodged in the cavities of rocks.

[In a letter to the Secretary of the Geological Society.]

Admiralty Survey, Oban,
October 31st, 1855.

I beg herewith to forward a tracing of part of the West Coast of Jura which exhibits the most remarkable raised beaches of the district; they can also be traced nearly to the northern extreme of the island; and there is a conspicuous one to the south. Upon the Isles of Colonsay and Oronsay they are equally distinctly marked; the bare shingle being exposed at the medium level of about 40 feet. I was not on the survey of Islay, but should think they would be traceable there also.

These beaches are remarkable under several considerations. First, their uniform level, although separated many miles apart, as between Loch Tarbert and Lunga eighteen miles, between Lunga and Kerrera fifteen miles;—secondly, their uniform horizontal position;—thirdly, the vast extent of exposed shingle, from the polished pebble the size of a pigeon's egg to the rough stone of near a hundredweight, covering many acres of land;—and fourthly, their undisturbed state, exhibiting every undulation, basin, and channel as when formed ages since by the thundering ocean-wave. With regard to the period and method of their formation, I must leave the subject to more experienced heads than mine,—gratified should the correct notice and illustration of them afford interesting matter for discussion to the members of the Geological Society.

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2. *On the* Section *exposed in the Excavation of the* Swansea Docks. By M. Moggridge, Esq.

[Communicated by Sir Roderick Murchison, V.P.G.S.]

Ancient legends which point out different courses for the Swansea and Neath Rivers from those which they at present take, induced me to watch the progress of the excavations made for the Swansea Docks from their commencement. Of my success in tracing the old bed of one if not both of those streams I need not here speak,—the *geological* features are those to which I would draw attention.

The Swansea Docks consist of a "half-tide-" and a floating-basin. They are situated on the brink of the sea, which lies to the S.E., while the N.E. boundary is the harbour through which flows the river Tawe. The entrance is from the harbour into the half-tide basin; and thence, through a large lock, vessels will pass into the main dock. The greater part of the stuff which has been removed consists of gravel and rolled stones, many of which have been transported full twenty miles.

The sections exposed varied greatly in different parts of the cuttings, but the best and most regular occurred at the N.E. end of the main docks exhibiting (August, 1853):—

1. Made ground, sand, and loose gravel of variable thickness from 20 feet to 6 feet.
2. Peat, with leaves, trees, &c., 2 feet.
3. Blue marine clay, 8 feet 6 inches.
4. Peat of rather greater density than No. 2, 10 inches.
5. Blue marine clay, 4 feet 1 inch.
6. Peat with trees, 3 feet 1 inch.
7. Brown clay and gravel, not penetrated.

The bottom of the dock is 24½ feet below high water and 4½ feet above low water at ordinary spring tides.

I have said "marine clay," because I found imbedded in it *Scrobicularia piperata*, a sea-shell still living on these coasts and burrowing in a similar clay now forming in some of our estuaries. The valves of this shell are dispersed in pairs throughout the whole of the clay, but abound most in the upper portion of each stratum.

As to the peat, I have been met with the remark, that it might have been brought together by submarine currents, and that therefore the *alternation* of sea and land was not proved. To this I answer that in very many cases roots still attached to plants which constitute a portion of the peat descend into and ramify among the clay, proving that those plants *lived and died* where they now are.

Thus then we have three beds of peat (2, 4, and 6), separated by two strata of marine clay (3 and 5).

In another place, four of peat and four of clay were exposed, but I chose the spot above referred to because the formations were horizontal, more regular, and easily measured. In the peat we find the oak, beech, birch, alder, hazel, and crab-tree still easily identified. The bark of the birch is little changed, that of the other trees has lost much of its character.

I have not met with any of the Coniferæ; but reeds and grasses abound. In the peat I could find nothing besides the vegetables composing it; the same plants occurring in the different beds, but less distinct as they became more distant from the surface.

The gravel (No. 1) in the dock-section, has, I think, been brought down from the very large accumulation of that material at Landore, $1\frac{3}{4}$ mile N., where water has cut through a deep deposit which appears to me to be an ancient moraine.

The origin or parent source of the gravel must be sought in the sandstones of the coal-measures, which have contributed the largest portion; the millstone-grit 20 miles N., next in abundance; the limestone 21 miles N., pieces of which are rare; and the Old Red Sandstone, 22 miles N., nearly as frequent as the millstone-grit. The size generally ranges from small gravel up to large shingle; but boulders have occurred, some large enough to require blasting: one of these was limestone.

Appendix.—*On the Sunken Portion of Swansea Bay.*

According to the ancient legends before referred to, Swansea Bay was once land, the sea-boundary running from the Mumble Point to near Aberavon, a distance of 7 miles. The present high-water line runs far into the land, there being on an average 3 miles between the actual and the traditionary limit of the sea, more than half of which is dry at the low-water of average spring tides. The western portion is said to have been covered by a forest called Silverwood. It is also stated that the Neath River joined the Swansea River near Swansea, and that their waters flowed out to the sea close to the Mumble Rocks.

How much of the legends may be true, we will not stop to inquire; but in the dock-cutting, I found the beds of two rivers and their junction, while the stool and root of many a noble tree covered at every high tide tell of the ancient forest.

The peat and clay extend along the shore 4 miles to the W. and 2 miles to the E. of Swansea; further on towards the Neath River the sand has accumulated to such an extent that I can only infer their continuity from the water being thrown out with considerable regularity, as if by the out crop of those impervious beds, and at the same level.

I know not how far these formations extend inland, but the uppermost is traceable from the shore for distances varying from a few yards to more than a mile (at Crumlyn Bog).

I ought perhaps to add that to the west of the Mumbles, we find a *raised beach*, while the contents of the caves show that the contour of the coast must have been very different in the days of the extinct quadrupeds to that which we at present see.

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3. *Notice of the* Recent Eruption *of* Mauna Loa, *in* Hawaii. By W. Miller, Esq., H.M. Consul-general for the Sandwich Islands.

[Forwarded from the Foreign Office by order of Lord Clarendon.]

(Abstract.)

The late volcanic eruption* in the Sandwich Islands broke out in August last, near the summit of Mauna Loa, which is 14,000 feet high and sixty miles from Hilo, Byron's Bay, in Hawaii.

The stream of lava, having a breadth of from two to three miles, continued to flow in a north-east direction until the end of October, when the lava-current, after having traversed a great part of the dense forest, appeared to have been checked in its progress at about ten miles from the town of Hilo.

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4. Experimental Researches *on the* Granites *of* Ireland. By the Rev. Samuel Haughton, M.A., F.G.S., Professor of Geology in the University of Dublin.

PART I.—On the Granites of the South-east of Ireland.

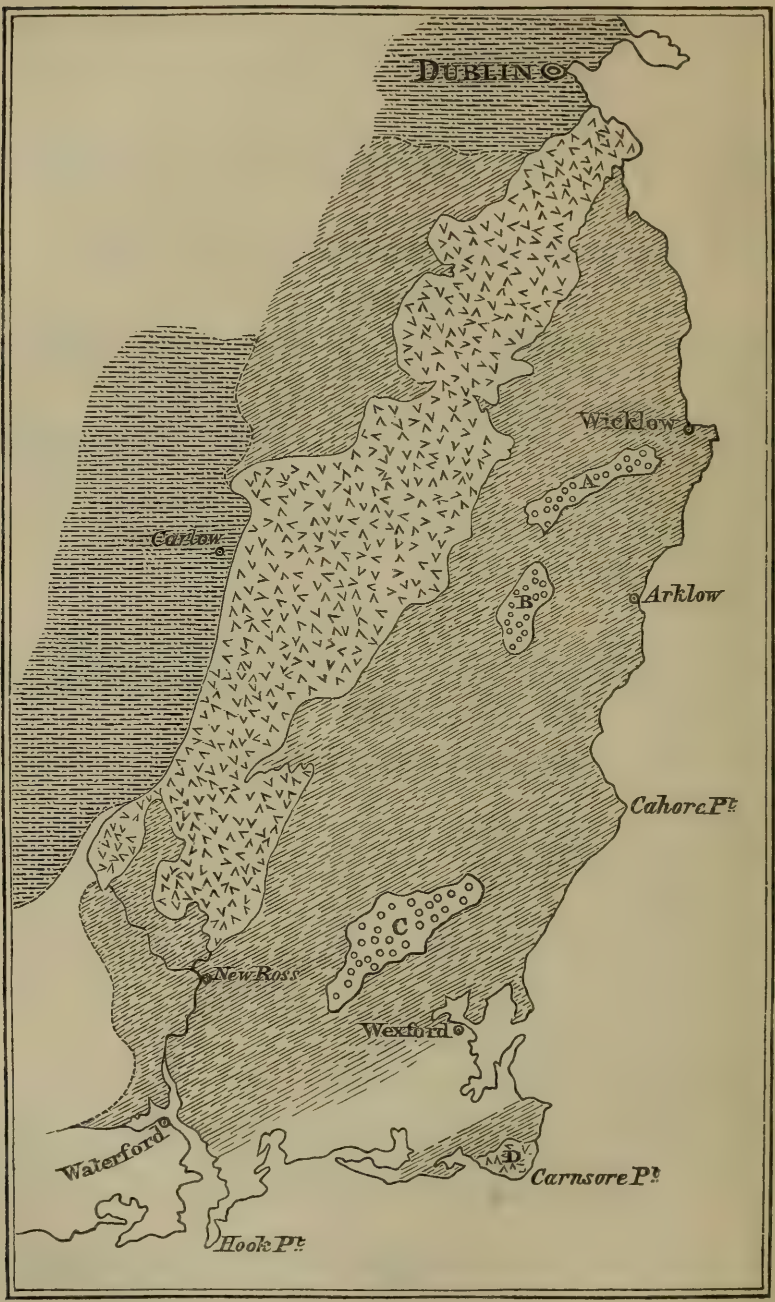
The granitic rocks of Leinster, or South-east of Ireland, occur in the counties of Dublin, Carlow, Kilkenny, Wicklow, and Wexford, and may be divided physically into two distinct groups (see Map, fig. 1, p. 172) :—

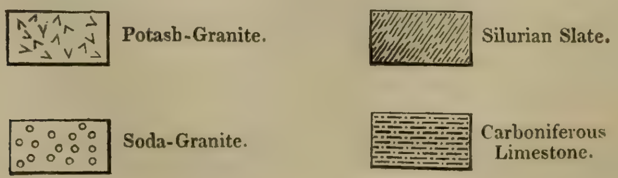
1. The main chain of granite-hills, extending from Booterstown, county Dublin, to Poulmonnty, in the south of the county of Carlow, within five miles of New Ross. This granite-chain is unbroken throughout its extent, and has a length of sixty-eight miles, and a breadth varying from eight to fifteen miles.

2. Besides the main chain there are about twenty isolated granitic

* For detailed notices of this eruption of Mauna Loa, by Messrs. Coan and Dana, see Silliman's American Journal of Science and Arts, vol. xxi. January and March, 1856.

Fig. 1.—*Map of the Leinster Granites.*





districts in the counties of Wicklow and Wexford, forming small islands, as it were, of granite, which have penetrated and broken through the Silurian slate of those counties. The general axis of each of these granitic outbursts is parallel to that of the main chain; these secondary granitic rocks are found at intervals for a distance of forty-three miles, from Ballinaclash, county Wicklow, to Camaross Hill, county Wexford.

I propose to give a short mineralogical sketch of these two groups of granitic rocks, which, considered as groups, are distinguished from each other by well-marked chemical differences, not hitherto observed.

I. Granites of the Main Chain.

Elementary Minerals composing the Granite of the Main Chain.

The granite of the main chain varies less than might be supposed from its great extent, and specimens from the southern end of the chain might easily be mistaken for northern specimens. This similarity of appearance arises from the prevalence of the same constituent minerals, blended together in not very dissimilar proportions. The elementary minerals, which may be seen distinctly crystallized in the granite of this whole range, are

1. Quartz.
2. Orthoclase.
3. Silvery grey biaxial mica.
4. Black mica.

1. *Quartz.*—The quartz of this district is grey transparent, and presents no variety of colour or appearance; smoky quartz is, so far as I am aware, unknown in this range, although so abundant in the Mourne granites. The mean specific gravity of the quartz, taken from the granite of distant localities, is = 2·645.

2. *Orthoclase.*—The feldspar of the granite of the main chain is invariably white and opaque, and occasionally crystallizes out from the mass in large crystals; these crystals were examined from seven different localities by Professor Galbraith of Trinity College, and found to be, without exception, pure Orthoclase. I here subjoin, in a tabular form, the results of his examination of this mineral in the granite-range.

Table I.—*Analyses of Feldspars.*

	1.	2.	3.	4.	5.	6.	7.	Average.
Silica	64·00	65·40	65·44	65·05	64·19	63·60	64·48	64·59
Alumina	18·11	17·71	18·36	17·72	18·39	18·84	19·04	18·31
Lime	......	......	0·80	0·23	0·70	......	......	0·25
Magnesia	0·57	1·77	......	......	0·34	0·40	1·02	0·58
Potash	12·73	10·68	12·34	13·42	11·39	14·33	10·74	12·23
Soda	3·00	3·26	2·73	2·75	2·95	1·92	2·64	2·75
Loss by ignition	0·55	0·69	0·52	0·36	0·58	0·60	0·78	0·58
Total	98·96	99·51	100·19	99·53	98·54	99·69	98·70	99·29

No. 1.	Quarries of Dalkey, county Dublin	Specific gravity = 2·540
No. 2.	Three Rock Mountain, county Dublin	„ „ = 2·562
No. 3.	Lough Bray, county Dublin	„ „ = 2·554
No. 4.	Lough Dan, county Wicklow	„ „ = 2·559
No. 5.	Glenmacanass, county Wicklow	„ „ = 2·553
No. 6.	Glendalough, county Wicklow	„ „ = 2·453
No. 7.	Glenmalure, county Wicklow	„ „ = 2·560
		Mean .... = 2·5401

These feldspars, crystallographically considered, were found to be monoclinic, or of the fifth crystalline system of Rose. The analyses of the granites of the main chain, which will be given subsequently, prove that the constituent feldspar of the granite differs from the large crystals of the mass, in containing somewhat more soda. It might be supposed that this arises from the admixture of other varieties of feldspar, in addition to Orthoclase; but a careful examination of the district has failed to prove the existence of any other variety of the feldspar-family in distinct crystals. In this respect the granites of the south-eastern district differ remarkably from the granites of Mourne, which contain distinct crystals of both Orthoclase and Albite, both which feldspars may be distinguished by the practised eye, in every hand-specimen of granite from that district. No Albite, so far as I am aware, or other feldspar than Orthoclase, has ever been found in the Leinster granites.

The mineralogical formula of the Orthoclase of the Leinster granites may be deduced from the last column of Table I.; dividing by the atomic weights, we find for the numbers of atoms:—

Silica	1·404	1·404	4
Alumina......	0·356	0·356	1
Lime	0·009		
Magnesia	0·029		
Potash	0·260	0·387	1
Soda	0·089		

from which results the well-known formula

$$RO, SiO_3 + Al_2O_3, 3SiO_3.$$

3. *Grey Silvery Mica.*—The grey mica of the district under consideration is frequently of considerable dimensions, sometimes attaining a diameter of between 2 and 3 inches; and even in the mass of the granite it is occasionally very variable in size, large plates being sometimes mixed with plates not exceeding one-tenth of an inch in diameter. This mica is trimetric, occuring in either flat right rhombic prisms, or in hexagonal plates, formed from the former by the replacement of the acute angles; the angles of the prisms in all the specimens which I have had an opportunity of examining are 120° and 60°, and the plane of the optic axes was invariably found to contain the greater diagonal of the rhomb, joining the acute angles. Of the angles between the optic axes recorded in my note-book, I subjoin the following:—

	°	′
1. Three Rock Mica	53	8
2. Glendalough Mica	70	4
3. Mount Leinster Mica	72	18
4. Lough Dan Mica	70	0
5. Glenmalure Mica	67	11

Chemically considered, this mica is the Margarodite of mineralogists, and is very constant in its composition, as appears from the following analyses :—

TABLE II.—*Analyses of Grey Mica.*

	1.	2.	3.	Average.
Silica	44·71	44·64	43·47	44·27
Alumina	31·13	30·18	31·42	30·91
Peroxide of iron ..	4·69	6·35	4·79	5·27
Lime	1·09	......	1·38	0·82
Magnesia	0·90	0·72	1·13	0·92
Potash	9·91	12·40	10·71	11·01
Soda	1·27	......	1·44	0·90
Loss by ignition ...	6·22	5·32	5·43	5·66
	99·92	99·61	99·77	99·76

No. 1. Glendalough Valley, county Wicklow .... Specific gravity = 2·793
No. 2. Mount Leinster, county Carlow ....
No. 3. Three Rock Mountain, county Dublin......... „ „ = 2·771

Dividing the last column of the foregoing Table by the respective atomic weights of the constituents, we find the following :—

Silica		....	0·962	 3
Alumina	0·601 }	....	0·667	 2
Peroxide of iron ..	0·066 }			
Lime	0·029 }			
Magnesia	0·046 }	....	0·338	 1
Potash	0·234 }			
Soda	0·029 }			
Water	0·629	....	0·629	 2

From the foregoing figures may be inferred the formula,

$$RO, SiO_3 + 2\{R_2O_3, SiO_3\} + 2HO,$$

which coincides with the received mineralogical constitution of Margarodite.

4. *Black Mica.*—Besides the mica already described, black mica in small grains presents itself in the granite of several parts of Leinster; it is never present in great quantity, but appears to be distinct from the grey silvery mica, as it can be separated from it to a considerable extent by levigation, proving that it has a different specific gravity. I have never been able to procure it in sufficient quantity for examination, either chemical or optical. It is sometimes found, as in the granite of the Three Rock Mountain, county Dublin,

in small specks or grains imbedded in the larger plates of grey silvery mica; in such cases, it impairs but does not destroy the transparency of the latter; and it is worthy of remark, that the mica of this mountain, which contains specks of black mica, has a smaller angle between its optical axes than the pure silvery mica of the other districts.

Accidental Minerals found in the Granite of the Main Chain.

The following list contains the names of all the accidental minerals of the Leinster granite, with which I am acquainted. I have excluded from it the minerals found in the metallic lodes which occasionally traverse the granite and the neighbouring metamorphic slate, as at Glendalough and Glenmalure.

1. Schorl (black and dark green).
2. Beryl.
3. Apatite.
4. Killinite *.
5. Garnet (in small crystals).
6. Fluor Spar (cubic).
7. Spodumene.

Chemical Composition of the Granites of the Main Chain.

The following analyses show the composition of the granite, taken from localities distant from each other, in the extreme cases, by upwards of sixty miles. There is a striking similarity in all the constituents, considering that they are derived from rock-analyses, and this remarkable uniformity of composition is a proof of the great scale on which the fusion took place which gave rise to the Leinster range of granites. The range in per-centage of silica is less than four per cent., varying from 70·28 to 74·24; the small quantities of iron, lime, and magnesia are remarkable, when taken in conjunction with the uniform fact, that the soda falls short of the potash; as we shall show that in the granites in which soda predominates over potash, as a general rule, there is a larger quantity of iron, lime, and magnesia than in the granites here described.

* The title of Killinite to be considered a distinct mineral has been disputed; some mineralogists being disposed to consider it as an altered form of Spodumene. It is a rare mineral, and has been hitherto only found at Killiney, near Dublin. Its exact chemical composition has been recently satisfactorily determined by Professor Galbraith, who considers its mineralogical formula to be well represented by the following relative number of atoms:—

Silica 4	Protoxides...1
Alumina ...2	Water 3

Giving for mineralogical formula

$$RO, SiO_3 + 2Al_2O_3, 3SiO_3 + 3\,HO.$$

Professor Galbraith's discussion of this interesting question is published in the sixth volume of the Journal of the Geological Society of Dublin.

TABLE III.—*Analyses of Granites.*

	1.	2.	3.	4.	5.
Silica	70·38	73·00	70·28	70·32	74·24
Alumina	12·64	13·64	16·44	16·12	13·64
Peroxide of iron	3·16	2·44	2·60	3·20	1·40
Lime	2·84	1·84	2·04	1·34	1·48
Magnesia	0·53	0·11	......	......	......
Potash	5·90	4·21	5·79	4·65	3·95
Soda	3·13	3·53	2·82	3·39	2·72
Loss by ignition	1·16	1·20	......	0·96	1·20
Totals	99·74	99·97	99·97	99·98	98·63

	6.	7.	8.	9.	Average.
Silica	70·82	73·24	73·20	73·28	72·084
Alumina	14·08	15·45	15·48	12·64	14·459
Peroxide of iron	3·47	1·60	1·72	2·00	2·399
Lime	2·65	0·99	0·96	1·72	1·762
Magnesia	0·31	......	......	......	0·105
Potash	4·64	4·59	4·80	4·70	4·803
Soda	2·31	3·08	3·18	2·97	3·014
Loss by ignition	1·39	1·20	......	1·04	0·906
Totals	99·67	100·15	99·34	98·35	99·532

No. 1. Dalkey Quarries; specific gravity = 2·647; a fine-grained granite, containing both black and grey mica. This granite has been used in the construction of Kingstown Harbour.

No. 2. Fox Rock, county Dublin; specific gravity = 2·638; a coarse-grained granite, striking fire when struck with a hammer, and showing abundant grey quartz.

No. 3. Three Rock Mountain, county Dublin, Woodside Quarry; specific gravity = 2·652; a coarse-grained granite, containing rhomboidal and hexagonal plates of grey mica, speckled with grains of black mica.

No. 4. Three Rock Mountain, county Dublin; fine-grained granite, with occasional large plates of speckled mica, which appears to be characteristic of the granite of this mountain.

No. 5. Enniskerry, county Wicklow; specific gravity = 2·633; a rather coarse-grained granite, containing veins of black schorl.

No. 6. Ballyknocken, county Wicklow; specific gravity = 2·636; a fine-grained durable granite, considered to be the best building-stone near Dublin. The quarries are situated beyond Blessington, county Wicklow.

No. 7. Kilballyhugh, county Carlow; specific gravity = 2·616; a fine-grained granite and a good building-stone; it contains no trace of black mica.

No. 8. Blackstairs Mountain, county Wexford; specific gravity = 2·622; a medium-grained granite from Kiltealy, on the Wexford slope of Blackstairs Mountain.

No. 9. Ballyleigh, county Wexford; specific gravity = 2·627; a fine-grained granite, from near Poulmounty Bridge, at the extreme southern boundary of the main granite chain.

The mean specific gravity of the specimens examined is 2·634.

Mineralogical Composition of the Granites.

Various methods have been suggested for ascertaining the relative proportions of simple minerals, entering into the composition of compound rocks, such as granites. In Table III. I have given the ultimate chemical analysis of the rock ; in this section I propose to determine the physical or mineralogical analysis of the granites under consideration.

Of the different methods in which the per-centage of elementary minerals in a given rock may be found, the following appears to be more simple and accurate than the methods hitherto in use, which are based either on specific gravities or on measurements of surfaces of crystals in polished specimens of the rock.

Let the rock be assumed to be composed of a number of minerals whose mineralogical formula is known, and also their per-centage composition, and let the atoms of silica, peroxides, and protoxides in the rock be ascertained from the ultimate analysis of the rock, and denoted by α, β, γ; it is possible thus to obtain three equations from which the per-centage of elementary minerals, supposed to be not greater in number than three, may be ascertained.

If the elementary minerals exceed three in number, this method will fail to give a determinate solution, and will lead to an equation of condition, from which certain properties of the rock may be deduced, although its exact composition cannot be ascertained.

This reasoning will be made quite clear by its application to the granites under discussion.

Dividing the numbers in Table III. by their respective atomic weights, and adding together the isomorphous protoxides and peroxides, I find

TABLE IV.—*Atoms of Granitic Constituents.*

	1.	2.	3.	4.	5.
Silica	1·530	1·587	1·528	1·529	1·613
Peroxides	0·286	0·296	0·352	0·353	0·282
Protoxides	0·353	0·274	0·287	0·256	0·226

	6.	7.	8.	9.	Average.
Silica	1·540	1·592	1·587	1·593	1·567
Peroxides	0·317	0·321	0·322	0·271	0·311
Protoxides	0·282	0·232	0·238	0·257	0·267

Assuming the granite to be a ternary compound of quartz, margarodite-mica, and a feldspar rich in silica, we know that the mineralogical formulæ of these minerals are

$$\begin{aligned} \text{Quartz} &= SiO_3 \\ \text{Margarodite} &= RO,\ SiO_3 + 2\{R_2O_3,\ SiO_3\} + 2HO \\ \text{Feldspar} &= RO,\ SiO_3 + \quad R_2O_3,\ 3\,SiO_3. \end{aligned}$$

It follows from these expressions, and from the definitions given of α, β, γ, that, if Q, F, M denote the number of atoms of quartz, feldspar, and mica respectively contained in the granite,

$$\left.\begin{array}{l}\alpha = Q + 4F + 3M \\ \beta = F + 2M \\ \gamma = F + M\end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Substituting in these equations for α, β, γ their numerical values from the last column of Table IV., we find

$$\begin{array}{l}1{\cdot}567 = Q + 4F + 3M \\ 0{\cdot}311 = F + 2M \\ 0{\cdot}267 = F + M.\end{array}$$

From these equations, we find easily

$$\begin{array}{l}M = 0{\cdot}044 \\ F = 0{\cdot}223 \\ Q = 0{\cdot}543.\end{array}$$

These numbers express the atomic quotients of mica, feldspar, and quartz existing in the granite, and if m, f, q denote the atomic weights of these minerals, then

$$\left.\begin{array}{ll}\text{The per-centage of mica} & = M \times m \\ \quad\text{,,} \qquad \text{feldspar} & = F \times f \\ \quad\text{,,} \qquad \text{quartz} & = Q \times q\end{array}\right\} \quad . \quad . \quad . \quad (2).$$

And consequently, if our hypothesis be correct, the following equation must be satisfied:—

$$99{\cdot}53 = Mm + Ff + Qq \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

The left-hand side of the equation being taken from the last column of Table III.

But here a difficulty presents itself; we know the atomic weight of quartz, but not of margarodite or feldspar, unless we assume the per-centage composition of these minerals, or in other words assume the composition of the constituent minerals of the granite.

I shall assume the composition of the grey mica from Table II., from which and the subsequent list of atomic quotients, we may calculate the atomic weight of the grey mica of the granite as follows:—

The mineralogical formula of margarodite is in atoms = 3 silica + 2 peroxides + 1 protoxide + 2 water. The atomic weights of silica and water are known, and are 46 and 9 respectively; therefore, if x and y denote the atomic weights of the peroxides and protoxides respectively, we have

$$\text{Atomic weight of mica} = 3 \times 46 + 2x + y + 2 \times 9.$$

But the values of x and y are found by the relations

$$\left.\begin{array}{l} 36{\cdot}18 = 0{\cdot}667 \times x \\ 13{\cdot}65 = 0{\cdot}338 \times y \end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad (4).$$

The left-hand numbers being the *per-centages* of peroxides and protoxides respectively; and the right-hand numerical coefficients denoting the *atomic quotients* of peroxides and protoxides respectively; from these equations we find the values of x and y to be 54 and 40. And finally

Atomic weight of mica = 304.

Assuming this atomic weight for the grey mica, we find from equation (2) the quartz and mica per-centages directly, and the percentage of feldspar from equation (3) by difference.

Hence we obtain:

Mineralogical Analysis of Granite.

Mica..............	13·37
Feldspar	61·18
Quartz............	24·98
	99·53

Having ascertained the proportions of quartz, margarodite, mica, and feldspar which form this granite, we can ascertain with precision the composition of the feldspar of the granite, and at the same time verify the entire calculation as follows. Adopting the mineralogical analysis of the granite already found, and the average composition of the mica, we can form the following Table, which assigns to each mineral its own share of each constituent of the granite; the feldspar column being found by difference.

TABLE V.

	Quartz.	Mica.	Feldspar.	Granite.
Silica	24·98	5·93	41·18	72·09
Alumina.........	—	4·14	10·32	14·46
Peroxide of iron	—	0·70	1·70	2·40
Lime	—	0·16	1·60	1·76
Magnesia	—	0·10	—	0·10
Potash	—	1·47	3·33	4·80
Soda	—	0·12	2·89	3·01
Loss by ignition	—	0·75	0·16	0·91
Totals	24·98	13·37	61·18	99·53

If the preceding calculations be correct in theory, the feldspar column must give us a true feldspar rich in silica; which is verified as follows. Raising the proportions of the feldspar column to percentages, we find—

Calculated Composition of Granite-Feldspar.

	Per cent.	Atoms.		
Silica	67·30	1·464	1·464	4
Alumina	16·85	0·328	0·364	1
Peroxide of iron	2·87	0·036		
Lime	2·60	0·093	0·360	1
Magnesia	—	—		
Potash	5·43	0·115		
Soda	4·71	0·152		
Loss by ignition	0·24			
	100·00			

This is a genuine tersilicated feldspar; from which fact we may draw the conclusion, that our original hypothesis as to the granite is admissible, viz. that it is composed of quartz, margarodite-mica, and tersilicated feldspar; if other minerals enter into its average composition, they must do so to such a slight extent as practically to have no influence on the composition of the granitic mass. On comparing the calculated feldspar just determined with the average feldspar of Table I. the following interesting difference may be observed; that the feldspar of the main body of the granite contains more soda, and lime replacing potash, than the crystals of feldspar, whose composition is given in that Table. It would appear from this fact, that in cooling from a molten condition, the large crystals of feldspar, in assuming their crystalline state, had appropriated to themselves more than their share of potash. It is possible, inasmuch as the typical orthoclase of the fifth system contains a large proportion of potash, that the excess of potash may be an essential condition for the formation of such large and distinct crystals. In fact, in a molten mass, like that under consideration, if no alkali were present besides potash, all the crystals of feldspar would belong to the monoclinic system; and if the only alkali present were soda, all the feldspar crystals would be found in the triclinic system. There must therefore be some intermediate mixture of potash and soda for which the crystals of feldspar are, as it were, undecided in which system to crystallize; or, in other words, the feldspar will remain in a confused crystalline mass, as in the body of the granite, while the large crystals which occur take their character from the predominant alkali, and consist, as in the case before us, exclusively of orthoclase crystals, of typical composition, in the monoclinic system.

II. Isolated Granites.

The isolated granites of Wicklow and Wexford are shown on the Map, fig. 1, p. 172; they appear in the form of isolated detached ranges A, B, C, having an elongated form, running N.N.E. and S.S.W., or parallel to the axis of the main chain. The granites composing these detached hills are frequently associated with and penetrated by dykes of greenstone and other forms of trap-rocks. Mineralogically they are distinguished by the presence of black mica, chlorite, dark-green mica, and hornblende. These minerals do not enter into the composition of all the isolated granites, which present greater differences of mineral constitution than occur in the main chain. Topographically considered on the large scale, it has been suggested to me by Dr. Griffith, who is well acquainted with this district, that we may refer the isolated granites to four parallel broken chains, as follows :—

1. From the north-east of Rathdrum, A, passing south-west through Ballinaclash, to the village of Aughrim, in the county of Wicklow.

2. From Croghan Kinshela, B, south-west to Conna Hill, in the county of Wexford.

3. From the south of Oulart, county Wexford, C, through Ballinamuddagh to Camarus Hill, midway between Wexford and New Ross.

4. The extreme south-east of Ireland, at Carnsore, D, extending to the Saltee Islands, in the same general direction as the other outbursts.

First, or Western Group of Isolated Granites.

The granites of this district extend in a broken manner from near Rathdrum to Aughrim, a distance of ten miles north-east and south-west, and attain in Cushbawn Hill an altitude of 1318 feet. In the northern part of this chain, the granite contains red feldspar and black mica, at West Acton; but the general character of the granite is best exhibited in Cushbawn Hill, which is composed of a fine-grained granite, containing grey quartz, white feldspar, and minute particles of grey and dark-green mica. An average specimen from this hill, selected with care, gave the following analysis :—

Granite of First Isolated Group.

Specific gravity = 2·671.

	Per cent.	Atoms.
Silica	70·32	1·529
Alumina	11·24	0·278
Peroxide of iron	4·80	
Lime	3·01	0·300
Magnesia	0·73	
Potash	2·27	
Soda	3·39	
Carbonate of lime	1·34	
Loss by ignition	1·62	
	98·72	

The carbonate of lime in this granite is present accidentally, and has been introduced by infiltration from the limestone-gravel of the drift which covers the district. On comparing the preceding analysis with the average granite of Table III. we may observe the following differences :—

1. In the granite of Cushbawn there is an increase of peroxide of iron replacing alumina, and attended with an increase of specific gravity.

2. The quantity of lime and soda is increased, so as to invert the relative proportions of potash and soda, rendering the granite of Cushbawn a soda-granite, and showing that it has proceeded from

an igneous focus, different from that of the main chain, and one containing more soda and lime. Neglecting the small quantity of mica which enters into the composition of this granite, it may be represented by the mineralogical analysis following :—

Quartz	17·4 per cent.
Feldspar	82·6 „
	100·0

Comparing this result with the mineralogical analysis of the main chain, we observe a deficiency of quartz and an increase of basic earths.

Second Group of Isolated Granites.

The second group of isolated granites consists of Croghan Kinshela, rising to a height of 1985 feet, and Conna Hill. The line joining these hills is N.N.E. and S.S.W., and the greatest length of the granitic outburst may be stated at six miles. The granite of Croghan Kinshela rises through and alters the slate of the district, converting it in a great degree into hornblendic and chloritic metamorphic slate. On the northern slope of Croghan Kinshela are situated the famous gold-mines of Wicklow, which consist of stream-gold brought down from some undiscovered source in the mountains by the floods of winter; they are still occasionally wrought by the neighbouring peasantry, when other employment is wanting in the district. The granite of Croghan Kinshela differs from all other granites I have seen in the south-east of Ireland in its mineralogical composition. It is, on the whole, a binary compound of quartz and albite, containing variable quantities of chlorite, which is sometimes nearly wanting, at other times present in considerable quantities. It is to be observed, that the quartz occurs in small rounded granules in the rock. The following analysis of a specimen, as free from chlorite as could be procured, will give a good idea of the nature of this rock.

Granite of Croghan Kinshela.

Specific gravity =2·629.

	Per cent.	Atoms.
Silica	80·24	1·744
Alumina	12·24	0·247
Peroxide of iron	0·72	
Lime	0·89	0·213
Magnesia	trace	
Potash	0·40	
Soda	5·58	
	100·07	

From the foregoing analysis we can infer the following mineralogical analysis of the granite of Croghan Kinshela.

Quartz	=38 per cent.
Albite	=62 „
	100

This is evidently a granite *sui generis*, eminently siliceous, and containing a minimum of bases. It possesses a brilliant white colour, except where stained by the patches of chlorite. This lustrous white colour is due to the presence of the feldspar, which is exclusively albite. If it were not for the chlorite, which appears to take the place of mica, rendering this rock a genuine ternary compound, we might consider it as an albitic Pegmatite; but since it contains a mineral so closely allied to the mica-family as chlorite, I believe it is fairly entitled to rank as a variety of the extensive family of granites.

On comparing the composition of this remarkable granite with the granites already discussed, we may draw the following inferences:—

1. That it is eminently a soda-granite.

2. That the addition of soda to the igneous source from which it is derived, has not been accompanied by the corresponding addition of lime and iron, which was remarkable in the Cushbawn granite.

3. That this increase in soda has been accompanied by a remarkable increase in the quantity of free silex, existing as quartz in the rock.

4. From the rounded appearance of the quartz-granules, I should be disposed to infer that their angles were rounded off by fusion, consequent on the addition of the powerful base soda, which acted as a flux on the siliceous rock.

Third Group of Isolated Granites.

The third chain of isolated granites commences a little to the south-west of the village of Oulart in the county of Wexford, and extends, at intervals for fifteen miles south-west, to Camorus Hill.

Mineralogically considered, these granites are composed of grey quartz, white feldspar (passing occasionally into yellowish and pink feldspar), and black mica, the latter mineral being probably sometimes accompanied by hornblende.

I subjoin the analyses of two specimens, which may be taken as typical of the district.

Granite of Third Isolated Group.

	No. 1.	No. 2.	Average.	Atoms.
Silica	66·60	68·56	67·58	...1·469
Alumina	13·26	14·44	13·85	0·346 (Alumina, Peroxide of iron)
Peroxide of iron	7·32	5·04	6·18	
Lime	3·36	3·85	3·60	0·335 (Lime to Soda)
Magnesia	1·22	0·43	0·82	
Potash	2·31	2·78	2·55	
Soda	3·60	3·36	3·48	
Loss by ignition	2·34	1·00	1·67	
Totals	100·01	99·46	99·73	

No. 1.—A fine-grained granite from Ballymotymore, containing black mica; specific gravity = 2·659.

No. 2.—A coarse-grained granite from Ballinamuddagh, containing distinct and large plates of black mica, of $\frac{3}{16}$th inch in breadth; specific gravity = 2·670.

It is not possible to obtain the mineralogical analysis of these granites without assuming the composition of the black mica, which has never been determined. If we assume, provisionally, that the formula of the black mica is the same as that of the gray mica (as seems probable from the manner in which it replaces it, isomorphously, in the crystals of the Three Rock Mountain), we can obtain the relative atoms of quartz, feldspar, and mica in this granite from equations (1);

$$1{\cdot}469 = Q + 4F + 3M$$
$$0{\cdot}346 = F + 2M \quad \ldots\ldots\ldots\ldots (1)$$
$$0{\cdot}335 = F + M.$$

From which we readily obtain as atoms of quartz, feldspar, and mica:—

$$Q = 0{\cdot}140$$
$$F = 0{\cdot}324$$
$$M = 0{\cdot}011.$$

The per-centage mineral composition of the rock cannot be deduced from these figures without assuming the ultimate analysis of either the mica or feldspar, both of which are unknown; but we can readily assign the limits of error. Let us suppose the mica to contain no alumina. In this case its peroxides are iron, and therefore the atomic weight of the mineral is 356. If the mica contains no iron, its peroxides are all alumina, and its atomic weight will be 299. These are the extreme atomic weights of margarodite-mica, possible on the supposition that its protoxides remain as in Table II. Multiplying the preceding numbers by M, we find,—

Major per-centage of mica...... $356 \times 0{\cdot}011 = 3{\cdot}91$
Minor per-centage of mica...... $299 \times 0{\cdot}011 = 3{\cdot}29$.

Assuming the mean of these as the per-centage of mica, and determining the quartz as before, and the feldspar by difference, we obtain the following

Mineralogical Analysis.

Quartz	= 6·44
Feldspar	= 89·69
Mica............	= 3·60
	99·73

In the Cushbawn, or first group of isolated granites, the quartz was diminished from 25 to 17 per cent. of the entire rock, as compared with the granite of the main chain; in the granites of the third group of isolated granites, we observe a further reduction of quartz to 6 per cent.

This third group of granites agrees with the first, and differs from the main chain in the following particulars:—

1st. The diminution in per-centage of silex.
2nd. The increase in iron and lime.
3rd. The preponderance of soda over potash.

4th. The increase in specific gravity; the mean specific gravity of the two specimens being =2·665.

In addition to the foregoing peculiarities common to both groups of granites, it may be remarked that the change of character, as respects the iron and lime, is carried further in the third isolated group than in the first.

Fourth Group of Isolated Granites.

In the extreme south-eastern corner of Ireland an outburst of granite occurs, at Carnsore, which appears to be continued to a considerable distance under the sea in an E.N.E. and W.S.W. direction. This granite consists principally of grey quartz and reddish-pink feldspar, associated with which in many specimens are green mica, and apparently a variety of hornblende. I selected for examination a specimen consisting almost exclusively of quartz and feldspar, containing a few specks of dark-green mica, but no trace of hornblende. This appears to be the prevailing character of the rock; the hornblende, when it does occur, appears to be very irregularly distributed.

The specific gravity of the specimen examined by me was found to be 2·636.

Analysis of Carnsore Granite.

	Per cent.	Atoms.	
Silica	71·80	....	1·561
Alumina	11·72	0·228	0·276
Peroxide of iron	3·88	0·048	
Lime	2·12	0·076	
Magnesia	trace		
Potash	4·77	0·101	0·276
Soda	3·06	0·099	
Loss by ignition	0·95		
	98·30		

The most cursory examination of this analysis, compared with the average granite of the main chain in Table III., serves to show that we have recovered in Carnsore the original type of potash-granite from which we set out in the main chain. To render this important fact more evident, I shall enter into some further calculations.

It is plain from the atomic quotients that the quantity of mica present is trifling in amount, and that the rock may be regarded as composed of quartz and feldspar in the following proportions:—

Quartz	=21·50
Feldspar	=78·50
	100·00

From this analysis we can calculate readily the theoretical composition of the feldspar of the Carnsore granite:—

Calculated Feldspar of Carnsore Granite.

Silica	65·68
Alumina	14·92
Peroxide of iron	4·93
Lime	3·30
Magnesia	——
Potash	6·07
Soda	3·90
Loss by ignition	1·20
	100·00

From the analysis of the granite and its calculated feldspar, the following inferences may be drawn:—

1st. The Carnsore granite, as respects its ultimate analysis, is absolutely identical with the average granite of the main chain, in the constituents, silica, lime, magnesia, potash, and soda.

2nd. In the Carnsore granite, peroxide of iron to some extent replaces the alumina, giving to the feldspar its reddish-pink colour.

3nd. The free quartz in the Carnsore granite is nearly equal in amount to that of the main chain.

Type-Granites of the South-east of Ireland.

From the preceding facts, the following inferences appear to me to follow:—

1st. In the south-east of Ireland, the granites may be classified by the preponderance of potash over soda, or *vice versâ.*

2nd. The granites of the main chain and of Carnsore, are potash-granites.

3rd. The granites of the intermediate groups are soda-granites, and are reducible to two types:—

a. The Croghan Kinshela granite;
b. The soda-granite proper.

The former of these is exceptional, and of rare occurrence; the latter is common, and reappears in the County Down and County Armagh granites.

4th. The potash- and soda-granites, properly so called, or type-granites, differ from each other in a regular manner, in respect to the other constituents, as well as in respect to the alkalies; the most striking differences being the deficiency of silica in the soda-granites, this deficiency being made up by the addition of peroxide of iron and lime; and the increase in specific gravity of the soda-granites.

Note.—At the Meeting of the Geological Society at which this paper was read, I was requested to state whether there was any geological evidence of difference of age between the potash- and soda-granites of Leinster. I know of no conclusive evidence on this point; but the age of the potash-granites is known within certain limits; it is subsequent in time to the Silurian rocks of Wicklow and Wexford, supposed to lie on the geological horizon of the Lingula-beds of Wales; and it is older than the calp-deposits of the carboniferous limestone of the county Dublin, as is proved by the latter, as at Crumlin, county Dublin, containing angular fragments of the granite of the potash-type in question.

The soda-granites of Wicklow and Wexford also are subsequent to the same Silurian rocks of these counties, as they convert the latter, when in contact with them, into hornblende- and mica-slate, and exhibit the usual phenomena of metamorphic action, such as the development of minerals.—S. H.

Trinity College, Dublin, March 3, 1856.

PART II.—On the Granites of the North-east of Ireland.

The granite-rocks of the north-east of Ireland are mostly collected into a limited district on the borders of the counties of Down, Louth, and Armagh. This district contains all the granites of the north-east of Ireland, with the exception of a small outburst near Cushundun in the county Antrim, of which separate mention will be made. The granitic district of the north-east of Ireland admits of subdivision into three natural groups.

1st. The granite-district of Mourne; which consists of a nearly circular mass of granite, having a diameter of about nine miles, lying to the north of Carlingford Bay.

2nd. The granite-district of Carlingford, which is also nearly circular, having a diameter of nearly five miles, and lying to the south of Carlingford Bay. In this district, in addition to the granite proper, there is much hornblende-rock and syenite, with varieties of greenstone, the exact relations of which to the granite have never been precisely ascertained.

3rd. The granite-district of Newry, extending from Slieve Croob, on the north-east, in a south-westerly direction to Forkhill and Jonesborough, a distance of twenty-eight miles, and having an average breadth of six miles.

I. Granite of the Mourne District.

Elementary Minerals composing the Granite of the Mourne District.

The granite of the Mourne mountains is very fine-grained, and contains numerous vughs or cavities, which are lined with distinct crystals of the minerals composing the granite and also with some rare accidental minerals, from the occurrence of which the Mourne district has become well known to mineral-collectors. The granite of this district has been described by some writers as a pegmatite, but the distinction between this variety of granite and ordinary fine-grained granites does not appear of sufficient importance to be worthy of a separate name. Whether the Mourne rocks be called granite or pegmatite, they consist essentially of four distinct and well-marked minerals.

1. Quartz.
2. Orthoclase.
3. Albite.
4. Green Mica.

1. *Quartz.*—The quartz of the Mourne granite is of a brown smoky colour, and occurs in hexagonal crystals lining the numerous cavities of the rock.

2. *Orthoclase.*—The orthoclase of the Mourne granite occurs in large opaque white crystals, and is interesting to the crystallographer from the number of measurable faces which it presents; it is frequently found, in company with quartz-crystals, albite, green mica, and some of the accidental minerals, lining the surfaces of cavities. In order to ascertain its average composition, I have examined specimens from different localities, and in one instance determined with care its crystallographic constants, which differ slightly from those recorded from other localities. I should add, that the crystals of orthoclase from the Mourne mountains are sometimes, but erroneously, confounded with the albite of the same district, in consequence of their brilliant, though opaque white colour.

The following Table contains the results of my analyses of orthoclase.

TABLE I.—*Analyses of Orthoclase.*

	1.	2.	3.	Mean.
Silica	66·32	66·33	66·10	66·25
Alumina............	17·56	17·47	17·01	17·35
Lime	1·36	1·15	1·26	1·25
Magnesia	0·17	......	......	0·05
Potash	10·60	12·10	10·95	11·22
Soda	2·33	2·67	4·14	3·05
Loss by ignition...	0·90	......	......	0·30
Total	99·24	99·72	99·46	99·47

No. 1. Orthoclase from Slieve Kevita, north-west of Slieve Donard, Mourne mountains, in monoclinic system. Specific gravity = 2·490.

No. 2. Orthoclase from Slieve Corragh, Mourne mountains, occurring in beautiful crystals, lining cavities in the granite. Specific gravity = 2·415.

No. 3. Opalescent translucent orthoclase, or moonstone, from Slieve Corragh; occurs in large crystals. Specific gravity = 2·557.

From the preceding analyses it is plain that this feldspar is an orthoclase; and its mean specific gravity is 2·487, being somewhat less than the specific gravity of the orthoclase of the Leinster granites.

The following angles of No. 2 were measured with great care and gave the following results; using Miller's notation:—

$$(001)\ (010) = 90^\circ\ 0'$$
$$(001)\ (110) = 68\ \ 5$$
$$(001)\ (1\bar{1}0) = 68\ \ 5$$
$$(110)\ (1\bar{1}0) = 118\ \ 46$$
$$(111)\ (001) = (111)\ (110) = 124\ \ 2$$

From these data we can easily calculate the following crystallographic constants:—

Angle between *a* and *c*	=64° 18′.
Ratio of *b* to *a*........	=1·5223.
Ratio of *c* to *a*........	=0·8358.

Besides the faces already mentioned, many crystals exhibit face having the notation (101) and (102); the angles of which giv results consistent with the above constants.

Albite.—The albite of the Mourne granite is found in twin crystals incrusting the interstices of the orthoclase and quartz in the cavitie of the rock, and may also be traced by its translucent appearance in the body of the rock itself in small quantities.

It is distinctly triclinic, and a specimen from Slieve Corragh, on being submitted to analysis, gave the following results:—

Analysis of Albite.

	Per cent.	Atoms.
Silica	68·97	1·499
Alumina....	19·23	0·375
Lime	1·21	0·369 (Lime, Magnesia, Potash, Soda together)
Magnesia ..	0·24	
Potash	1·56	
Soda	8·71	
	99·92	

From the preceding analysis it is evident that this is a pure albite, having the usual formula of a tersilicated feldspar,

$$RO, SiO_3 + Al_2O_3, 3SiO_3.$$

The following angles were measured between three of its planes, two of which (viz. (010) and (001)) are planes of cleavage:—

$$(010)\ (001) = 86^\circ\ 52'$$
$$(010)\ (101) = 54\ \ 53$$
$$(001)\ (101) = 92\ \ 37.$$

Green Mica.—The mica of the Mourne mountains occurs in small quantities through the mass of the granite and in larger crystals accompanying the quartz, orthoclase, and albite, which line the cavities.

It is of a dark-green colour, nearly opaque, and crystallized in regular hexagonal plates, all the angles of the hexagon being 120°. A specimen from Slieve Corragh was found to have the following composition:—

Analysis of Green Mica.

	Per cent.	Atoms.	
Silica	43·42	0·944	5
Alumina	19·00	0·590	3
Peroxide of iron	17·64		
Lime	1·81	0·395	2
Magnesia	0·54		
Potash	8·77		
Soda	3·66		
Loss by ignition	4·30	0·477	2
	99·14		

From this analysis, it appears that the composition of this mica is closely represented by the formula

$$2(RO, SiO_3) + 3(R_2O_3, SiO_3) + 2HO.$$

The green colour of the mineral is due to the large quantity of iron replacing alumina. On comparing the formula just given with that obtained for the mica of the Leinster granites, it is plain that they both come under the general formula of the mica-family, viz.,

$$p(RO, SiO_3) + q(R_2O_3, SiO_3) + rHO,$$

p, q, r, having different integer values, and the value of r being sometimes cypher, as in the formula for muscovite.

Accidental Minerals of the Mourne Granite.

A number of beautiful specimens of occasional minerals are found in the cavities of the granite of this district, especially in the granite of Slieve Bingian and Slieve Corragh. I have endeavoured to render the following list as complete as possible.

1. Beryl.
2. Chrysoberyl.
3. Fluor-spar (octahedral).
4. Topaz.
5. Peridot.

These minerals occur in the cavities of the granite, accompanied by hexahedral crystals of smoky quartz, crystals of orthoclase, albite, and green mica. The fluor-spar, which is very rare both in the Mourne and Leinster granites, is found octahedral in Mourne and cubic in Leinster, a curious difference, which probably arises from some unknown difference in the conditions of cooling of the granite masses in the two localities.

Composition of the Mourne Granite.

The Mourne granite is very fine-grained, and would be called elvan in Cornwall; it contains distinctly quartz, orthoclase (both the opaque variety and the translucent kind known as moonstone), albite, and green mica. An average specimen from Slieve Corragh gave the following results:—

Composition of Granite.

Specific gravity =2·595.

Silica	75·00
Alumina	13·24
Peroxide of iron	2·52
Lime	0·69
Magnesia	—
Potash	4·33
Soda	3·07
Loss by ignition	0·80
	99·65

A comparison of this analysis with the average analysis of the potash-granites of Leinster shows a striking similarity in all the constituents excepting the quartz, which is three per cent. greater in the Mourne granite; this excess of silica being accompanied with a falling off in the lime and magnesia. Neglecting the small quantity of mica in this granite, its mineralogical composition may be considered as—

Quartz	28·0 per cent.
Orthoclase	44·2
Albite	27·8
	100·0

II. Granites of the Carlingford District.

Description of the Igneous Rocks of Carlingford District.

The granitic and other igneous rocks of the district south of Carlingford Bay, although only occupying a circular area of about five miles in diameter, present to the geologist a variety and complication which is at first perplexing. Although I propose to confine my attention to the granitic rocks of the district, yet it is necessary to give a summary of all the igneous rocks, and a statement of what is known of their relative ages.

Igneous Rocks of Carlingford.

1. Medium-grained granite: quartz, feldspar, green mica.
2. Fine-grained granite: quartz, feldspar, hornblende.
3. Syenite: hornblende and anorthite.
4. Hornblende-rock.
5. Amygdaloidal or pockmarked greenstone.
6. Fine-grained grey dolerite.

The following geological relations were observed by me to exist among these rocks. The two varieties of granite pass into each other, as may be seen in Slieve na glogh, of which the base is composed of No. 1, and the upper parts of No. 2. At the summit of this hill, the fine-grained granite, No. 2, is observed to pierce the pockmarked greenstone, No. 5, in numerous veins.

At Grange Irish, the granite, No. 2, penetrates the lower beds of carboniferous limestone, which there rest upon the granite; at the junction of the granite and limestone the limestone is converted into a bluish sugary marble, containing garnets, and the granite is converted into the remarkable syenite, No. 3, composed of anorthite and hornblende.

The summit of Carlingford Mountains is composed of the syenite No. 3 and the hornblende-rock No. 4, passing into each other; the hornblende-rock, however, being penetrated with numerous veins of fine-grained syenite.

The metamorphic mica-slate, of the Silurian age, which rests on the north slope of Carlingford Mountain, is penetrated by dykes of the pockmarked greenstone No. 5; and the slates, carboniferous limestone, and pockmarked greenstone are all penetrated by thin dykes of the grey dolerite No. 6.

Judging from the variety and interlacing of the igneous rocks of this district, there can be little doubt that it once formed the active focus and vent of a most extensive volcanic outburst.

If we suppose all the amygdaloidal or pockmarked greenstone to be of the same, or nearly the same age, it must be considered as post-silurian, and the oldest igneous rock in the district. The two granites, the syenites, and the hornblende-rock must be considered as probably of the same age and post-carboniferous; as it will be shown that the granite is converted by the metamorphic action of the limestone into the syenite in a particular locality; and it is highly probable that the whole of the syenite of the district owes its origin to the limestone penetrated by the eruption of granite. The grey dolerite has been observed to penetrate all the other rocks, excepting the granite; and it is probably of the same age as the latter. My attention was first directed to this district by Dr. Griffith, who informed me that it contained post-carboniferous granite. Mr. Griffith considers the granite of Carlingford district, and also a granite found near the top of Slieve Gullion in the Newry district, to be newer than the granites of Mourne and Newry. It presents certain structural differences which distinguish it from the granites of those districts*. Having described—so far as they are known to me—the geological relations of the granitiform rocks of this district, I shall now proceed to the mineralogical investigation of these rocks, which is full of interest.

Composition of the Granites.

There are two varieties of granite in this district, one composed of

* See Journal of the Geological Society of Dublin, vol. ii. p. 113.

quartz, feldspar, and green mica, and the other, fine-grained, of quartz, feldspar, and hornblende.

First Variety of Carlingford Granite.

Specific gravity =2·593.

	Per cent.	Atoms.
Silica	70·48	1·532
Alumina	14·24	0·323 (Alumina and Peroxide of iron)
Peroxide of iron	3·72	
Lime	1·48	0·281 (Lime, Magnesia, Potash, Soda)
Magnesia	0·40	
Potash	4·26	
Soda	3·66	
Loss by ignition	1·59	
	99·83	

This granite was taken from the base of Slieve na glogh, is medium-grained, and resembles the usual specimens of Dublin granites, excepting that its mica is green and not grey silvery. Assuming, however, that the mica is margarodite, we easily deduce the following equations, from which its mineralogical composition may be inferred.

$$1·532 = Q + 4F + 3M,$$
$$0·323 = F + 2M,$$
$$0·281 = F + M.$$

From these data we infer—

$$Q = 0·450$$
$$M = 0·042$$
$$F = 0·239$$

If we assume the atomic weight of mica as before to be 304, we can obtain the mineral composition of the rock; in this calculation the mica is slightly in *defect*, because there is more iron in this mica than in the mica from which the number 304 is inferred.

Mineralogical Composition of the Granite of the First Variety.

Quartz	20·70 per cent.
Feldspar	66·37
Mica	12·76
	99·83

From the preceding discussion we are entitled to draw the inference that the first variety of granite of Carlingford is a potash-granite, and has a mineral composition very like that of the main chain of Leinster.

The second variety of granite is very fine-grained, but distinctly composed of quartz, white feldspar, and hornblende, without any mica; and the first and second varieties of granite pass into each other. I shall show, that although physically, and mineralogically, these two varieties of granite are so distinct, yet chemically they are closely allied; a fact which explains the passage of one into the other; and also shows the necessity for some more certain criterion of the true character of an igneous rock than either its physical aspect or its mineralogical character, as both these may vary within wide limits, although the ultimate analysis of the rock has changed but little.

Second Variety of Carlingford Granite.

Specific gravity = 2·632.

Silica	71·41	1·552
Alumina	12·64	0·246
Protoxide of iron	4·76	} 0·441
Lime	1·80	
Magnesia	0·63	
Potash	5·47	
Soda	3·03	
	99·74	

The preceding granite was taken from Grange Irish, from the main body of granite, within ten yards of the point where the granite penetrates the carboniferous limestone in dykes, and is converted into a crystalline syenite. I have considered its iron as protoxide, for, as there is no mica, and the feldspar is a pure white, the iron must belong to the hornblende, and therefore must be protoxide.

If we suppose the alkalies and alumina to belong exclusively to the feldspar, and consider the hornblende to be of the form

$$RO, SiO_3,$$

we have from the preceding numbers

$$1·552 = Q + 4F + H$$
$$0·246 = F$$
$$0·441 = F + H;$$

from which we obtain

$$Q = 0·246$$
$$F = 0·373$$
$$H = 0·195.$$

If we calculate the atomic weight of the hornblende, referring to it the iron and lime, we find it to be 79; from which we may infer the composition of the granite to be as follows:—

Mineralogical Composition of the Granite of the Second Variety.

Quartz	17·16	per cent.
Feldspar	67·18	
Hornblende	15·40	
	99·74	

This is a potash-granite, similar in composition to the first variety, containing about the same quantity of feldspar, but differing in the other minerals. In fact, it would be easy to assign the conditions under which the first or second variety of granite would be formed, which consist of similar elements, but of different minerals.

Composition of the Syenites.

The syenites of Carlingford, which are coarse-grained and fine-grained, and occasionally pass into pure hornblende-rock, are composed of two minerals, anorthite and hornblende. As this is the first time that anorthite is noticed as a British mineral, it may be useful to discuss its chemico-mineralogical formula.

Carlingford Anorthite.

	Per cent.	Atoms.	
Silica	45·87	0·997	3
Alumina	34·73	0·676	2
Lime	17·10	0·688 (Lime + Magnesia)	2
Magnesia	1·55		
	99·25		

The formula deducible from this composition is

$$2RO, SiO_3 + 2\{Al_2O_3, SiO_3\}.$$

It is plain that this feldspar is the anorthite of Vesuvius and Hecla, and is identical with the anorthite of Java, of Columbia, and of meteoric stones. It is essentially a volcanic mineral and is the most basic of all the feldspar-family, as it contains disilicate of lime. It is completely decomposed by muriatic acid, and is harder than ordinary feldspar, striking fire under the hammer freely.

At Grange Irish, this mineral is formed by the addition of carboniferous limestone to the fused granite of the second variety already described.

I shall now describe the hornblende which forms part of the syenites.

Carlingford Hornblende.

Specific gravity =2·923.

	Per cent.	Atoms.
Silica	50·72	1·284 (Silica + Alumina)
Alumina	9·36	
Protoxide of iron	18·61	1·243 (Protoxide of iron + Lime + Magnesia)
Lime	16·96	
Magnesia	2·40	
Loss by ignition	1·52	
	99·57	

From the preceding analysis, uniting, as Rammelsberg does, the alumina with the silica, we obtain

$$RO; \{SiO_3, Al_2O_3\};$$

a formula which is frequently found for the hornblende containing alumina.

The syenites of Carlingford are composed of variable proportions of the anorthite and hornblende just described; and a remarkable instance of the formation of this syenite from granite occurs at Grange Irish. The granite No. 2 there pierces the carboniferous limestone in dykes, and in the dykes is converted into a coarse-grained syenite, composed of anorthite and hornblende, in no way distinguishable, physically or chemically, from the syenites of Carlingford Mountain.

The metamorphic reaction of the granite and limestone upon each other is strikingly shown at this point; the limestone being converted from an earthy bluish-brown stone into a crystalline marble of a light bluish-white colour, and having garnets developed in many places; on the other hand, the granite is converted from a ternary compound of quartz, orthoclase, and hornblende, into a binary compound of anorthite and hornblende, of the following composition:—

Granite converted into Syenite, from Grange Irish.

Specific gravity = 2·757.

	Per cent.	Atoms.
Silica	47·52	1·033
Alumina	28·56	0·555
Protoxide of iron	7·23	} 0·715
Lime	15·44	
Magnesia	1·48	
	100·23	

Specific gravity of average specimen of medium-grained syenite from Carlingford Mountain = 2·877.

From the preceding analysis we can show that this rock is a binary compound of anorthite and hornblende. From the formula for anorthite already given, and assuming hornblende to be a simple silicate of protoxides, as shown from the analysis of the hornblende of this district, we have, denoting by A and H the number of atoms of anorthite and hornblende in the rock,—

$$1·033 = 3A + xH$$
$$0·555 = 2A + (1-x) H$$
$$0·715 = 2A + H.$$

In these equations, x denotes the proportion of silica, considered as atomic quotient, which enters into the composition of each atom of hornblende.

Adding together the first two equations so as to eliminate x, and solving from this sum and the third equation, we find

$$1·588 = 5A + H$$
$$0·715 = 2A + H,$$

from which we deduce

$$A = 0{\cdot}291$$
$$H = 0{\cdot}133.$$

Referring to the analysis of the anorthite, it is easy to see that its atomic weight is

$$46 \times 3 + 51{\cdot}4 \times 2 + 27{\cdot}1 \times 2,$$

or exactly 295; from which, multiplying by the value of A just found, we have, finding the hornblende by difference,—

Mineralogical Composition of altered Granite.

Anorthite	= 85·84
Hornblende	= 14·16
	100·00

On comparing this result with that obtained in page 195 from the granite before it is metamorphosed, it is interesting to observe that the total quantity of hornblende remains almost unaltered, and that the effect of the addition of the limestone to the melted granite has been to convert the quartz and orthoclase into anorthite. In this operation, the alkalies of the orthoclase have disappeared; the lime, being a more fixed base at high temperatures, has altogether displaced the alkalies; showing on a grand scale, in the great laboratory of Nature, an experiment, which is in daily use on a small scale by chemists, for the determination of the amount of alkaline constituents in an earthy mineral.

III. Granites of the Newry District.

The Newry district of granite extends, as already described, N.E. and S.W. about thirty miles, from Slieve Croob to Forkhill. My examination of the granites of this chain is incomplete, but interesting, so far as it has extended, as proving in this district the existence of the two types of potash- and soda-granite, which I have established in the granites of the south-east of Ireland.

Taking a nearly N.S. line through Newry, from Goragh Wood on the north, through the Wellington Inn on the south to Jonesborough, I have obtained the following results: that on this line there is soda-granite to the north of Newry, and potash-granite to the south; I am not prepared to say that the potash- and soda-granites are confined to the limits here indicated, nor do I know the relations between them; but I hope shortly to be in a position to state more precisely the exact connexion between these two varieties of granite in this district.

Potash-Granites of the Newry District.

To the south of Newry much of the granite has the character of the medium-grained granite No. 1 of the Carlingford district, of which it is in all probability a continuation, as shown in the accompanying map of parts of Down and Armagh, fig. 2. It is composed

Fig. 2.—*Map of the Ulster Granites.*

of quartz, white feldspar, and green mica, and resembles in its physical and mineralogical character the granite at the base of Slieve na glogh. This resemblance is not confined to its external character, but exists as to its chemical composition, as is shown by the following analysis of the average granite, near Wellington Inn. In the cutting of the Belfast Junction Railway near this place, numerous trap-dykes are seen penetrating the granite, and may be traced for a considerable distance in the small quarries of the neighbourhood.

Wellington Inn Granite.

Quartz, Orthoclase, Green Mica.

Specific gravity = 2·615.

	Per cent.	Atoms.
Silica	71·24	1·549
Alumina	14·36	0·321 (Alumina + Peroxide of iron)
Peroxide of iron	3·36	
Lime	1·48	0·273 (Lime + Magnesia + Potash + Soda)
Magnesia	0·64	
Potash	4·09	
Soda	3·13	
Loss by ignition	1·50	
	99·80	

If we assume, as in the discussion of the corresponding granite of

Slieve na glogh, that the green mica is margarodite, we readily find by the principles so often explained:—

$$Q=0{\cdot}505$$
$$F=0{\cdot}225$$
$$M=0{\cdot}048$$

From which we deduce—

Mineralogical Composition of Wellington Inn Granite.

Quartz......	23·23 per cent.
Feldspar	61·98
Mica	14·59
	99·80

Whether we consider the physical aspect, the mineralogical character, or the chemical composition of this granite, it is strikingly like the granite of the base of Slieve na glogh, with which I have no hesitation in identifying it. Combining both together, we find:—

Mineralogical Composition of Potash-Granite.

Quartz, Orthoclase, and Green Mica, South of Newry.

Quartz......	21·96 per cent.
Feldspar	64·17
Mica	13·67
	99·80

In the granite of Jonesborough, at the southern extremity of our section, large crystals of white opaque orthoclase are found, of which the following is the composition:—

Jonesborough Orthoclase.

Specific gravity=2·546.

	Per cent.	Atoms.
Silica	64·20	1·40
Alumina........	19·33	0·37 (Alumina and Peroxide of iron)
Peroxide of iron..	trace	
Lime	1·00	0·39 (Lime, Magnesia, Potash and Soda)
Magnesia	0·18	
Potash	13·47	
Soda	1·89	
	100·07	

This analysis shows the feldspar to be a pure orthoclase.

The potash-granite, composed of quartz, white feldspar, and green mica, common to the South Newry and Carlingford districts, presents a remarkable similarity in mineral composition to the potash-granites of Leinster. The only question as to which any doubt remains is as to whether the green mica is a margarodite, in which peroxide of iron replaces alumina to a considerable extent, or not; I have been unable to determine this point by direct experiment, either chemically or optically, from the difficulty of procuring a sufficient quantity of pure mica for examination.

If the green mica be not the margarodite of the Leinster granites, but similar in composition to the green mica of the Mourne Mountains already described, we shall then have, taking the mean of the atoms of the Wellington Inn and Slieve na glogh granites:—

$$1{\cdot}540 = Q + 4F + 5M$$
$$0{\cdot}322 = F + 3M$$
$$0{\cdot}277 = F + 2M.$$

Solving these equations, for *Q, F, M,* we find:—

$$Q = 0{\cdot}567$$
$$F = 0{\cdot}187$$
$$M = 0{\cdot}045$$

In calculating per-centages from these results, we must use the atomic weight of the mica found from the analysis of green mica in page 191, which is found to be 508 instead of 304. Hence we obtain finally:—

Potash-Granite of Newry and Carlingford.

Quartz......	26·08 per cent.
Feldspar....	50·76
Green mica..	22·86
	99·70

It is worthy of remark, and confirms the preceding view of this granite, that, if we suppose the peroxide of iron of the granite (which is 3·54 per cent.) to belong exclusively to a mica similar to the green mica of Mourne, we shall obtain 20·07 per cent. of mica in the granite; a result which is sufficiently near the per-centage just given.

I have noticed as a curious fact that the mica of the potash-granites of Mourne and Carlingford is the green mica, without any transparent grey mica, and that the mica of the soda-granites of Newry is a jet-black mica, identical in appearance with the black mica which is found in the soda-granites of Oulart and Wexford; and that this black mica, both in Newry and Wexford, is unaccompanied by any of the grey margarodite of Leinster.

Soda-Granites of the Newry District.

As I have not as yet satisfied myself as to the true mineralogical character of the type of granites to which I propose to apply the term "Soda-Granites," I shall here confine my attention exclusively to their chemical composition, which is sufficient to identify them with the soda-granites of Wicklow and Wexford. The soda-granites of the Newry district are characterized by the presence of black mica, of the exact composition of which I have no means of forming an opinion at present.

Soda-Granites of the Newry District.

	No. 1.	No. 2.	Mean.	Atoms.
Silica	64·60	62·08	63·34	1·377
Alumina	14·64	15·92	15·28	} 0·383
Peroxide of iron	6·04	7·72	6·88	
Lime	3·16	5·52	4·34	} 0·455
Magnesia	2·80	2·16	2·48	
Potash	3·15	2·19	2·67	
Soda	4·02	3·34	3·68	
Loss by ignition	1·13	0·89	1·01	
	99·54	99·82	99·68	

No. 1.—Coarse-grained granite, from Newry Quarry, intersected by trap-dykes and veins of fine-grained pink granite; consists of quartz, white feldspar, passing into pale pink, and black mica.

Specific gravity = 2·695.

No. 2.—Coarse-grained granite, from Goragh Wood Station; composed of quartz, white feldspar, and black mica.

Specific gravity = 2·731.

A comparison of these results with the granites of the third isolated group of Leinster, shows a remarkable similarity, and the column of atoms proves that this granite cannot consist of quartz, tersilicated feldspar, and common mica.

The soda-granites of Newry agree with the soda-granites of Leinster in the reduced per-centage of silica, in the increase of iron, lime, and magnesia, and in the preponderance of soda over potash.

I hope, on a future occasion, to be in a condition to complete this account of the Newry granites.

February 15, 1856.

Annual General Meeting.

[For Reports and Address see the beginning of this volume.]

February 20, 1856.

W. Howland Roberts, M.D., was elected a Fellow.

The following Communications were read:—

1. *Notice of a Visit to the* Dead Sea. By H. Poole, Esq.

[Forwarded from the Foreign Office by order of Lord Clarendon.]

[Abstract.]

Mr. Poole went to this district to look for nitre, which was reported to occur there; but he met with none, and found reason to suppose that the report was unfounded. The same word in Arabic means "bitter or rock salt," as well as "nitre," hence possibly the erroneous information. Further, the cave (at Usdum) in which the nitre was said to have occurred is called "the cave of the Gun-men," not from the Arabs getting their nitre there for gunpowder, but as the spot from which they watch for the crossing of the hostile tribes across the plain.

Mr. Poole and Mr. E. Mashallam spent nearly two days at Usdum, going to several caves (in which fine stalactites of salt occur), climbing nearly to the top of the mountain, and walking about the shore, but in no instance could they find a deposit or even a sample of nitre. Mr. Finn, H.M. Consul at Jerusalem, also informed Mr. Poole that he had never seen any; nor had the Sheik Aboo Daook and his men. The Arabs generally make their own nitre by boiling the dung of goats; others scrape it off old walls or limestone-caves, but never in any large quantity.

The Arabs charge 60 piastres or 10 shillings for a camel-load of salt, about 500 lbs., delivered in Jerusalem, and the purchaser pays the Turkish government 15 piastres more for duty. Each camel will make about twenty-four trips in a year, thus carrying altogether 12,000 lbs. a year.

From Usdum Mr. Poole proceeded to El Lisan (the Peninsula), and travelled all round it. The ridge of high land is highly impregnated with sulphur; but the nodules of native sulphur are very rare.

At the present time it would be almost impossible to do anything on El Lisan, for the road between it and Usdum is open to the attacks of four independent tribes of Bedouins, including the Sultan of Kerak, over whom the Turkish government has no control.

Previously to visiting Usdum, Mr. Poole made a trip to the northern end of the Dead Sea. At Nebi Mousa (half-way from Jerusalem to the Dead Sea), there is a quantity of bituminous shale or "blind coal," from which ornaments are cut; and a thick bed of soil highly impregnated with sulphur occurs there. Nothing but saline incrustations were found on the north shore of the Dead Sea.

The author exhibited to the Meeting a series of the specimens of sulphur, sulphurous earths, salt, and other minerals from the vicinity of the Dead Sea, together with recent natural-history specimens, volcanic and other rock-specimens, and some tertiary and cretaceous fossils* from the district visited.

* For descriptions and figures of a series of fossils from this and other districts in Palestine, see Conrad's 'Appendix to Lieut. Lynch's Official Report of the U.S. Expedition to explore the Dead Sea and the River Jordan.' 4to. Baltimore, 1852.—Ed.

2. *On the* Affinities *of the* large extinct Bird (Gastornis parisiensis, *Hébert*), *indicated by a Fossil Femur and Tibia discovered in the* Lowest Eocene Formation *near* Paris. By Prof. Owen, F.R.S., F.G.S., &c.

[Plate III.]

Perhaps no part of the progress of Palæontology, since the demise, in 1832, of the founder of that science, has been more striking and unexpected than that which relates to the discovery and restoration of giant members of the feathered Class.

First indicated by the foot-prints in the New Red Sandstones of the valley of the Connecticut, described by Hitchcock, in 1836*; next demonstrated by the evidence of the bones themselves from the recent deposits in New Zealand, in 1839† and 1843‡; afterwards exemplified by the great eggs and associated fragments of skeleton discovered in alluvial banks of streams in Madagascar, in 1851§; the list of extinct giant birds has lastly been recruited by the fossil remains of a species, at least as large as an Ostrich, from the Eocene conglomerate|| at Meudon near Paris, which lies between the plastic clay and the surface of the chalk¶.

It is this last example of extinct Birds, discovered in the early part of the year 1855, which is the subject of the present communication. Associated, as I have been, with the work of reconstructing gigantic species of that class, I received immediate notice of the discovery by M. Gaston Planté and M. Hébert of the fossil bones which indicated the large bird in question, in letters from scientific friends at Paris, and more especially from the accomplished ornithologist, Prince Charles Lucien Bonaparte, then occupied in completing his admirable and celebrated summary of the genera and species of Birds, by a record of all the known fossil kinds.

On my arrival in Paris on the service of the Jury of the Universal Exhibition of 1855, the specimens themselves, consisting of an almost entire tibia (Pl. III. figs. 1 *a* & 1 *b*) and the shaft of a femur, were brought to the Institut, by MM. Hébert and Lartet, to be shown to me; and, on my expressing the wish to carry out a series of comparisons with the answerable bones in other birds, accurate and beautifully prepared coloured casts of the fossils were most liberally and kindly made and presented to me before my return to London, with the desire that I would endeavour to arrive at some definite conclusion as to the nature and affinities of the bird to which the fossils belonged. In the meanwhile the opinions of M. Hébert,

* In the American Journal of Science and Arts, January 1836, vol. xxix.

† Zoological Transactions, vol. iii. p. 29. ‡ Ib. vol. iii. p. 235.

§ Isidore Geoffroy St. Hilaire, in Comptes Rendus de l'Académie des Sciences, Paris, January 27, 1851.

|| Particularly described by D'Orbigny, in the Bulletin de la Société Géologique de France, 1ère série, vol. vii. p. 280.

¶ The uppermost cretaceous stratum called *calcaire pisolithique*.

Director of the Scientific Instruction at the 'Ecole Normale supérieure,' of M. Lartet, the well-known and accomplished Palæontologist of the tertiary formations in middle and southern France, and of Prof. Valenciennes were briefly recorded in the notice of the discovery of the tibia, communicated to the Institut, in March, 1855*. In the month of June in the same year M. Hébert communicated to the Academy of Sciences, his discovery of the femur, at about 3 mètres of horizontal distance from the spot, and in the same formation, where the tibia had been previously found by M. Gaston Planté.

The femur is the shaft of that bone of the left limb, with both articular ends broken away: it measures 11½ inches in length, and 2 inches by 1 inch 9 lines in the two diameters of its middle part. The entire femur of a large male Ostrich measures 13 inches in length; and 2 inches by 1 inch 5 lines in the two diameters of its middle part.

The tibia also has its proximal end broken away and its distal condyles mutilated: its length, when entire, would be 1 foot 7 inches: it is 1 inch 9 lines by 1 inch 6 lines in the diameters of the middle of the shaft. The tibia of a large male Ostrich measures 1 foot 11½ inches in length; the diameters of the middle of the shaft being 1 inch 6 lines by 1 inch 3 lines.

The femur of the Parisian eocene bird, for which the name *Gastornis Parisiensis* has been proposed, has a rounder and thicker shaft in proportion to its length than in the Ostrich, and the tibia is shorter and thicker than in the Ostrich; whence, as M. Hébert rightly infers, the *Gastornis* was a proportionally heavier bird than the Ostrich. In the size and proportions of the two above-specified bones of the leg it closely corresponds with the species of *Dinornis* which I have called *Dinornis casuarinus* (figs. 2 *a* & 2 *b*). As the conclusions, in reference to the more immediate affinities of the *Gastornis,* to which the above-cited able naturalists and palæontologists of Paris have arrived, were founded almost exclusively on the characters presented by the lower or distal end of the tibia, I shall premise a brief summary of the leading modifications of that part of the skeleton in the different orders of the class of Birds.

Characters of Birds' Tibiæ.—The tibia is a well-marked and characteristic bone in birds. At the proximal end the intercondyloid convexity is more marked than the entocondyloid concavity, which is the principal articular surface there developed: next may be noticed the strong rotular process dividing into the procnemial and ectocnemial ridges†. Below and behind these is the usually short fibular ridge, marking the outer side of the proximal third or fourth part of the shaft. The distal end of the tibia resembles that of a mammalian femur, with the back of the two condyles turned forwards. All these characters, common to birds in general, distinguish this

* Compte Rendu, Mars 12, 1855.

† First so named and defined in my memoir on the *Dinornis* of June 1846, Zool. Trans. vol. iii. p. 323; these ridges are not developed in the Hornbill (*Buceros*).

bone from that of all other known existing animals: save as regards the proximal end, they are sufficiently evident in the tibia of the *Gastornis*, and permit no manner of doubt as to the class of animals to which that bone belongs. There is, however, a great range of variety in some of these, and of other less constant, characters of the birds' tibia.

In comparing the distal end of the tibia, attention must be paid to the following points:—Relative breadth and depth of that end: Relative size and shape of the anterior productions of the condyles, fig. 2, *a*, *b*, and of the interspace between them: Configuration of the rest of the trochlear surface, fig. 2, *a*, *d*: Presence or absence of a bridge, *e*, completing a canal, *f*, for the exterior tendon of the toes on the fore-part of the distal end of the tibia: Direction, position, and size of the bridge: Position and aspect of its lower outlet, *g*; Entocondyloid, *h*, and ectocondyloid, *i*, surfaces,—or those that are found on the inner side of the inner condyle, *a*, and the outer side of the outer condyle, *b*.

The distal end of the tibia varies in its degree of expansion as compared with the shaft, in the relative prominence and thickness of the condyles, in the width and depth of the intercondyloid space, and especially in modifications of the anterior surface above that space. This surface is traversed by the 'extensor communis' tendon of the toes, and here the tendon, in all young birds, is strongly bound down by a more or less oblique or transverse ligament, which in most species becomes ossified before full growth is attained: it then forms the 'bridge' or 'supra-tendinal bridge,' *e*. The existing *Struthionidæ*, viz. the *Ostrich*, *Rhea*, *Emeu*, and *Cassowary*, are exceptions, also the Hornbills and Parrots: in them the ligament retains its nature throughout life.

Order Raptores *seu* Accipitres.

In the Sea Eagle (*Haliaëtus albicilla*) the breadth of the condyles exceeds the depth*; the anterior convexities each equal the intercondyloid depression: the posterior trochlear space is broad and oblique. The bridge is broad, median, and very oblique from above downwards and outwards. Below the bridge a thin transverse rising bounds the intercondyloid depression above. There is a shallow depression at the sides of the distal end, above each condyle; an obtuse tubercle projects from the middle of the inner concavity. The inner side of the shaft is thinner than the outer one, which is contrary to the proportions of the part in most birds.

In the Vulture (*Sarcoramphus papa*, fig. 3) the depth and breadth of the condyles are nearly equal; the inner one is smaller than the outer; the bridge lies to the inner side of the mid-line, and is more nearly transverse than in the Eagle. A small fossa is defined by a transverse ridge at the intercondyloid space: the tuberosity in the depression above the inner condyle is less developed. The posterior

* By depth I mean the fore-and-aft, or antero-posterior diameter.

trochlear surface is narrow and slightly concave. The fibula is not anchylosed to the tibia in the Vulture.

Order Insessores.

In the Raven (*Corvus corax*, fig. 4) the breadth and depth of the condyles are nearly equal: the condyles are of the same size, and are equally prominent behind; the intercondyloid space is wider than either condyle; there is a depression in it, bounded above by a transverse ridge. The bridge is broad, median, and nearly transverse; the canal is rather oblique. The posterior condyloid surface is divided by a median longitudinal rising. The sides are slightly concave: there is a low protuberance in the inner one.

The Crow (*Corvus corone*) shows but a feeble rudiment of the ridge at the narrow posterior condyloid surface: the anterior intercondyloid space equals each condyle: the depression in it is well marked: the bridge is broader than in the Raven. The tubercle in the shallow entocondyloid surface is minute.

In the tibia of the Hornbill (*Buceros*), the pro- and ecto-cnemial ridges are rudimentary. At the lower end of the bone the breadth of the condyles exceeds their depth: the inner condyle is longer, broader, more prominent posteriorly, but not anteriorly, than the outer one. The intercondyloid space equals the outer condyle: the depression in that space is deep, and well-defined by the superior transverse bar: above this the narrow ligamentous bridge remains unossified. Posteriorly the condyles are divided by a deep and narrow longitudinal groove; the sides are slightly concave.

Order Scansores.

In the Parrot (*Psittacus*) the breadth of the condyles exceeds the depth: the intercondyloid space is rather broader than either condyle, and retains its depth and breadth from the fore to the back part of the trochleæ. The intercondyloid fossa is a transverse groove at the lowest part of the space. The bridge is unossified.

In the Woodpecker (*Picus viridis*) the procnemial ridge extends down the inner side of the proximal third of the shaft. The breadth of the condyles a little exceeds their depth: the intercondyloid space is broader than each condyle, which are equal in degree of convexity and prominence anteriorly: the condyles contract to mere ridges behind. Here the space is divided by a low median longitudinal rising. The intercondyloid fossa is broad and deep. The bridge is broad; its lower outlet forms a small foramen.

Family Columbidæ.

In the Crown-Pigeon (*Lophyrus coronatus*, fig. 5) the depth of the inner condyle exceeds the breadth of that end of the tibia. The anterior convexities of the condyles are subequal, the inner one being rather more prominent. The intercondyloid space is of the breadth of each condyle. The posterior trochlear surface is very slightly concave transversely. The sides of the condyles are almost flat. The bridge is broad, transverse, submedian: the canal is narrow, with the lower outlet oblique and close to the inner condyle.

Order Gallinæ.

In the Curassow (*Crax Alector*) the breadth and depth of the condyles are equal; their anterior convexities slope gradually to the intercondyloid space, which has a small well-marked pit at its lower part; the sides of the condyles are very shallow, the outer ligamentous tubercle is slightly marked. The bridge is a little to the inner side of the mid-line, and is very broad, subtransverse; with the lower outlet oblique, and close above the inner condyle.

In the Cock (*Phasianus gallus*) the condyloid convexities are more distinct, or relieved from the intercondyloid space, than in the Curassow (*Crax*), and the fossa in that space is less marked:—in other respects the same characters prevail.

In the Turkey (*Meleagris gallopavo*, fig. 6) the relative breadth of the distal end of the tibia is rather greater; it has a relatively narrower bridge and a wider canal than in the Cock; the bridge is rather nearer the mid-line; external to the bridge is a low tubercle, just above the outer condyle: a narrow and shallow canal divides the bridge from the tubercle; the fossa, at the bottom of the intercondyloid space, is well-marked. In other respects the tibia of the Turkey closely resembles that of the Cock.

Order Grallæ.

In the Bustard (*Otis tarda*, fig. 7) the breadth and depth of the distal end are subequal: the condyles slope to a very narrow interspace: they are equal, but the innermost is most prominent, and most convex. The bridge, on the inner half of the bone, is broad, subtransverse, supporting a transverse ridge, which bounds above the cavity into which the lower outlet of the canal opens. The posterior part of the trochlear surface is deeper, its borders being more produced and sharper than in the Turkey and other *Gallinæ*. The ectocondyloid surface is slightly concave, with a median tubercle; the entocondyloid surface is more concave, with a larger tubercle near the anterior end of the inner condyle. The groove leading to the bridge has a ridge on the inner side, but none on the outer side of the bone.

In the Adjutant Crane (*Ciconia argala*) the depth exceeds the breadth of the lower end of the tibia more than in any other bird: the condyles are equal; the interspace is very short and narrow; that space is represented by the deep cavity formed by the tubercle and ridge developed from the bridge above, and by the oblique converging upper borders of the condyles below. The bridge is very broad, internal; the lower outlet is round, looks obliquely downwards and forwards, and opens into the supracondyloid concavity two lines above the inner condyle. The lower and hinder trochlear space is concave transversely; the lateral surfaces are slightly concave.

In the Seres Crane (*Grus Antigone*, figs. 8 *a*, 8 *b*) the breadth and depth of the condyles are equal. The intercondyloid space (answering to the supercondyloid in the Argala) exceeds in breadth either condyle; of these the inner one is the shorter in vertical extent, and is the more convex and prominent one: the outer and vertically longer condyle slopes gradually to the wide mid-space, which shows no special pit or depression. The canal leading to the bridge is broad, but is defined by a well-marked ridge on each side; the bridge is to the inner side of the mid-line, is very broad, transverse, with a transversely-oblong lower outlet pretty close to the inner condyle, looking directly forwards. The chief peculiarity is a tubercle, external to this aperture. The lower border of the outlet defines, with the tubercle, or bounds above, the shallow intercondyloid or supra-condyloid space; but there is no special depression. The posterior condyloid space is deeper than in the *Gallinæ*, especially towards the inner side, the bounding ridge of which is well-marked: the under surface is flattened. The outer side of the condyle shows a middle low tubercular ridge; the inner side is rather more concave, with a rising near the base of the anterior prominent part of the condyle.

In the Common Stork (*Grus nigra*) the breadth of the condyles anteriorly rather exceeds their depth. The trochlear space is rather flattened at its under surface; and in all the other modifications the correspondence with the *Grus Antigone* is close. The fore part of the trochlea is more remarkable for the tubercle external to the bridge than for the depth of the depression (intercondyloid or supercondyloid space) below the bridge.

In the Heron (*Ardea cinerea*) the depth a little exceeds the breadth of the condyles: the intercondyloid space is twice the width of the inner condyle, which is rather narrower than the outer one: the bridge is broad, oblique, internal: the lower outlet is transversely oval; immediately above the inner part of the intercondyloid space, which is shallow and has no special depression. There is no tubercle or ridge upon the bridge; the posterior trochlear surface is concave transversely.

In the Spoonbill (*Platalea leucorodia*) the depth of the condyles exceeds the breadth. The intercondyloid space is deep, and is wider than either condyle, which are narrow and prominent: the trochlear surface is flattened below, and is shallow behind. The bridge is near the inner border, and is broad and transverse: a low ridge is continued from it outwards, which forms the upper boundary of the shallow super- or inter-condyloid space: there is a slight special depression in this space just below the outlet of the bridge. The ectocondyloid surface is almost flat: the entocondyloid one has the tubercle for the attachment of the lateral ligament.

In the *Hæmatopus* the breadth of the distal end of the tibia exceeds the depth. The intercondyloid space equals the outer and exceeds the inner condyle: the outer one slopes more gradually to it:

the rest of the trochlear surface is a little concave transversely, with a feeble median rising behind. The bridge is to the left of the mid-line, short, and transverse: the lower outlet is above the inner side of the intercondyloid space: its lower border bounds above the shallow cavity at the upper part of, and continuous with, that space. There is a short ridge on the outer side of the bridge: the ecto- and ento-condyloid surfaces are as in *Grus*.

The distal end of the tibia of the Woodcock (*Scolopax rusticola*) closely conforms to that of the Oyster-catcher. The trochlea is a little flatter below, and the inner condyle is relatively smaller and more prominent: the lower border of the bridged canal, and a ridge continued outwards from it, define the shallow intercondyloid cavity above.

In the Gallinule (*Gallinula chloropus*, fig. 9) the bridge is broad, transverse and submedian: the lower outlet is large, and opens above the intercondyloid space, in which no particular cavity is defined. The canal leading to the bridge is broad, deep, and bounded by a ridge on each side. The inner condyle is much narrower than the outer one: the trochlear space is not flattened below; it is narrow and concave behind.

In the *Notornis*, or large short-winged Coot of New Zealand, figs. 10 *a*, 10 *b*, the breadth rather exceeds the depth of the condyles: the intercondyloid space is more than twice the breadth of either condyle. The bridge is of moderate breadth, transverse and median in position: its lower outlet is a transverse ellipse, looking forwards, just above the wide and shallow intercondyloid space: the canal leading to the bridge is wide and deep, with a boundary ridge on each side: the under and back parts of the trochlear surface are broader and flatter than in the Gallinule. The narrow inner condyle is very prominent.

The *Aptornis* (figs. 11 *a*, 11 *b*) chiefly differs from the *Notornis* in the less median position of the bridge, and the less depressed surface external to it: also in the much shallower canal leading to it, which has no external boundary ridge; the intercondyloid space, though wide and shallow, is less so relatively than in the *Notornis*: in other respects the tibiæ of this and the foregoing New Zealand birds resemble each other at the lower end.

Order Cursores.

In the *Apteryx* (fig. 12) the breadth and depth of the condyles are equal: the inner one is the more prominent; the intercondyloid space is rather narrower than either condyle. The bridge—sometimes unossified—is internal; external to it the surface of the bone is moderately convex, and divided by a transverse linear groove from the intercondyloid space, in which is no special depression. The hinder trochlear space is slightly concave transversely.

In *Dinornis* (figs. 2 *a*, 2 *b*) the breadth and depth of the condyles are equal: the outer condyle (*b*) is the broader, the inner one (*a*) is the more prominent; their articular surfaces are so continuous as to leave no space answering to the intercondyloid one in *Aptornis, Notornis*, &c.; but the continuous surfaces form a ridge which bounds below the supracondyloid space, the same being bounded above by the ridge extending outwards from the supratendinal bridge, *e*. This is nearer the inner side of the bone, is subtransverse, rather narrow, with a widely elliptical lower outlet opening above the inner condyle: the canal (*f*) leading to the bridge has an internal boundary ridge: a shallow longitudinal groove divides the outer side of the bridge from a tuberosity above the outer condyle. The under and hinder parts of the trochlear surface are concave transversely.

In the Ostrich (*Struthio camelus*) the breadth and depth of the condyles are equal: they are less produced anteriorly than in other birds, and their articular surfaces are so continuous as to leave no well-defined intercondyloid space; that surface projects in a transverse concave line some way in advance of the supracondyloid space, which is marked by a submedian transverse ridge or broad tubercle, external to which is a rounded depression. There is no supratendinal bridge or groove. The under trochlear surface is broad and slightly concave from side to side; posteriorly it is deepened by the development of its borders, of which the inner one is the sharpest and most suddenly produced. This surface is traversed by a slight median longitudinal rising. The ectocondyloid surface is concave, and has a pit fitting the end of a finger. The entocondyloid surface shows a deep pit near its anterior part, whence a wide groove curves backwards, becoming broader and shallower to the posterior part of the condyle. The distal condyles expand more suddenly beyond the shaft than in most birds.

Order Natatores.

In the Swan (*Cygnus ferus*) the breadth and depth of the condyles are equal: the intercondyloid space, fig. 13, *a*, exceeds either condyle: it has a very shallow transverse fossa. The bridge, *e*, of moderate breadth, is median, transverse, and straight; it spans a wide and deep canal, the lower aperture of which looks forwards and opens immediately above the intercondyloid space. The canal leading to the bridge has no lateral sharp ridge: the inner border is most developed and is rounded. The under and hinder trochlear surface is very slightly concave transversely. Both ecto- and ento-condyloid surfaces are flat.

I have received from the brick-earth at Grays, in Essex, the lower end of a fossil tibia (figs. 13 *a*, 13 *b*) corresponding precisely in the modifications of its distal end with those of the *Cygnus ferus*: it is very little larger than the tibia of the Wild Swan, and may be of the same species. The bone had undergone the same change as the bones of the *Elephas primigenius, Rhinoceros tichorhinus*, &c., from the same formation.

The above characters are very closely repeated in the Goose (*Anser palustris*): the bridge is broader in proportion to the size of the canal. The under surface of the trochlea has a feeble median prominence, as in the Swan. The inner border of the canal above the bridge is more defined than in the Swan.

In the Falkland Island Goose, the tendinal canal is more oblique and its lower outlet more to the inner side than in the Common Goose.

In the Pelican (*Pelecanus onocrotalus*), the lower end of the tibia is less expanded than in the *Anatidæ* and most extinct birds: the breadth and depth are equal. The intercondyloid space is wider than either condyle, which are alike. The bridge is median, but narrow and oblique; spanning a wide and deep canal, the lower outlet of which looks forward, opening immediately above the intercondyloid space. The posterior trochlear surface is nearly flat transversely, and has a low and broad median rising.

The Great Gull (*Larus marinus*), with the breadth and depth of the expanded lower end of the tibia equal, has a wide intercondyloid space; the inner condyle is more prominent, and is shorter than the outer one: the posterior trochlear surface is concave across. The bridge is submedian, narrow, descending rather obliquely from the inner to the outer side; spanning a wide canal, with the lower outlet above the intercondyloid space, and separated from it by a feeble narrow ridge. The canal leading to the bridge is broad, and is bounded on each side by a short sharp ridge.

In the Albatros (*Diomedea exulans*, fig. 14), the breadth, depth, and prominence of the condyles are equal; but neither of them is so broad as the intercondyloid space. The bridge is submedian, transverse, broad, with the lower outlet of the wide canal transversely elliptical and large, looking directly forwards, just above the inner half of the intercondyloid space, and situated relatively lower down than in the Swan. The trochlear articular surface is not produced forwards in advance of the intercondyloid space, nor does that space show any fossa or depression.

In the *Alca torda*, the breadth a little exceeds the depth of the condyles. These are subequal, with a wide intercondyloid space: the posterior trochlear surface is very slightly concave across, and with a feeble median rising. The bridge is submedian and broad: the inner ridge of the canal leading to it is most developed, the lower outlet is transversely elliptical and just above the intercondyloid space. The ectocondyloid surface is flat: the entocondyloid one is subconcave, with a median tubercle.

In the Grebe (*Colymbus glacialis*)—so remarkable for the modification of the proximal end of the tibia,—the distal end of the bone deviates little from the usual natatory type. The wide intercondyloid space is deeper, the narrow convex condyles being more produced than in the Albatros and *Anatidæ*. The posterior trochlear surface has a well-marked outer ridge, and a feeble median rising. The bridge is median, transverse, very narrow in the middle, spanning a very deep and wide canal, the large lower aperture of which looks directly forwards, opens just above the intercondyloid space, and has a thin sharp lower transverse border. The canal leading to the bridge occupies almost the whole of the breadth of the bone.

Comparison. — Having premised the foregoing remarks on the modifications of the distal end of the tibia in some existing examples of every order of birds, I proceed to apply this knowledge to the elucidation of the nature of the fossil tibia of the *Gastornis* discovered in the lowest eocene beds in the vicinity of Paris.

In this fossil, fig. 1, the distal end is much mutilated: the anterior projecting convexities of both condyles are broken away, and both the under and posterior trochlear surfaces are to a certain extent wanting: a small tract of the original smooth articular surface remains there, and a smaller portion is left on the broken outer condyle. The proportion of breadth to depth of this end of the bone is, therefore, indeterminable in the sole example discovered. It would seem as if the anterior intercondyloid or supercondyloid surface had been divided from the articular surface by as abrupt a transverse bar as in the Ostrich, Dinornis, and certain *Grallæ*; and the under surface appears to have had a similar extent and contour of surface to that in the *Gruidæ*: it seems to have been broader and flatter than in the Dinornis. Posteriorly the trochlea is relatively as broad as in the *Gallinæ*, and is broader than in the *Grallæ*. The rough fractured base of the inner condyle shows that the intercondyloid space was relatively narrower than in the *Anatidæ*, and most other water-birds. The supratendinal bridge is more median in position than in most of the *Grallæ*; though not more so than in the Gallinule and Oyster-catcher. This median position, though common in the *Natatores*, is not peculiar to them. The Curlew, Notornis, Raven, Eagle, and the Crown Pigeon have a similar position of the bridge.

The direction of the bridge appears to have been nearly transverse; but much of it is broken away. The canal leading to it is bounded by a well-marked ridge internally, but seems to want an outer boundary: the aspect of the lower opening is obliquely forwards and downwards, as in the *Gallinæ* and some *Grallæ*; not directly forwards, as in most *Natatores*. As to the distance of that opening from the lower surface of the trochlea, it is not relatively greater than in the Turkey, the Cock, the Gallinule, and the *Anatidæ*. The depression beneath that outlet in the fossil, if it be natural, is a peculiarity I do not find in any Wading-bird. The depression above the articular trochlear surface in the Bustard, *e.g.*, is one into which the tendinous canal opens, and is chiefly due to the transverse ridge developed from the bridge spanning the canal. In the Argala it is due to the strong tubercle similarly developed above the outlet of the canal; in the *Grus* to a similar tubercle projecting forwards external to the outlet.

The Curlew (*Numenius arcuata*, fig. 15) and Oyster-catcher (*Hæmatopus*) show a more shallow depression below the outlet. The smooth surface of the middle of the depression on the outer side of the condyle appears to indicate its concavity, but the border is too much broken away to enable one to judge of its original depth.

The relative breadth of the posterior part of the trochlear surface agrees with that in the Turkey and the Swan; but the borders are here, also, too much broken away to enable one to determine its original degree of concavity: the margins were, however, evidently more developed than in the Swan.

The general proportions of the fossil tibia from the Paris eocene, fig. 1, are most like those of the *Dinornis casuarinus*, fig. 2: the size is nearly the same. The differences at the distal end are seen in the more median position of the supratendinal bridge, *e*, in the *Gastornis*; it is close to the inner side in the *Dinornis*; in the absence of the depression below the outlet in the *Dinornis*; in the greater posterior breadth of the trochlea in *Gastornis*; and in a greater antero-posterior diameter of the inner side of the shaft. The shallow groove and low tuberosity external to the canal are present in both these extinct birds.

From the tibia of the Solitaire (*Pezophaps*), that of the *Gastornis* differs in the more median position of the bridge, and in the depression below the bridge: in other respects it makes a close approximation to that extinct bird.

The *Aptornis* further differs from the *Gastornis* in the wider intercondyloid space, and in the narrower and (probably) more prominent inner condyle; but the mutilated state of that part in the Parisian fossil prevents a decided opinion on this point.

The *Notornis* resembles the *Gastornis* in the median position of the bridge, but differs in the absence of the depression below it, in the aspect and shape of the lower outlet, in the wider intercondyloid space and narrower inner condyle, and in the well-developed outer boundary of the canal leading to the bridge.

Conclusion.—Having made the foregoing observations and comparisons of the tibiæ of recent and fossil birds with that of the *Gastornis*, as much as possible independently of any preconception or bias from previous opinions published as to the nature and affinities of that bird, I propose to review those opinions, commencing with the remarks of M. le Prof. Hébert, who has given a very accurate description of the fossil in question. After rightly pointing out the gradual increase of the transverse over the antero-posterior diameter of the bone as the lower fourth of the shaft approaches the condyles, he remarks:—"Cet aplatissement du tibia est très remarquable et constitue un bon caractère distinctif*." It offers a marked difference as compared with the tibia of the large species of Crane (*Ciconia*), Stork (*Grus*), Bustard (*Otis*), and most Waders, and also from the *Gallinæ* and the *Natatores*, especially in the development of the ridge or angle between the fore and outer surfaces of the bone leading to the outer condyle. The Eagle shows something like this, which is due to the anchylosed lower point of the fibula, which forms the corresponding ridge; the lower third of the tibia in all the great Aquiline birds is proportionally more compressed from before backwards; but the inner side is by no means so thick antero-posteriorly. The correspondence, however, between the *Gastornis* and the *Dinornis casuarinus* in the general form and proportions of the lower end of the tibia is very

* Compte Rendu de l'Académie des Sciences, Mars 12, 1855, p. 579.

close; and the same may be said with regard to the *Aptornis* and *Notornis*. The outer ridge is not developed in the *Pezophaps*. The fibular crest, supposing it to be entire in the fossil, is not so strongly developed as in the Swan, the Pelican, and other *Natatores*, or as in the *Ciconia, Otis, Notornis*, and other *Grallæ*; the proportions of that ridge in the Turkey and other *Gallinæ* most resemble those in *Gastornis*.

As to the form and extent of the inferior trochlear articular surface, nothing precise can be affirmed of its much-mutilated condition in the fossil: the development of the boundary margins and prominent condyles in perfectly preserved tibiæ of *Dinornis, Palapteryx, Aptornis*, &c. has so much surpassed any indications given by the first-received mutilated bones of those extinct birds, that due caution has been impressed upon me in regard to inferences from abraded bases of such prominences of their natural state. Far from inferring a flattened surface on the non-articular sides of the condyles of the *Gastornis**, the rugged broken peripheral tract surrounding the small portion of the natural surface intimates the concavity which one would find there were the borders of those lateral surfaces perfect.

The *Dinornis, Pezophaps, Notornis, Platalea, Crax*, Turkey, and Common Fowl have the lateral surfaces in question as flat as in the *Lamellirostres*, or as it is possible for them to have been in the *Gastornis*. No especial affinity of the Paris fossil to any tribe of aquatic birds can be inferred from the external or lateral surfaces of the condyles. The greater prominence of the upper and fore part of that surface of the inner condyle ("malléole interne," Hébert) is a character common to most birds of every order: a strong lateral ligament is attached to that prominence.

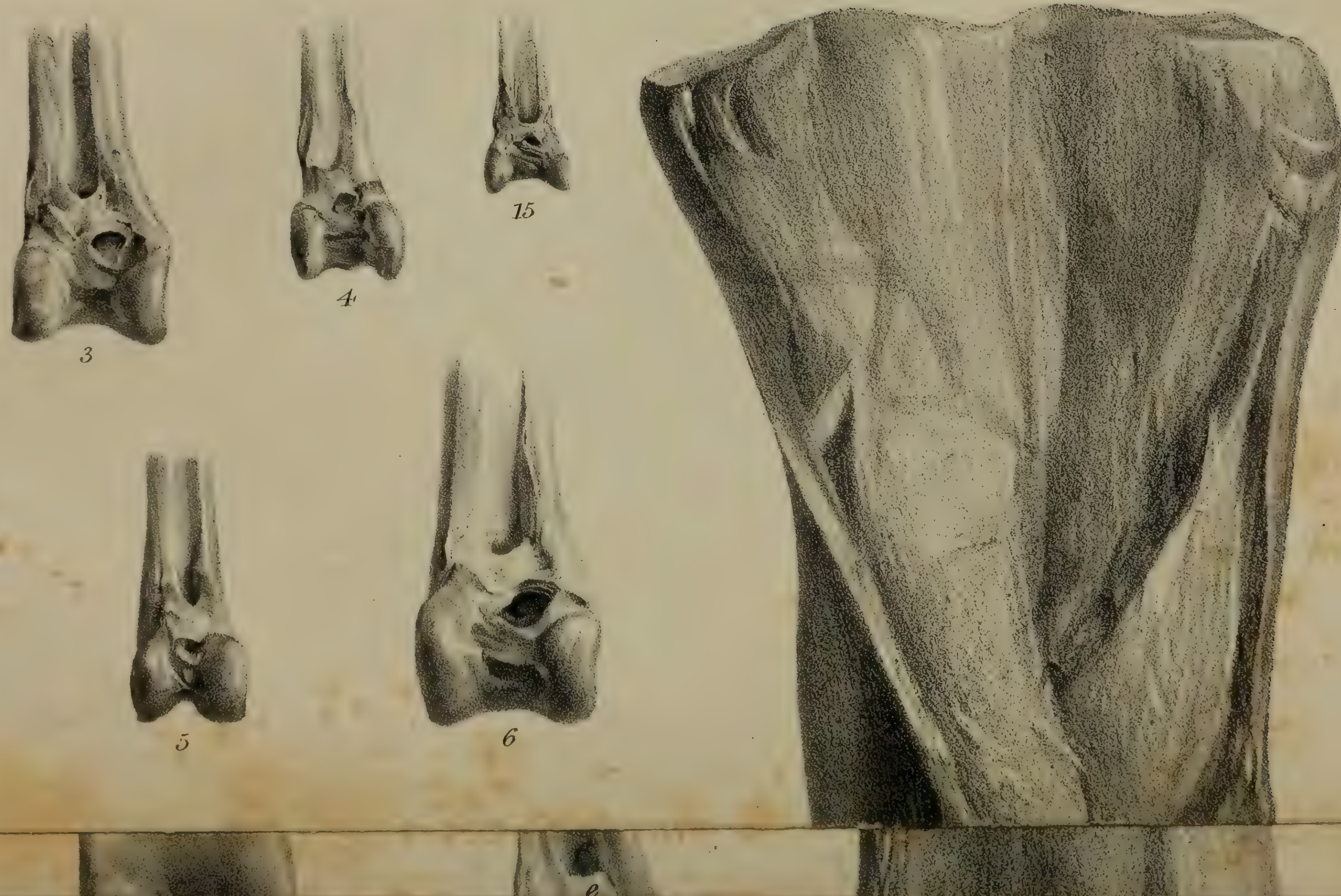
Interesting unquestionably is the median position of the supratendinal bridge in *Gastornis*†, and it would satisfactorily indicate its affinities to the Swan and Goose, were not the same bridge equally medianly situated in the Gallinule, the *Notornis*, the Raven, some Accipitrine birds, &c. Amongst the *Gallinæ*, also, the Turkey so nearly resembles the *Gastornis* in the position of the bridge, and so much more closely resembles it than does the Swan or Goose in the low tuberosity external to the bridge above the base of the outer condyle, and in the shallow groove dividing that tuberosity from the bridge, that I should infer an affinity of the *Gastornis* to the *Gallinacea* from the characters of the bridge, rather than to the *Lamellirostres*. That very inclination of the canal to the inner side, and the position of the lower outlet to the left of the median plane, in the *Gastornis*, while it is a departure from the anserine type, is an approximation to the Gallinaceous and Dinornithic structures. The lower outlet of the tendinous canal, while it is relatively higher in

* "Les deux condyles portent latéralement en dehors une facette plane, comme chez les Palmipèdes lamellirostres, et non-excavée comme cela a lieu chez l'autruche et les autres coureurs."—Ib. p. 579.

† "L'arcade osseuse est située à peu près dans la partie médiane de la face antérieure, comme dans le cygne et l'oie."—Ib. p. 580.

Gastornis than in the *Lamellirostres*, does not appear to me to have been more above the level of the trochlear surface than in the *Aptornis, Pezophaps, Dinornis*, or the *Gallinacea*. I believe, indeed, that, if the prominent anterior parts of the condyles had been preserved in the *Gastornis*, the appearance of the high position of the bridge would have been much modified. The aspect, or plane, of the lower outlet offers a useful character of comparison, and it appears to me that it can be judged of in the Parisian fossil. The border of the outlet is sufficiently entire to show that its upper and inner part was most prominent, causing the outlet to look a little downwards as well as forwards, or in some degree into the supra-condyloid cavity below the canal. Now in the *Lamellirostres*, and in the *Diomedea* and other Longipennate Palmipeds, the corresponding foramen looks directly forwards : its plane is vertical, or, if inclined therefrom, it is by the greater projection of the lower border. This foramen being relatively lower in the Albatros than in the Swan, makes the Albatros depart further from *Gastornis*.

In the aspect of the lower outlet of the tendinous canal, the *Gastornis* more resembles the known large wading and land birds and the *Dinornithidæ*, than it does any aquatic bird ; this character appears not to have been taken into consideration in previous comparisons of the *Gastornis*. The fossa beneath the canal, bounded below by the projecting border of the intercondyloid trochlear surface, is a character which, though not precisely repeated, as to the form, proportion, and position of that fossa, in any of the *Grallatores*, finds its nearest correspondence in the usually larger cavity at the corresponding part of the tibia in most birds of that order : and I concur with MM. Hébert and Lartet in deeming the fossa in question to indicate more directly an affinity of the *Gastornis* to the *Grallatorial* order, than any other character which the fossil bone presents. The anterior border of the trochlear surface presents a similar projection in the *Dinornis* ; it bounds a cavity below, which has its upper boundary in the ridge continued transversely above the bridge, and into which the lower outlet of the canal opens, as in the Bustard. The Swan, the Albatros, and other Palmipeds show no trace of this anterior prominence of the trochlear border ; nor can any more trace be seen of a fossa below the tendinous canal in the Albatros, than in the Swan or Goose. The proportions of the tibia—its thickness, *e. g.*, in proportion to its length—would plainly show, however, that the Parisian eocene bird had more robust and shorter legs than in the typical waders ; and probably was, as in other birds of like dimensions, better adapted for terrestrial life. The result of the numerous comparisons which I have made lead me entirely to concur in the final conclusion of M. Hébert, viz. that the *Gastornis* belongs to a genus of birds distinct from all previously known.



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DESCRIPTION OF PLATE III.

Fig. 1*a*. The fossil tibia of the *Gastornis parisiensis*, nat. size.
Fig. 1*b*. The lower articular surface of the same bone.
Fig. 2*a*. The lower end of the tibia of the *Dinornis casuarinus*, nat. size.
Fig. 2*b*. The lower articular surface of the same bone.
Fig. 3. The lower end of the tibia of the Vulture (*Sarcoramphus papa*).
Fig. 4. *Ib.* *ib.* *ib.* Raven (*Corvus corax*).
Fig. 5. *Ib.* *ib.* *ib.* Crown Pigeon (*Lophyrus coronatus*).
Fig. 6. *Ib.* *ib.* *ib.* Turkey (*Meleagris gallopavo*).
Fig. 7. *Ib.* *ib.* *ib.* Bustard (*Otis tarda*).
Fig. 8*a*. *Ib.* *ib.* *ib.* Seres Crane (*Grus Antigone*).
Fig. 8. The lower articular surface of the same bone.
Fig. 9. The lower end of the tibia of the Gallinule (*Gallinula chloropus*).
Fig. 10*a*. *Ib.* *ib.* *ib.* *Notornis Mantelli.*
Fig. 10*b*. The lower articular surface of the same bone.
Fig. 11*a*. The lower end of the tibia of the *Aptornis otidiformis.*
Fig. 11*b*. The lower articular surface of the same bone.
Fig. 12. The lower end of the tibia of the *Apteryx australis.*
Fig. 13*a*. *Ib.* *ib.* *ib.* of a Swan (*Cygnus ferus?*): fossil, from a pleistocene formation.
Fig. 13*b*. The lower articular surface of the same bone.
Fig. 14. The lower end of the tibia of the Albatros (*Diomedea exulans*).
Fig. 15. The lower end of the tibia of the Curlew (*Numenius arcuata*).

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3. *Description of some* MAMMALIAN FOSSILS *from the* RED CRAG *of* SUFFOLK. By Prof. OWEN, F.R.S., F.G.S.

SINCE my description of the mammalian fossils of the Red Crag, collected by Sir Charles Lyell at Newbourn, Suffolk, in 1840*, and the publication of the 'History of British Fossil Mammalia,' in which these and subsequently discovered Cetacean Crag fossils were figured, I have visited several localities where the Red Crag is worked for phosphatic nodules, in Suffolk, and have myself collected, and have received from other collectors, numerous specimens of mammalian remains, from the Red Crag, of which I have selected the following as most worthy of being described.

Genus *Rhinoceros*.

There is some difficulty in determining the species of Rhinoceros by detached fossil molar teeth—the only recognizable parts of the genus that I have yet obtained from the Red Crag of Suffolk.

Most of the detached molars of *Rhinoceros* from this formation appear by their size, want of roots, and indications of absorbent action at the base of the crown, to have belonged to the deciduous series of teeth, and to have been shed by young individuals; and the milk-teeth are less characteristic even than the permanent ones, as indeed most structures of the immature period of life partake more of the general and less of a special character than those of the adult. There are, however, specimens of the permanent teeth sufficiently cha-

* Annals and Magazine of Natural History, vol. iv. 1840, p. 186.

Tibia of Gastornis Parisiensis.

(Compared with the Tibiæ of other Birds)

racteristic and well-preserved to determine their relations to the like evidences of extinct Rhinoceroses previously discovered in England. The most characteristic examples of these teeth from the Red Crag are figured for the present communication*, and, having previously studied and endeavoured to demonstrate the differences between the upper molars of the *Rhinoceros tichorhinus* and those of the *Rhinoceros leptorhinus* in my 'British Fossil Mammalia,' figs. 122, 125, and 126 (*Rh. tichorhinus*), fig. 141 (*Rh. leptorhinus*), I have been, in some degree, prepared to deduce satisfactory evidence of the nature of the molars of the Rhinoceros from the Red Crag.

Baron Cuvier†, Prof. Kaup‡, Dr. Buckland, and Prof. Jaeger§ have given the laudable example of figuring such fossil teeth of the natural size: all who are reduced, as in the present case, to mere teeth for the determination of species must regret that the authors of the excellent 'Zoologie et Paléontologie Françaises‖,' and of the 'Nouvelles Études sur les Rhinoceros Fossiles¶,' should not have followed that example: for, reduced figures of objects rarely exceeding two or three inches in natural size cannot afford satisfactory means of comparison, and the loss to science is greater than such saving of expense or space can compensate for.

In the upper molar (fig. 1, probably the third of the right side) from a 'Red Crag' or 'Coprolite' pit, at Wolverston, Suffolk, the contour of the outer side of the tooth, *d*, *d'*, *d''*, more resembles that of the older pliocene and miocene Rhinoceroses (*Rh. megarhinus*, Christol, *Rh. Schleiermacheri*, Kaup), than that of the pleistocene *Rh. tichorhinus* or *Rh. leptorhinus*; the vertical ridge *d'* is relatively more produced and is nearer the antero-external angle of the crown, *d*, than in the *Rh. tichorhinus*, in which the outer border of the crown is more undulated. From the ridge *d'*, the outer border of the crag-tooth has extended to the hinder angle of the tooth, *d''*, in a nearly straight line; a part of the enamel near that angle has been, unluckily, broken away, but the body of dentine seems there to be entire, whence one may refer the resemblance of the contour of that border to that of the fourth and fifth upper molars of the *Rhinoceros megarhinus*, figured (half nat. size) by M. Christol, in the 'Annales des Sciences Naturelles,' tom. iv. 2nd sér. pl. 2. figs. 3^e, 4^e, 5^e.

In that species of *Rhinoceros* the second, third, and fourth molars (premolars) are distinguished from the three following molars (true molars) by a basal ridge extending along the inner side of the tooth, and continued along a part of both the anterior and posterior sides of the tooth. The present crag-fossil shows the same basal ridge, *f*, *f*, commencing at the inner half of the anterior side of the crown, sweeping across the whole inner side, and gradually ascending to

* The woodcuts illustrative of the Teeth, Bones, and Antlers described in this communication will be found at pages 231–236.

† Ossemens Fossiles, tom. ii. pls. 6, 13, 1822.

‡ Ossemens Fossiles de Darmstadt, 4to et fol. 1833.

§ Fossilen Säugethiere Wurtembergs, fol. 1839.

‖ Gervais, 4to, 1852–54.

¶ Duvernoy, in the 'Archives du Muséum d'Histoire Nat.,' tom. vii.

terminate near the entry of the posterior valley *a*, where, however, it has been worn away by pressure against the adjoining tooth. There is no evidence of such a ridge in any of the upper molars of the *Rhinoceros tichorhinus*. In the excellent figures of the upper molars of the *Rhinoceros Schleiermacheri*, of the natural size, given by Prof. Kaup*, the third and fourth molars exhibit a similar basal ridge to that in the *Rhinoceros megarhinus*, and in the crag-tooth, fig. 1.

In the greater depth and width of the entry to the internal (*b*) and posterior (*a*) valleys, the crag-tooth resembles the pliocene and miocene Rhinoceroses above-cited, and differs from the pleistocene *Rhinoceros tichorhinus*; in which, owing to the entry of the corresponding valleys being relatively shallower, and those valleys deepening more as they penetrate the crown, they are sooner converted into pits circumscribed by islands of enamel, as shown in the teeth, figs. 1, 2, & 4, pl. 6, and in figs. 1 & 6, pl. 13, of the 'Ossemens Fossiles' of Cuvier, in the paper by Dr. Buckland in the 'Philosophical Transactions' for 1822, pl. 21. fig. 3, and in my 'British Fossil Mammalia,' figs. 122 & 126.

The internal valley, *b*, is bilobed in the *Rhinoceros tichorhinus*, or bends back so abruptly at its termination, that that termination becomes insulated by attrition from the rest of the valley, as in some of the figures above-cited; such a change does not take place in the *Rhinoceros megarhinus* and *Rh. Schleiermacheri*; in the latter the end of the valley *b* slightly expands, and sometimes it is festooned by small processes of enamel and dentine re-entering it, as is shown in the crag-tooth, fig. 1, *b*, and in the penultimate upper molar of the *Rhinoceros Schleiermacheri*, figured in tab. 9. fig. 5, of Prof. Kaup's excellent work above quoted.

Prof. Christol does not represent this structure in any of the molars of his *Rhinoceros megarhinus*; but in the sixth (penultimate or second true) molar, attributed by M. Gervais to the same species, and figured, of half the natural size, in the 'Paléontologie Française,' pl. 2. fig. 5, the same modification of the end of the valley, *b*, reappears, as is shown in the corresponding tooth of the *Rhinoceros Schleiermacheri*. From these differences I conclude that the fossil tooth from the Red Crag of Wolverston does not belong to the species of *Rhinoceros* (*Rh. tichorhinus*) which is associated in our pleistocene gravels, drifts, and bone-caves with the *Elephas primigenius*, but that it belongs to a species much more nearly allied to, if not identical with, either the *Rhinoceros megarhinus* of the older pliocene formations, near Montpellier, or the *Rhinoceros Schleiermacheri* of the miocene formations near Darmstadt.

The second example of the upper molar of a Rhinoceros, from the Red Crag of Suffolk, fig. 2, is also from the right side; but the outer third of the crown is broken away together with the base of the tooth. It is worn down more deeply than the preceding molar, the valley *b* being insulated, and the valley *a* connected by an isthmus of little more than a line in breadth with the outer wall of

* *Op. cit.* tab. 11. fig. 5.

enamel. The amount of attrition to which this tooth has been subject is about the same as that of the teeth of the *Rhinoceros tichorhinus* figured by Cuvier in the 'Ossemens Fossiles,' tom. ii. pl. 6. figs. 1 & 2. But, whereas it is the shorter posterior valley which is still uninsulated in the crag-tooth (fig. 2), the long internal valley is the one which retains the narrow continuity of enamel in the molar teeth figured by Cuvier; moreover, these teeth show the third island due to the separation of the hinder divison of the expanding and bifurcating valley *b*, in the *Rhinoceros tichorhinus,* whilst no trace of the third enamel-island exists in the crag-molar in question. This molar, moreover, shows a well-developed internal basal ridge, *f*, commencing, as in the foregoing crag-tooth, fig. 1, near the middle of the anterior surface, and rising as it extends along to the inner surface to terminate at the postero-internal angle of the crown.

From the above characters it may be concluded that the portion of the upper molar, fig. 2, from the crag-pit near Felixstow, Suffolk, does not belong to the *Rhinoceros tichorhinus,* but to a species more nearly allied to, if not identical with, either the *Rhinoceros megarhinus* or the *Rhinoceros Schleiermacheri.*

The third example of the upper molar of *Rhinoceros,* from the Suffolk Red Crag, fig. 3, is from the left side, and had been but little used in mastication,—not more, for example, than the tooth of the *Rhinoceros leptorhinus,* from the Clacton pleistocene, fig. 141, p. 373, of my 'History of British Fossil Mammals,' and to about the same extent as the premolar teeth of the *Rhinoceros Schleiermacheri,* figured by Prof. Kaup in tab. 11. fig. 7, of his most useful Illustrations of the Fossils of Darmstadt. In the disposition of the enamel-folds, the present crag-tooth so closely accords with the upper molars of the miocene *Rhinoceros* (*Rh. Schleiermacheri*), that I am strongly inclined to regard it as belonging to that species; I have not, however, had the opportunity of comparing it with an upper molar of the *Rhinoceros megarhinus* in the same stage of attrition.

The valley, *b*, as in the *Rhinoceros Schleiermacheri,* after penetrating along a line parallel with the anterior border, two-thirds across the crown, suddenly bends backwards at a right angle; the commencement of the valley is very wide and deep. The posterior valley *a* is triangular, and in form and place closely resembles that in the *Rhinoceros Schleiermacheri.* The position of the longitudinal ridge *d'* accords with that in the crag-tooth, fig. 1, and with that in the upper molars of both *Rhinoceros Schleiermacheri* and *Rh. megarhinus.* The basal ridge *f* extends as far along the fore part of the crown as in the *Rh. Schleiermacheri,* and it is continued, as in some premolars of that species, around the inner side of the lobe *c*. The basal ridge is confined to the fore part of the crown in the *Rhinoceros leptorhinus.*

In all the characters in which the present crag-molar resembles those of the *Rhinoceros Schleiermacheri* it differs from those of the *Rh. tichorhinus.*

The lower molar teeth of *Rhinoceros* from the Suffolk Crag are more numerous than the upper ones. Unfortunately they are less characteristic of species. I have figured three of the best-marked specimens.

If the teeth in the lower jaw of the *Rhinoceros Schleiermacheri* figured by Kaup in tab. 11. fig. 8, *op. cit.*, be compared with the figures of the lower molar teeth of the *Rhinoceros tichorhinus* given by Cuvier in pl. 6. fig. 7 and pl. 13. fig. 3, *op. cit.*, and by Buckland in pl. 21. fig. 5, *op. cit.*, it will be seen that the tract of dentine exposed by moderate abrasion in the hinder lobe of the tooth is more angular in the miocene *Rhinoceros*, and more gradually bent in the pleistocene one.

If the figure of the lower molar of the *Rhinoceros* from the Red Crag at Sutton, fig. 4, be compared with that of a probably answerable molar, only a little more worn, of the *Rhinoceros tichorhinus* in the 'History of British Fossil Mammals,' fig. 127, p. 337, the same difference will be recognized, together with the difference in the thickness of the enamel, the greater thickness of which characterizes all the teeth of the *Rhinoceros tichorhinus* as contrasted with those of the *Rhinoceros megarhinus* and *Rhinoceros Schleiermacheri* *. I have no hesitation, therefore, in affirming that the crag-tooth, fig. 4, does not belong to the *Rhinoceros tichorhinus*; although, in the absence of means of comparing it with the lower molars of the pliocene and miocene Rhinoceroses hitherto defined, I cannot positively refer it to any of those species. There is a short oblique, basal ridge at the outer and anterior angle of the tooth, and a short rudimentary one at the back part of the crown.

Fig. 5 is a lower molar from the left side of the lower jaw of a *Rhinoceros*, from the Red Crag at Felixstow; it is more worn than the preceding, but repeats all its characters of resemblance to the lower molars of the *Rh. Schleiermacheri*, and of difference from those of the *Rh. tichorhinus*.

The crown of a right lower molar of a *Rhinoceros*, from the Red Crag at Sutton, fig. 6 *a*, *b*, *c*, of which the summit of the anterior lobe had only just begun to be abraded, shows the anterior oblique basal ridge continued, of less thickness, along the fore part of the anterior lobe, where it describes a curve convex upwards, fig. 6 *b*; there is a shorter and thicker curved basal ridge, behind, fig. 6 *c*.

The small lower molar from the right side of the jaw of a Rhinoceros, fig. 7, found in a crag-pit at Sutton, corresponds in size and general form with the second molar of the *Rhinoceros Schleiermacheri* figured in tab. 12. fig. 11, of Prof. Kaup's work above cited.

The above-described specimens of fossil teeth of *Rhinoceros*, from the crag-pits of Suffolk, afford satisfactory evidence of the remains of a species distinct from the common Tichorhine *Rhinoceros* and from the Leptorhine *Rhinoceros* of the pleistocene era, and more nearly allied to, if not identical with, either a species of *Rhinoceros*,

* The figure of the lower molars of the *Rhinoceros megarhinus*, given by Christol in the Annales des Sciences Nat. vol. iv. 2nd ser. pl. 2. fig. 1, and by Gervais, in pl. 30. fig. 1. of the Paléontologie Française, as well as that of the *Rhinoceros pleuroceros*, in pl. 8 of the Archives du Muséum, tom. vii., are too much reduced to be of use in this comparison.

viz. *Rh. megarhinus*, from the older pliocene, or with one, viz. *Rh. Schleiermacheri*, from the miocene tertiary formations.

Genus *Tapirus*.

At the period of the publication of my 'History of British Fossil Mammals,' 1845, no remains referable to the genus *Tapirus* had come under my notice from any British locality; the Tapiroid family was represented only by species of *Coryphodon* and *Lophiodon*.

The existence of a true Tapir in tertiary strata was first made known by Prof. Kaup, in the miocene deposits at Eppelsheim; an almost entire under jaw and part of an upper jaw, with the characteristic teeth of both, are described and figured, tab. 6. *op. cit.*, under the name of *Tapirus priscus*. Remains of a Tapir have also been discovered in both miocene and old pliocene strata in Auvergne and other parts of France: these fossils M. de Blainville thought not to be specifically distinct from the *Tapirus priscus* of Kaup. They are assigned, in Gervais' 'Paléontologie Française,' to a species named *Tapirus arvernensis* (from the Puy-de-Dome), to a *Tapirus minor* (from the pliocene sands of Montpellier), and to a *Tapirus Poirieri* (from the miocene deposits of the Bourbonnais).

It may seem hazardous to affirm the existence of a British fossil Tapir from a single tooth, and that a lower one; but the molar tooth figured, fig. 8, from the crag-pit of Sutton, from which the upper molars of the *Rhinoceros* so near to, if not identical with, the *Rhinoceros Schleiermacheri* were obtained, bears a closer resemblance to a newly risen and unworn molar of the lower jaw of the *Tapirus priscus*, Kaup, than to any other recent or fossil tooth with which I have been able to compare it. There are the same two principal transverse ridges, the same low basal ridge at the fore and back parts of the crown, the same slight concavity of that side of the principal ridge which is directed upwards;—the closest agreement, in fact, both as to form and size, prevails. I am, therefore, led to expect that the former existence of a British Tapir, probably not distinguishable from the *Tapirus priscus*, Kaup, will be confirmed by subsequent discoveries of the more characteristic upper teeth, in the Suffolk crag-pits.

[Since the above paragraph was in type, I have had the desired opportunity of comparing an upper molar tooth (fig. 9) from the Red Crag of Suffolk, now in the British Museum, with those of the *Tapirus priscus*, Kaup, and the comparison has afforded the anticipated confirmation.—R. O., July 1856.]

Genus *Sus*.

Since my first determination of a fossil of the genus *Sus* in the Red Crag of Suffolk*, viz. the external incisor of the lower jaw (p. 428, fig. 173, Brit. Foss. Mamm.), several molar teeth of the Hog genus have been obtained from that formation, and some of them in the

* Annals of Natural History, vol. iv. 1840, p. 185.

usual mineralized state of its characteristic fossils. Of these I have figured the last upper molar tooth of the left side, fig. 10, from the Red Crag at Sutton. It differs from the corresponding tooth in the *Sus scrofa* by the shorter antero-posterior diameter as compared with the transverse diameter of the crown, the latter dimension at the fore part of the tooth being the same as in the corresponding tooth of an ordinary wild boar; but the crown of the fossil tooth wants one-fifth of the length of the grinding surface in the corresponding tooth of the recent species (*Sus scrofa*). Prof. Kaup has described (p. 11) and figured (tab. 9. fig. 3, *op. cit.*) an almost precisely corresponding tooth to that represented in fig. 9; and, for the species of Hog represented by portions of jaws with similar teeth he proposes the name of *Sus palæochœrus*; founding the specific difference chiefly on the same differences in the proportions of the molar teeth which are illustrated by the crag-fossil under consideration. To those who will compare the figure of this fossil, fig. 9, with the figure above cited from Kaup's excellent work, there need not be more said in favour of referring the crag-tooth to the same extinct species of Hog (*Sus palæochœrus*) from the miocene formation near Eppelsheim.

Fig. 11 represents a portion of the crown of a molar of apparently a larger species of *Sus*, from the Red Crag at Ramsholt, Suffolk; it probably belongs to the same species as the *Sus antiquus*, Kaup, founded on fossils from the miocene sands at Eppelsheim.

Genus *Equus*.

Molar teeth, from both upper and lower jaws, of a large species of *Equus*, occur in the Red Crag, and in the usual condition of the fossils of that formation. The disposition of the enamel on the grinding surface of one of these molars from the upper jaw, fig. 12, *b*, resembles that of the tooth from the Oreston cavern, referred to the species called *Equus plicidens* in the 'Brit. Foss. Mamm.' p. 393, fig. 153. It is of large size, and presents the heavy, mineralized, deeply stained characters of the true Red-crag fossils.

Similarly fossilized teeth of a smaller species of *Equus*, probably of the subgenus *Hipparion*, have likewise come under my notice from the Red-crag of Suffolk.

Genus *Mastodon*.

The specimens of teeth and portions of teeth of *Mastodon*, from the crag-pits of Suffolk, are not distinguishable specifically from those referred to the *Mastodon angustidens* (*Mastodon longirostris*, Kaup) from the fluvio-marine crag of Norfolk, in my 'History of British Fossil Mammals,' pp. 276–284. In the Ipswich Museum there is a considerable proportion of the crown of a molar corresponding with the fourth of the upper jaw in Kaup's *Mastodon longirostris*; also a well-preserved atlas vertebra of, apparently, the same species of *Mastodon*.

Family *Cervidæ.*

In the miocene strata near Darmstadt the remains of a peculiar form of small Deer, with pedunculated antlers like those of the Muntjac, but with the typical number of molars, 7—7, at least in the upper jaw, have been found, on which remains Prof. Kaup has founded his genus *Dorcatherium*. With this were associated other and somewhat larger species of Deer, represented by more or less mutilated antlers, which Prof. Kaup refers to his species *Cervus dicranocerus* (tab. 24. figs. 3, 3 *e*, *op. cit.*). In this species the beam of the antler rises from one to two inches above the burr without sending off any brow-snag, but at that distance it sends obliquely forward a branch so large, that the beam seems here to bifurcate, the anterior division being, however, rather the smallest and shortest.

I have received the bases of similar antlers, which had been shed, from different Red-crag pits of Suffolk, some corresponding in size with, others larger than, the largest of the specimens figured by Kaup*; none of these specimens, however, have either branch of the beam entire.

Dicranoceros (Subgeneric division of *Cervus*).

The specimen (fig. 14) from a crag-pit near Sutton, Suffolk, is the base of a shed antler of a species of Deer, identical with, or nearly allied to—certainly belonging to the same section in the Deer tribe as—the *Cervus dicranocerus* of Kaup. The absorbed basal surface is slightly convex, subcircular, 1 inch in long diameter; the base of the antler extends from 2 to 3 lines beyond it: in one half of the circumference, the base is continued with a mere convex bend into the ascending beam; in the other half it projects outward, at first slightly, then more prominently, forming a ridge or "burr," which extends 4 lines from the margin of the absorbed surface. The proportion of the absorbed, and formerly adhering, part of the base to the non-adherent part of the base indicates that the antler was supported by a persistent bony process of the frontal, or by a pedicle, as in the *Cervus anocerus*, Kaup (probably identical with the *Dorcatherium*, Kaup), and in the existing Muntjac. The beam is 2 inches in length before it divides; and it is more extensively and deeply excavated on one side (the excavation widening to the division) than on the other. The antler is marked by longitudinal grooves and a few low ridges, but is equally devoid, with the Darmstadt specimens, of any of the tubercles which characterize the antlers of the Roe. The length from the base to the broken end of the main branch is 3 inches 3 lines; the circumference of the beam above the base is 3 inches 5 lines.

From the same Red-crag pit, I have received a left lower true molar, fig. 15, with proportions of the lobes and their crescents more resembling those of *Cervus* than of other genera of *Ruminantia*,—in the greater angular production *e. g.* of the outer crescents, *e*, *e*, and the greater proportion of dentine between the apex of the triangle and

* Kaup, Description d'Ossemens Fossiles de Mammifères de Darmstadt, 4to 1839, tab. 24. figs. 3, 3 *c*.

the base formed by the enamel-islands. There is a low accessory tubercle at the bottom of the cleft between the two outer crescents*.

A second specimen of antler, from a crag-pit near Felixstow, is larger than the foregoing, but offers the same characteristics. The beam is rather shorter in proportion to its girth above the burr; it is 2 inches long and 4 inches in girth; but it shows the same convexity at the side next the burr and the same concavity on the opposite side. It has been a shed antler; the slightly convex, absorbed surface bears the same proportion to the entire base of the antler as in fig. 14; the burr, in like manner, is limited to, or chiefly developed from, one half of the circumference of the base, where it has projected from 3 to 4 lines beyond the line of attachment.

Assuming one and perhaps the chief use of the burr to be to defend the subjacent skin from abrasion, in actions of the antlers when they are strongly rubbed from above downwards against a hard body—and were it not for such projecting ledge, such actions might peel off the skin where it abruptly terminates at the circumference of the basal adhesion of the antler to the skull,—I infer, from the partial development of the burr in the *Dicranoceros* of the Red-crag, that the pedicle supporting the antler was so oblique as to render such defence necessary only on one—probably the anterior and outer—side of the antler.

M. Gervais has figured, pl. 7. fig. 1. *op. cit.*, a shed antler of a Deer having the same short, simply bifurcated form as the *C. dicranocerus* of the Eppelsheim miocene and the Suffolk crag. It is rather more slender in proportion to its length; the burr, according to the figure, shows the same partial development from one-half of the basal circumference. The fossil is from the lower pliocene (marine sands and blue and yellow marls) of Montpellier. The accomplished French naturalist refers this bifurcate antler to the *Cervus australis* of M. de Serres.

Similar bifurcated antlers, probably not materially differing from the foregoing, or from the *Cervus dicranocerus* of Kaup, except in having been found attached to their supporting bony pedicles, form the type of the subgenus "*Dicroceros*" of M. Lartet, and occur in the miocene lacustrine molasse at Sansan, Gers.

The largest portion of antler of the *Cervus dicranocerus* which I have, as yet, received from the Suffolk crag-pits, is 4 inches in length, and the preserved part of the main branch of this antler is continued in a more direct line from the base than is either of the divisions of the best-preserved antler figured by Kaup, tab. 24. fig. 3 *c*, *op. cit.* The example of the *Cervus dicranocerus*, from a crag-pit near Ipswich, Suffolk, fig. 16, sends off the smaller or subsidiary fork a little nearer the base than in the smaller specimens; the base, however, shows well the same characteristic partial development of the burr, *a*, *a*, as in the other fossils. The circumference of the antler, above the burr, is 4 inches 9 lines; the breadth of the burr is from 5 to 6 lines, being proportionally more than its vertical thickness,

* See the figures of the modifications of homologous similar molars in my 'Odontography,' pl. 134. figs. 1–8, fig. 5 being that of the *Cervus megaceros*.

as compared with the burr in the *Cervus elaphus*. The length of the beam to its bifurcation is only 2 inches.

The individual variations in size and proportion which the crag-specimens of fossilized and more or less rolled antlers of the *Cervus dicranocerus* have presented are not greater than those observed in antlers of different individuals and of different ages of the Fallow or Red Deer.

Fig. 17 *a, b*, are views of an upper molar, of probably the *Cervus dicranocerus*, from the same crag-pit as the foregoing antler.

Megaceros (Subgenus of *Cervus*).

A very interesting evidence of the Deer-tribe from the Red Crag of Suffolk is the base of the left antler (fig. 18), which had been shed, of a deer as large as the *Megaceros hibernicus* or of the *Strongyloceros spelæus**.

In the relative size and position, immediately above the burr, of the origin of the brow-snag, in the absence of a second snag at the distance above the brow-snag where such second snag arises in the *Strongyloceros spelæus*, in the commencing flatness of one side, and expansion, of the beam at the broken end, eleven inches from the burr, this crag-fossil resembles the corresponding part of the antler of the Great Irish Deer (*Megaceros hibernicus*). The circumference of the burr is 11 inches. In colour and ponderosity this remarkable fossil agrees with the ordinary fossils of the Red Crag.

I have had similar evidence of the *Megaceros* from the pleistocene brick-earth of Essex, but equally agreeing in colour and mineral characters with the fossil bones of the Mammalia usually occurring in that formation.

Order Carnivora.

Of this order I have received clear evidences of the genera *Ursus*, *Felis*, and *Canis* from the Red Crag. Some more or less imperfect and waterworn canine teeth indicate other genera, as *Phoca*, and apparently a species of the family *Viverridæ*, but do not yield safe ground for a decided reference. I therefore limit my present notice to those molar teeth which satisfactorily determine, at least, genera of the *Carnivora*.

Genus *Felis*.

This genus is represented by a lower sectorial or carnassial tooth resembling in size and other characters that of the *Felis pardoides* of the 'Brit. Foss. Mamm.' p. 169, fig. 66. The specimen, from a Red-crag pit, five miles from Newbourn, consists of the crown and base of the fangs, most of which are worn away, of the lower carnassial or sectorial molar, fig. 19. The two compressed triangular, trenchant, and pointed lobes of the crown have the same near equality of size, as in the corresponding fossil from Newbourn†.

* History of Brit. Fossil Mammals, p. 469, figs. 193, 194.
† *Ib.* p. 169, fig. 66.

As the strata of the Red Crag at that village, from which the mammalian fossils originally determined by me* were obtained, were traversed by vertical fissures, Sir Charles Lyell in his description of the formation remarks:—"It might be suggested, that the mammalian relic was possibly derived from the contents of one of the fissures, the filling of which was an event certainly posterior, and perhaps long subsequent, to the era of the deposition of the crag†."

The subsequent discovery of a feline carnassial tooth of the same size, and apparently species, as that of the *Felis pardoides*, adds satisfactorily to the high probability—founded upon the original feline tooth having undergone the same process of trituration and impregnation with colouring matter as the associated bone and teeth of fishes known to be from the regular strata of the Red Crag—that the *Felis pardoides* is a fossil of that period. The *Felis antediluviana* of Kaup, from the miocene sand at Eppelsheim, and the *Felis pardinensis* of Croizet and Jobert, from the miocene strata of Auvergne, correspond in size with the *Felis pardoides* of the Red Crag of Suffolk.

The lower sectorial tooth, fig. 20, deviates from the feline type, and approaches that of the carnassial in the Glutton, Hyæna, and Grison; but with a minor development of the hinder tubercle, and a major development of the outer cingulum. I suspect that we have, in this tooth, an indication of an extinct osculant genus, linking on the true Felines to the Hyæna or Musteline family. It closely resembles one of the teeth of the Miocene Carnivora to which the generic names *Hyænodon* and *Pterodon* have been given.

Genus *Canis*.

Three views (fig. 21) of a left upper carnassial tooth of a species of *Canis*, agreeing in size and shape with that of the Wolf (*Canis Lupus*), give an outside view, *c*; *a*, an inside view; and *b*, a view of the fore part of the tooth, from which the two fangs, outer and inner, of that part ascend. I am unable to detect any character by which I could positively distinguish this tooth from that of the existing Wolf, or of the species found in our bone-caves and pleistocene deposits. The specimen presents the usual characters of the crag-fossils, and was obtained from a crag-pit near Woodbridge. A portion of the lower jaw of a species of *Canis* from the same pit is figured at fig. 22, *a*, *b*.

Genus *Ursus*.

The Ursine genus is represented by an antepenultimate grinder of the right side, upper jaw, of a Bear, somewhat smaller than the corresponding tooth of the *Ursus spelæus*. The fossil in question was obtained by Mr. Colchester from the Red Crag at Newbourn, near Woodbridge, Suffolk. The specimen is now in the collection of the Rev. Edward Moore, of Bealings, near Woodbridge.

* Ann. of Nat. Hist. vol. iv. 1840, p. 185. † *Ib.* p. 186.

Order Cetacea.

By far the greatest proportion of the mammalian fossils from the Red Crag belong to this order. In reference to the largest specimens, I have little to add to the description of the fossils on which were founded the species of *Balæna* (*Balænodon?*) *affinis*, *Bal. definita*, *Bal. gibbosa*, and *Bal. emarginata*, in the 'Hist. of British Fossil Mammals' (pp. 526–542). Mr. James Carter of Cambridge submitted to me, July 1850, two pairs of *Cetotolites* from Sutton, differing from the *Bal. emarginata* in the thicker and squarer form of the greater end of the tympanic bone. The Rev. R. K. Cobbold has showed me a series of silicified fragments of *Balæna gibbosa*, and cetacean ribs, collected from the Red Crag in the parish of Sutton, where it is separated from Felixstow by the River Deben.

The front part of the atlas of a cetaceous animal, which must have been from 30 to 40 feet in length, was obtained by the Rev. Prof. Henslow, in 1855, from the Red Crag at Woodbridge, Suffolk.

Waterworn teeth, corresponding in size and form to the singular teeth from the marine miocene deposits of the "Département de la Drôme," figured by Gervais, in pl. 20 of his 'Paléontologie Française,' under the name of *Hoplocetus crassidens*, have been discovered in the Red Crag of Suffolk, and transmitted for my inspection.

Teeth corresponding in character with those of the Grampus (*Phocæna Orca*) have also reached me from the Red Crag. One specimen, from a crag-pit at Bawdsey, with a less expanded fang than ordinary, is figured at fig. 23.

Petro-tympanic bones of a species of *Delphinidæ*, about the size of the Grampus, and some of a smaller species, have been obtained from the Red Crag.

Portions of a long, slender, gradually attenuated, edentulous, upper jaw have been transmitted to me, by Mr. Edwards of Bunhill Row, from the Red Crag near Woodbridge, Suffolk: the specimen, fig. 24, from the Red-crag at Felixstow, was submitted to me by Mr. G. Ransome. They belong to that family of *Delphinidæ* of which the genus *Ziphius* is the type, and very closely resemble the species from the crag of Antwerp described by Cuvier* under the name of *Ziphius longirostris*, now forming the genus *Dioplodon* of Gervais. The original fossil from Antwerp appears to have been in a similar mineralized condition to those from our own Red Crag. Cuvier describes it as being "petrified and very heavy." MM. Gervais and Van Beneden distinguish the Antwerp Crag fossil in question from the true *Ziphius longirostris*, Cuvier, under the name of *Dioplodon Becanii*. They believe it to have come from a 'molasse' formation†. There is not enough of the upper jaw preserved in the Suffolk Crag fossils to enable me with certainty to pronounce on their specific identity with, but I have no doubt of their belonging to the same genus as, the Antwerp fossil. They are equally edentulous in respect of the upper jaw.

* Ossemens Fossiles, tom. v. (1823), p. 356, pl. 27. figs. 9 and 10.

† "Elle semble provenir d'un terrain de molasse," Pal. Franç. p. 155.

The following extinct species of *Delphinus* are given by M. Gervais in the 'Paléontologie Française':—

D. pseudodelphis, from the miocene molasse at Vendargues;

D. Dationum, from the miocene formation at Dax; and

D. Renovi, from the miocene molasse of the Département de l'Orne. M. Pictet refers the formation in which were found the fossil *Ziphius longirostris* of Cuvier (*Dioplodon*, Gervais) to the marine molasse of the miocene period.

Conclusion.—From the foregoing details it will be seen that the researches now applied during fifteen years to the mammalian fossils of the Red Crag of Suffolk have led to the very interesting result, that the majority of them are identical, or closely correspond, with miocene forms of Mammalia, and especially with those from the Eppelsheim locality, described by Prof. Kaup. In Suffolk, as in Darmstadt, we find the *Mastodon longirostris*, *Rhinoceros Schleiermacheri*, *Tapirus priscus*, *Sus palæochœrus*, and *Cervus dicranocerus*, associated together, in the same formation; and, with these miocene forms of extinct Mammalia in the Red Crag, we have, likewise, a Cetacean which most closely resembles a miocene species of that order, previously recognized in the crag or molasse of the continent. At the same time there are, as *e.g.* in the *Megaceros*, specimens of newer pliocene or pleistocene forms of Mammalia mingled with the older tertiary species; whilst on the other hand eocene forms of fish, as *e.g. Edaphodon*, with *Myliobatidæ* and eocene Crustacea, have been obtained from the Red-crag pits.

As, however, several of the Mammalia which occur in miocene formations are also found in the older pliocene deposits in parts of France, it would be rash, perhaps, to pronounce positively on the miocene age of any of the above-cited crag-fossils; but it is certain that the majority of those mammalian fossils, and by far the greatest proportion of individual specimens, belong to an older tertiary period than the Mammalia of the newer pliocene drifts, gravels, brick-earths, and bone-caves.

DESCRIPTION OF THE FIGURES.

Fig 1. Grinding surface of right upper molar (probably the third) of the *Rhinoceros Schleiermacheri?* (From a Crag-pit, Wolverton, Suffolk; communicated by W. C. Maclean, Esq., Collector of Customs at Woodbridge.)

Fig. 2. Grinding surface of the inner portion of the crown of a right upper molar of the *Rhinoceros Schleiermacheri?* (From a Crag-pit, Felixstow; communicated by George Ransome, Esq.)

Fig. 3. Grinding surface of a left upper molar of the *Rhinoceros Schleiermacheri?* (From a Crag-pit, Felixstow; communicated by W. C. Maclean, Esq.)

In these upper molars are marked—*a* the hinder valley, *b* the inner or front valley, *c* the inner end of the front lobe, *c'* the inner end of the back lobe, *d* the front angle, *d'* the ridge, *d''* the back angle of the outer surface, *f* the cingulum or basal ridge.

Fig. 4. Grinding surface of a right lower molar of the *Rhinoceros Schleiermacheri?* (From a Crag-pit, Sutton; communicated by W. C. Maclean, Esq.)

Fig. 5. Grinding surface of a left lower molar of the *Rhinoceros Schleiermacheri*? (From a Crag-pit, Felixstow; communicated by G. Ransome, Esq.)

In these lower molars are marked—*a* the outer side of the front lobe, *b* the outer side of the back lobe, *c* the front ridge, *d* the mid ridge, *e* the back ridge, of the grinding surface, *f* the front valley, *g* the back valley.

Fig. 6 *a*. Grinding surface of unworn crown of a right lower molar of the *Rhinoceros Schleiermacheri*? (From a Crag-pit, Sutton; communicated by George Ransome, Esq.)

Fig. 6 *b*. Anterior surface of the same.

Fig. 6 *c*. Posterior surface of the same.

Fig. 7. Grinding surface of second lower molar, right side, of the *Rhinoceros Schleiermacheri*? (From a Crag-pit, Sutton; communicated by W. C. Maclean, Esq.)

Fig. 8 *a*. Grinding surface of a lower molar tooth of the *Tapirus priscus*, Kaup. 8 *b*. Side view of the same. (From a Crag-pit, Sutton; communicated by W. C. Maclean, Esq.)

Fig. 9. Upper molar of *Tapirus priscus*. (From a Crag-pit, Suffolk: British Museum.)

Fig. 10. Grinding surface of the last left upper molar of the *Sus palæochœrus*. (From a Crag-pit at Sutton; communicated by W. C. Maclean, Esq.)

Fig. 11. Part of a molar tooth of the *Sus antiquus*? (From a Crag-pit at Ramsholt; communicated by W. C. Maclean, Esq.)

Fig. 12 *a*. An upper molar of the *Equus plicidens*? (From a Crag-pit at Bawdsey; communicated by Sir Charles Lyell.)

Fig. 12 *b*. Polished section of the grinding surface of the same tooth.

Fig. 13, *a*, *b*. A much-worn lower molar of a species of *Equus*: *a*, grinding surface; *b*, side view. (From the Fluvio-marine Crag at Norwich; communicated by W. C. Maclean, Esq.)

Fig. 14, *a*, *b*. Portion of a shed antler of the *Cervus dicranocerus*; *b*, base of the same. (From a Crag-pit, Sutton; communicated by George Ransome, Esq.)

Fig. 15. Grinding surface of a lower molar of the *Cervus dicranocerus*? (From a Crag-pit, Sutton; communicated by Ed. Acton, Esq.)

Fig. 16. Oblique basal view of a portion of a shed antler of a larger individual of the *Cervus dicranocerus*. (From a Crag-pit near Ipswich; communicated by George Ransome, Esq.)

Fig. 17 *a*, side view, 17 *b*, grinding surface, of an upper molar of the *Cervus dicranocerus*? (From the same pit; communicated by George Ransome, Esq.)

Fig. 19. The lower carnassial tooth of the *Felis pardoides*. (From a Crag-pit, Newbourn; communicated by W. C. Maclean, Esq.)

Fig. 20. The lower carnassial tooth of a Carnivore, allied to *Hyænodon* and *Pterodon*. (From a Crag-pit, Woodbridge; communicated by Ed. Acton, Esq.)

Fig. 21. The left upper carnassial tooth of a species of *Canis*: *c*, outer side; *a*, inner side; *b*, fore-part. (From a Crag-pit, Woodbridge; communicated by Ed. Acton, Esq.)

Fig. 22, *a*, *b*. Two views of a portion of the lower jaw of a species of *Canis*. (From a Crag-pit, Woodbridge; communicated by Ed. Acton, Esq.)

Fig. 23. The tooth of a Grampus (*Phocæna*, sp. ind.). (From a Crag-pit, Bawdsey; communicated by W. C. Maclean, Esq.)

Fig. 24. Portion of the upper jaw of the *Ziphius* (*Dioplodon*, Gervais). *a*, Section of the smaller end of ditto. (From a Crag-pit, Felixstow; communicated by George Ransome, Esq.)

All the foregoing figures are of the natural size.

Fig. 18. The base of the antler of the *Megaceros hibernicus*, one-third the natural size: *a*, the surface from which the brow-antler had been broken off. (From a Crag-pit at Felixstow; communicated by George Ransome, Esq.)

Fig. 1.

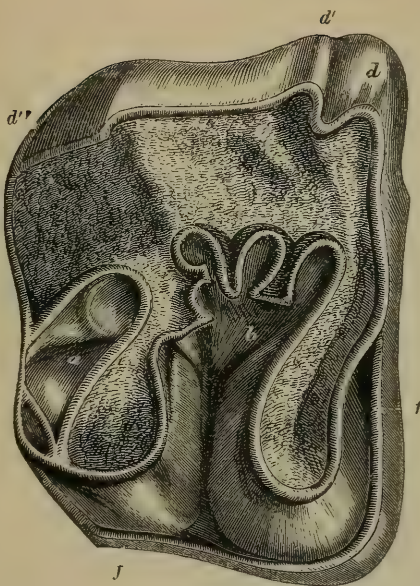
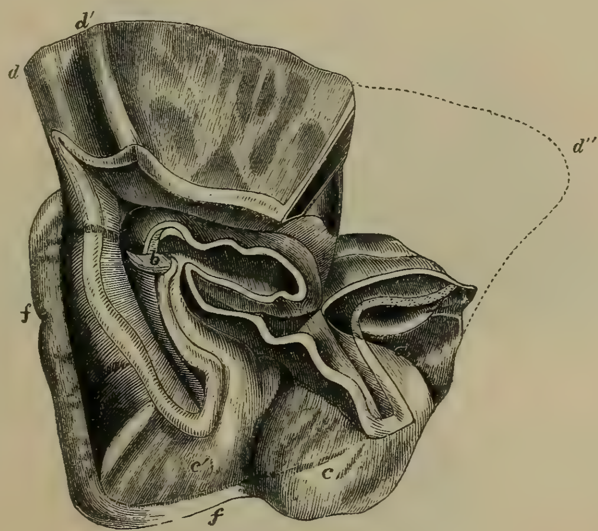


Fig. 2.

Fig. 3.



Mammalian Remains from the Red Crag.

Fig. 4.

Fig. 5.

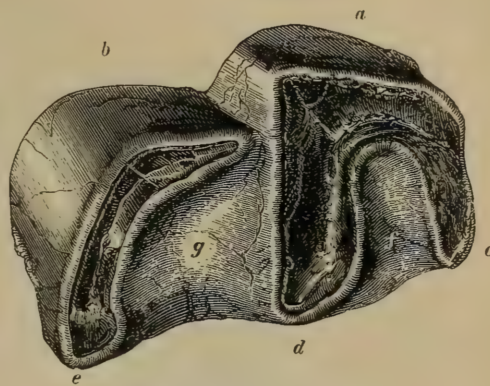


Fig. 6 *a*.

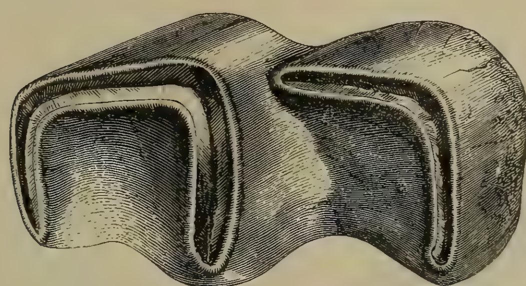


Fig. 6 *c*.

Fig. 6 *b*.

Fig. 7.

Mammalian Remains from the Red Crag.

Fig. 8 *a*.

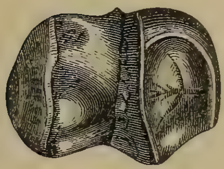


Fig. 8 *b*.

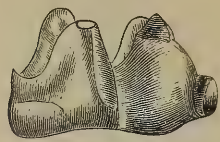


Fig. 9.

Fig. 10.

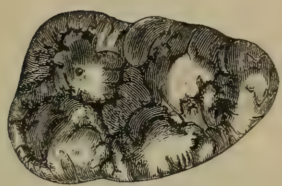


Fig. 11.

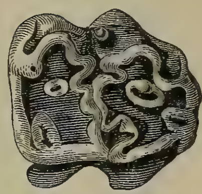
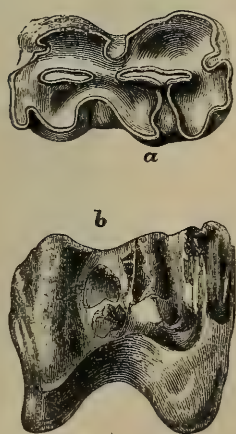


Fig. 12 *a*.

Fig. 12 *b*.

Fig. 13.



Mammalian Remains from the Red Crag.

Fig. 14 *a*.

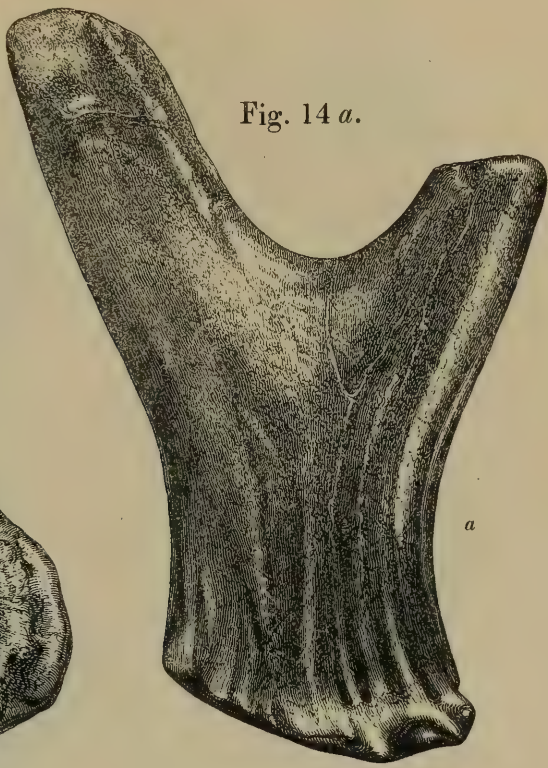


Fig. 14 *b*.

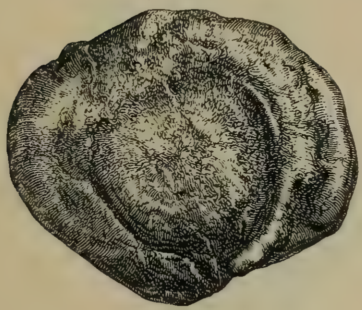
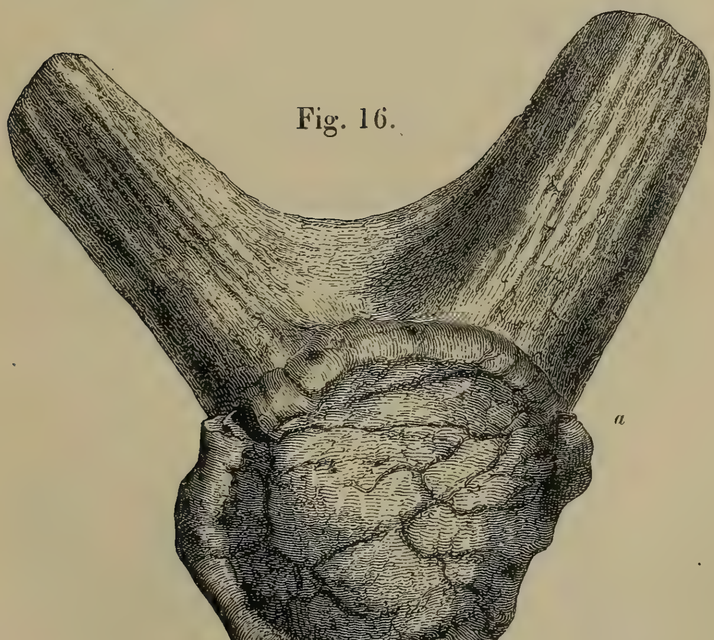


Fig. 16.



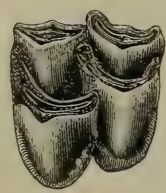
Mammalian Remains from the Red Crag.

Fig. 18.

Fig. 15.

Fig. 17 *a*.

Fig. 17 *b*.



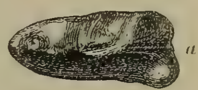


Fig. 20.

Fig. 19.

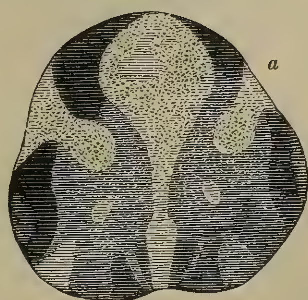
Fig. 21.

Mammalian Remains from the Red Crag.

Fig. 22.

Fig. 24.

Fig. 23.



Mammalian Remains from the Red Crag.

MARCH 5, 1856.

J. W. Tayler, Esq., W. H. Groser, Esq., H. B. Medlicott, Esq., H. G. Bowen, Esq., T. J. Smith, Esq., T. Moffat, M.D., W. Matthews, jun., Esq., were elected Fellows. Prof. Bunsen, of Heidelberg, was elected a Foreign Member.

The following communications were read:—

1. *Notes on the* GEOLOGY *of some parts of* SOUTH AFRICA. By R. N. RUBIDGE, M.B.

(In a letter* to Sir Roderick Murchison, F.G.S.)

[Abstract.]

DR. RUBIDGE first referred to the occurrence of gold at Smithfield in the Orange River Sovereignty, as detailed in his letter of May 1854, published in the Society's Journal, vol. xi. p. 1; and stated that several pieces of gold had since been found at the spot described in the letter referred to. Besides being found in the alluvium there, gold was met with in a quartz-vein in the trap traversing the stratified rock,—in other quartz associated with the trap,—and in a mass of limestone enclosed in the trap-dyke;—but none in the stratified rock itself (which belongs to the Dicynodon or Karoo Series).

Dr. Rubidge next alluded to the fossil plants which he there found in the strata; some of these he referred with doubt to *Calamites*. Six years ago, also, the author found numerous vegetable remains (some of which were possibly referable to *Lepidodendron*) at Jackal's Kop†, on the eastern side of the Stormberg Range, in the same formation as that of the Drakensberg and Smithfield; and Calamite-like plants in the western part of the Zuurbergen. The author remarked that the plant-remains above referred to much resembled those collected by Mr. Bain at the Ecca Heights in rocks of the Karoo Series. Dr. Rubidge had also found bones of the Dicynodon near the Caledon River and at Halse's farm six miles from Smithfield.

From various observations by himself and others, the author had been enabled to recognize the existence of the Dicynodon or Karoo rocks in the Drakensberg, at Harriesmith, at Winburg, and even at Megaliesberg; and Dr. Sutherland lately described the same rocks as occurring in Natal, where they are rich in coal‡.

The amygdaloid rock which supplies the agate-gravel of the Orange, Caledon, Kroai, and Vaal Rivers appears to exist in the "Mont des Sources" in the Drakensberg, as an unworn specimen was found in the Eland River (a tributary of the Vaal), not more than twelve miles from its source.

* Dated Namaqualand, April 16, 1855.

† Some of these plants were sent to Col. Portlock by Dr. Rubidge, and were exhibited to the Meeting of the British Association in 1851, together with some jurassic fossils from Sunday River. The plant-remains comprised specimens of *Pecopteris* and other ferns, with *Zamia*.—ED.

‡ Quart. Journ. Geol. Soc. vol. xi. p. 465.

Lastly, Dr. Rubidge supplied some remarks on the geology of the copper-district of Namaqualand and bordering countries. Granitic rocks of several varieties occur, together with gneiss, mica-schist, and talc-schist. The gneiss strikes 5° to 20° S. of W., and dips alternately N. and S.; one dip continuing for many miles. On the hills the gneiss and schists are covered by horizontal sandstones, which appear to be the same as the sandstone of Table Mountain, and continuous with it.

The copper is found in fissures of the gneiss, where the latter is locally disturbed in its dip, the strike remaining unaltered; that is, along anticlinal and synclinal folds or axes; also in fissures extending nearly in the direction of the magnetic meridian, and in crevices between masses of rock, with no veinstone or gangue: the oxides and silicates often appear to be infiltered into the rock-mass. The ores most common are red and black oxides, green and blue silicates, purple and yellow sulphurets, and a few carbonates. Granitic rocks are often found in the axes above referred to.

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2. *On the* Lowest Sedimentary Rocks *of the* South *of* Scotland. By R. Harkness, Esq., F.G.S., Professor of Geology and Mineralogy, Queen's College, Cork.

It is stated in Sir Roderick Murchison's 'Siluria,' page 151, on my authority, that the axis of the Silurians of the South of Scotland ranges in the direction of the Dryfe Water. In order to satisfy myself as to the exact position of this axis, and of the deposits with which it is more immediately associated, I examined in detail, during last summer, that portion of the county of Dumfries where this axis occurs. Its position in the adjoining county of Roxburgh is laid down by Professor Nicol as near the course of the River Teviot*. West from Hawick, however, it appears to leave this stream, and follows nearly the direction of the Borthwick Water.

In the high mountainous district which separates Roxburghshire from Dumfriesshire, the exact position of the axis is difficult to determine owing to the want of good sections, and from the thick covering of soil which here invests the mountains. Even in the course of the River Esk, in Dumfriesshire, which intersects the country almost at right angles to the strike of the strata (and in which, on looking at the map, we should naturally expect to find good sections, and the axis well exhibited), the solid rock is not well exposed in consequence of the gravelly nature of the bed of this river. Yet through the whole course of this stream, from Skipper's Bridge, about a mile south of Langholm, where the Silurians first make their appearance, to near Eskdale-muir Bridge, wherever we have the strata exposed, these possess (when not perpendicular) the prevailing south dips which mark the deposits forming the Silurians on the south side of the axis.

* 'Siluria,' page 152.

At Eskdale-muir Bridge we have evidence of proximity to the axis, for here north dips begin to manifest themselves.

There is a small burn which joins the Esk, a little to the south of Eskdale-muir Bridge, from the east, called the Rennel Burn; and in the course of this we have the axis well developed (see fig. 1); and here it consists of hard purple grits intersected by veins of calc-spar. From this locality it takes a W.S.W. route; and, crossing the Esk, we have it displayed near the road which connects Eskdale with Annandale; and, running nearly parallel to this road, through the farm of Twiglees, it enters the parish of Hutton, and is here well seen in the course of the Dryfe Water about half a mile above Borland Bridge. In this locality it is seen in the form of an anticlinal axis consisting of purple grits, like those seen in Rennel Burn, and having also the calc-spar veins traversing them.

In a small burn to the west, the Shaw Burn, a short distance from the Dryfe, the axis also makes its appearance, and here it seems to run in the direction of Shaw House. In the other small burns, to the westward, we have S.S.E. dips obtaining, which indicate strata occupying a position on the south side of the axis; but at a quarry situated a short distance N.E. of Newbiggin House, the N. N. W. dips occur, pointing out strata on the north side of the axis. In the course of the Auchenrodden Burn, in the parish of Applegarth, we have evidence that the axis crosses the higher portion of this stream; and here it makes its last appearance on the eastern side of Annandale; the area occupied by the Corncockle-muir sandstone coming on immediately to the westward.

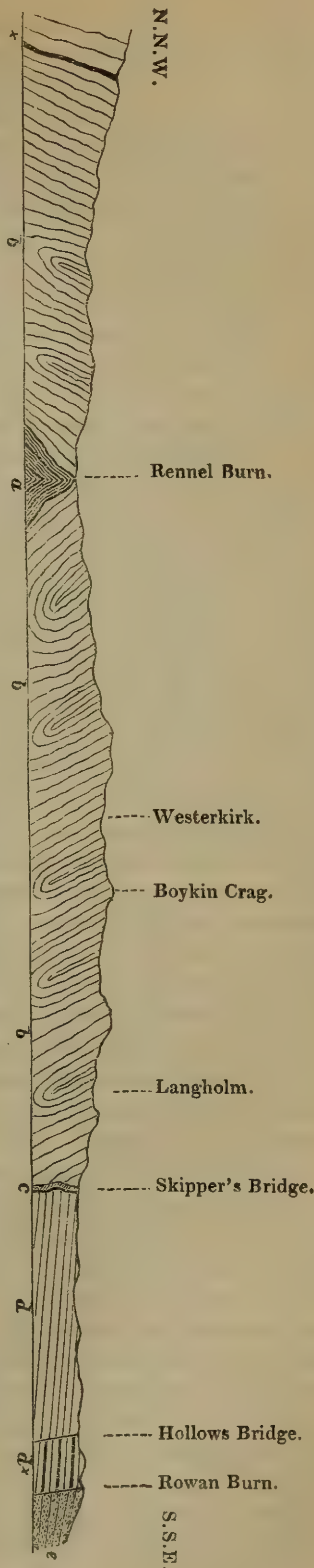


Fig. 1.—*Section of Eskdale.*

e. Red sandstones (Bunter?).
d*. Canobie Coal-field.
d. Carboniferous grits and limestones.
c. Trap-rock.
b. Anthracite schist, grey and reddish-purple shales and sandstones (Silurian).
a. Purple grits (Axis).

With reference to the appearance of the axis on the opposite side of the sandstone area, owing to the thick deposits of clay and gravel which cover up both the red sandstone and the Silurians on the west side of the valley of the Annan and the east flanks of the Tinwald Hills, we lose sight of these deposits until we reach a spot called Blaweary in the parish of Lochmaben; and at this locality N.N.W. dips show themselves, leading to the inference that the axis is to the S.S.W. from this. In the course of the Bellridding Burn, in the parish of Torthorwald, on the south side of the high-road, we meet with both N.N.W. and S.S.E. dips, indicating a proximity to the axis; and in the same parish, in the course of the Peartree Burn, the same circumstances are exhibited; and here too the purple grits, which constitute the axis, are also seen. From this locality westward we lose all traces of both the axis and the Silurians themselves; but the former appears to strike in the direction of the syenitic mountain Criffel in Kirkcudbrightshire.

The course of the axis, as traced in Dumfriesshire, agrees with that laid down by Professor Nicol in Roxburghshire, and supports the inference that it has a E.N.E. and W.S.W. route through the Silurians of the South of Scotland.

The lithological nature of the strata composing the axis seems to be the same throughout, consisting of purple grits which have great resemblance to some of the bottom-rocks of the Longmynd.

With regard to the strata which lie conformable to the axis on both sides, they consist of thin-bedded greywacke sandstones, having grey and purplish red shales interstratified with them. The purplish-red shales are much more abundant in these lower portions of the Silurians than in the strata more immediately connected with the superior anthracitic and graptolitic shales; and their presence serves to mark a low zone in the Silurians of the South of Scotland.

Although the strata most intimately connected with the axis occupy a considerable breadth of country on both sides of this axis, there is reason to conclude that these beds do not attain any great thickness, but that they owe their wide area to frequent repetitions in consequence of flexures; these flexures on the north side having oblique curves towards the north, and the reverse occurring on the south side of the axis; in consequence of which we have almost uniform N.N.W. dips on one side and S.S.E. dips on the other. This, however, is not universally the case; for in the course of the Lambridden Burn in the parish of Torthorwald, on the north side of the axis, both a N. and a S. dip obtain, in consequence of curving in the strata, but the usual N.N.W. inclination soon succeeds. Like circumstances are seen on the south side of the axis in the same parish, at the farm of Barleiuth; and a similar occurrence may be seen in Eskdale on the farm of Billholm.

The occurrence of flexures among these deposits is also exhibited by the irregular angles of inclination, as well as by the comparatively uniform characters of the repeated strata.

There is another circumstance which tends to corroborate the inference that the beds immediately contiguous to the axis have been repeated several times both on the north and south side,—and this is the aspect which the deposits of a shaly nature present, which is of such a character as would result from the violent twisting of them and their associated strata. Many of the shaly beds in Eskdale are rarely capable of being divided along the laminæ of bedding, but have a broken-up appearance, the small fragments having a rhomboidal form; and at one locality in this portion of Dumfriesshire, namely Boykin Crag in the parish of Westerkirk, we have these shaly deposits so far changed (the result of pressure in consequence of oblique curving of the deposits) that the argillaceous beds here are possessed of a decided slaty cleavage, this being the only locality among the Silurians of the South of Scotland where this form of structure occurs, so far as I am aware of. So rare is this form of structure in the mountainous districts of the South of Scotland, that Prof. Sedgwick* cites the district as affording proof against cleavage resulting from lateral pressure,—an opinion in which I was disposed to agree; but more minute examination of the country, and a more enlarged experience of the nature and features of this structure, as it is manifested in the Devonians of the South-west of Ireland, have induced me to adopt an opposite conclusion.

The great mass of the strata which make up the Silurians of this part of Scotland are of an arenaceous nature; a composition which is not so susceptible of being impressed with cleavage as argillaceous deposits; and they have not been subjected to the same amount of flexuring as those small areas which are more intimately connected with the axis, and which it is the object of this communication to describe; therefore it is in these latter, which abound in argillaceous beds, that we have that rearrangement of particles which seems to result from lateral pressure in consequence of the oblique flexuring of strata.

The deposits which compose the beds lying on the bottom-rocks of the South of Scotland present some circumstances which afford considerable insight into the physical conditions under which these were formed. The alternations of thin-bedded sandstones and shales indicate that these strata resulted from comparatively shallow water; and the abundance of ripple-markings corroborates this inference. In one locality, on the south side of the axis, at Binks in Roxburghshire, about three miles N.E. from Mosspaul Inn, the ripple-marked surfaces of the sandstones are well seen, as well as the alternations of the thin argillaceous and arenaceous beds. Here also we meet with evidence of another character, which, considering the extremely low position of these sedimentary rocks, is of an important nature.

Some of the thin beds forming the deposits in this locality consist of alternating layers of very fine sedimentary matter, associated with coarser layers; deposits which have originally been fine and coarse mud. On the faces of the beds which are composed of the former, in one instance, we have distinct traces of desiccation-cracks,

* Brit. Palæoz. Fossils, page xxxvi, *note*.

in the state of fine lines emanating from several centres, and joining together in the usual manner of cracks in sun-dried mud.

The features which mark this occurrence, and also the laminæ in which it is seen, distinctly point out the deposition of mud in a locality where littoral conditions prevailed ; and where the subsequent exposure of this fine mud to solar influence caused it to shrink : these very ancient desiccation-cracks afford us the earliest direct evidence which we possess of land above the surface of the waters of the palæozoic sea.

In the deposits which occur at Binks, and also in similar beds on the north side of the axis in the Tinwald range of hills, there are found pitted hollow markings on the surfaces of the strata ; and, on splitting one of the thin beds in which these markings are seen, the latter are found frequently to extend through the thickness of the stratum. At first sight they appear to have been formed by marine worms in their burrowings ; but, as they decrease both in diameter and distinctness as we proceed downwards, they could not have resulted from such a cause. On examining the base of a stratum where these markings are seen, they are found to occur in the form of small, somewhat circular hollows, all tailing away in one direction.

These markings, from their nature and the mode of their occurrence, seem to have arisen from the influence of very slight currents, which, meeting with some small impediment, probably in the form of a grain of sand, washed a small hollow in the side offered to the flow of the water ; and during the deposition of the mud forming the strata these hollows continued to increase in size, until they assumed somewhat of the form of the burrows of Annelids.

In these low strata we possess proofs of currents in the form of ripple-markings, also in the gentle drifting of the mud which constitutes these beds ; and the lithological nature of the deposits indicates that they have had their origin in shoaling water ; and, even at this remote geological time, we see evidence of a muddy shore in the presence of the sun-cracks which fissure the laminæ of the fine shales of these beds, belonging to a series of strata which are among the most ancient of the palæozoic division of sedimentary deposits.

Nor are these beds altogether devoid of such evidence as shows the existence of animal life during the period when they were being formed. At the locality already alluded to as affording distinct proofs of the operation of causes such as now prevail in shallow water, we find the surfaces of some of the strata marked by the meandering tracks of Annelids ; showing the existence of this form of animal life in this locality at a very early period. These annelid-tracks are not, however, the only circumstances which indicate the occurrence of animal life ; for we have a track also of another kind, and such as seems to have had its origin in the wanderings of another tribe of animals, viz. Crustaceans. This track consists of a central line and two lateral series of markings (see fig. 2). The central line appears to have been formed by either a keel-like projection on the lower portion of the animal, or to have originated from the tail being dragged along the ground. On each side of this central line we have a regular series of other lines, of a more complex nature, arranged almost at right angles to the central line; these are about the one-fifth of an inch in length, and the nearest of these lines to the central one is at about the distance of its length, viz. one-fifth of an inch. These lateral lines, which are somewhat broken, and arranged at nearly right angles to the centre one, are broader and deeper at their extremities; and outside of them there is seen, slightly before each, a small pitted hole about the size of a pin's head. These lateral linear impressions appear to have been produced by legs, and the holes near their extremities seem to have arisen from joints, while the small hole in front looks like the markings caused by the tip of the leg. If these markings have resulted from Crustaceans, they afford us proof of the very early existence of Crustaceans with feet.

Fig. 2.—*Impression on the surface of the flagstone at Binks, Roxburghshire.* (Natural size.)

[*Note on the Fossil Track from Binks, by Mr. Salter.*—We may apply to this imprint—which through Mr. Harkness's kindness I have had full opportunity of studying—the name of *Protichnites scoticus.*

The imposition of this generic name does not in any way imply that the creature which made the track was generically identical with those which produced the tracks in the Potsdam sandstone, and which Professor Owen has so well described *. On the contrary, there are some differences of importance, indicating, as I think, that a single pair only of members (in addition to the median ridge of the body) were employed in making the impression; whilst in the Canadian tracks there were (according to Prof. Owen) certainly three, four, or five pairs; or, if (as appears to me most probable) each impression was made by its own independent limb, seven or eight pairs of such members may be supposed to have existed.

The inner and double imprints, *a a*, are all so closely like each other, and so much of the same size, as to indicate that the same instrument produced them in succession; and the smaller indents, *c*, are not so unlike but that they might have been also impressed by the tip of the same weapon in different positions. They were probably made (assuming that the creature was a Crustacean, as is most likely) by the basal joint or joints of a bent limb, or swimming foot; while the single indents, *b b*, not always present, might be made by the tip of the same limb during each stroke. These strokes appear to have been given at first at a greater distance from the central line or track (*e*) than the latter ones, which have gradually converged

* Quart. Journ. Geol. Soc. vol. viii. p. 214.

towards it, as if from want of muscular power, and to have been then renewed again with fresh vigour * ; and a corresponding difference is observable in the strength of the median track, as if the body had been elevated and depressed at intervals.

We have only traces of three of these successive, and, so to speak, spasmodic attempts at progression in what was probably very shallow water, scarcely deep enough to float the animal. In the lower or first group there are six pairs of larger imprints, gradually coming nearer to the central line, and somewhat closer also to each other ;—then a small one, *c*, which may have been a point of rest, much nearer to the groove than the others : the eighth pair suddenly starts out again, and with a breadth equal to those of the first set, and four, or probably five strokes of this series were given before the line of progression, having swerved a little from the original direction, was renewed again, somewhat to the left, at *f*, where we have only the central groove and a single pair of imprints, the rest being lost.

The whole would be consistent with the action of a single pair of swimming limbs, and the impression of a pointed or ridged sternal portion, but does not, I think, favour the supposition of a long body with a pointed caudal segment, such as *Hymenocaris* or *Eurypterus* possessed.—J. W. SALTER.]

At Binks also there are seen on the strata some branching bodies, which from their indeterminate form must at present be referred to that division which includes most indistinct organic bodies, viz. Fucoids.

Organic remains are not, however, restricted to this locality among these very low strata of the Lower Silurians of the South of Scotland. Fossils are found in the reddish-purple shales, which have been already alluded to as occurring, along with the thin grey shales and thin-bedded greywacke-sandstone (as developed in the parish of Applegarth at Upper Cleugh Burn, on the south side of the axis). These fossils consist of *Protovirgularia*, which was first discovered in this spot last year by my friend Sir William Jardine, and also some small branching bodies, which appear to bifurcate dichotomously, and have somewhat the character of branching Graptolites of the genus *Didymograpsus*. These were met with by the late Prof. E. Forbes and myself, in the same reddish-purple shale which affords *Protovirgularia*, in the autumn of 1854. They are, however, too indefinite to admit of their being assigned to any known forms.

Graptolites also occur on the south side of the axis at Dalton Rocks in the parish of Dalton, Dumfriesshire ; and these, from their relative breadths, seem to belong to two species. They are, however, in too imperfect a state to allow of their being referred to any particular species. They are met with in a shaly bed, associated with greywacke-sandstone very distinctly rippled ; deposits very different from those which contain these fossils elsewhere in Dumfriesshire.

On the south side of the axis, in this county, we have no traces

* Or it may be, as kindly suggested to me by Prof. Owen, that the body was elevated by the successive strokes, and the feet consequently touched the ground nearer to the central line.—J. W. S.

of the anthracites and the graptolitic shales which are connected with them; and it would appear that no strata occupying so high a position are developed on this side of the axis in this district. I have hitherto been led to the conclusion, that the beds of Griestone, Peeblesshire, and what I regard as their equivalents in Kirkcudbrightshire, the Barlae flags, occupy a higher position than the anthracite shales and their accompanying graptolite beds; but, when we take into consideration the flexures to which the Lower Silurians of the South of Scotland have been subjected, and the consequent repetition of the same strata, it is by no means improbable that the Griestone graptolite-flags, and the Barlae deposits affording these fossils along with Fucoids, are inferior in position to the anthracitic shales; and perhaps they may be the Scottish representatives of the fucoidal sandstones which underlie the graptolite-beds of Sweden and Norway *. There is one circumstance which serves to support this inference as to the inferior position of the Griestone and Barlae flags, which is based on fossil evidence,—this is the occurrence of the hitherto almost purely Scotch fossil, the *Protovirgularia,* in these beds and in the low-lying reddish-purple shales which are found near the axis †. The anthracite and graptolite schists, which abound in fossils, have as yet never afforded the genus *Protovirgularia* in Scotland, and its appearance in the low beds would tend to the conclusion that it is a fossil characteristic of a low zone among the Lower Silurians of the South of Scotland.

Formerly I was disposed to consider the several parallel bands of anthracite-shales as the result of faults: I now consider that they are the products of flexures,—a cause assigned for their occurrence by Sir Roderick Murchison ‡,—which would also account for these beds sometimes lying above, and at other times below, the flaggy beds of Griestone and Barlae.

The inferior position of these latter strata is also supported by the occurrence in them of a species of *Olenus,* which I found in these deposits last summer at Corfarding, in Penpont parish, Dumfriesshire.

Hitherto the lowest beds in the Lower Silurians of Scotland which have furnished animal remains are the graptolite and anthracite schists and the flaggy beds of Griestone and Barlae, and their equivalents.

The position of the strata more immediately referred to in this memoir is lower than either of the deposits just mentioned, and in them we have the earliest traces of animal life which have been detected in Scotland, and these may be looked upon as amongst the earliest records which we possess of organized existences.

* 'Siluria,' page 318.

† This form has been met with associated with the "larger *Nereites*" in Thüringerwald; see Sir R. I. Murchison and Prof. Morris's Memoir on the Palæozoic Rocks of Thüringerwald, Quart. Journ. Geol. Soc. vol. xi. p. 413.

‡ Quart. Journ. Geol. Soc. vol. vii. p. 163.

3. *On* Fossil Remains *in the* Cambrian Rocks *of the* Longmynd *and* North Wales. By J. W. Salter, Esq., F.G.S., of the Geological Survey of Great Britain.

[Plate IV.]

The occurrence of any organism in those ancient sediments which have been so often called Azoic is of sufficient interest for an account of it to be laid before the Society. We have hitherto been acquainted with but one genus—and that doubtfully an animal or a plant—in the oldest Cambrian schists of Ireland. No fossils from rocks of this age have been recorded from England except the forms which I now describe, and of which a brief notice was sent to the last meeting of the British Association. They are a new Sea-weed, or Zoophyte, traces of marine worms, and a Crustacean of the Trilobite group.

When, a few years back, I crossed the Longmynd with Prof. Ramsay and Mr. Aveline, the unaltered and flat-bedded sandstones which abound on the eastern side, and which are quite unaffected by cleavage, appeared most promising for fossil remains, if any organisms existed at the time when these rocks were deposited. Some of these beds were ripple-marked, and the sandstones and flaggy beds of greenish-grey stone were evidently not deposits from very deep water. I hoped, therefore, that at least *Oldhamia* or Fucoids might be found in them, if not more highly organized fossils; and in the summer of the past year, I was able to devote three or four weeks to the search.

A Fucoid, or at least one of those doubtful fossils we are in the habit of calling such, had been found by myself a few years back in the Cambrian grits near Bangor. It may be briefly described here.

Chondrites, sp.

The fossil alluded to is far too imperfect for any exact description to be given of it; yet, as it is the only species known in these old rocks, it should be noticed.

It occurs as elongated and nodular branches, generally $\frac{1}{4}$ of an inch thick, but of variable size, upon the surface of a coarse sandstone, the cleavage of which interferes much with the shape of the fossil. It is even possible that these apparent branches may have been produced by the crossing of separate tubes, and that the whole may be due to large Annelides, the filled-up burrows of which have a great resemblance to Fucoids, and are often mistaken for them.

Loc. Moel-y-ci, a mountain near Bangor (1850).—J. W. S.

That there may be no doubt about the geological position of the fossils about to be described, it is as well to say that they occur in nearly vertical beds of hard flag-like sandstone, which run along the strike of the Longmynd at about $1\frac{1}{2}$ mile E. from the principal ridge; and they form part of a series of bluish-grey sandstones, alternating with purplish slaty beds, which all lie *below* the conglomerates and red sandstones of the Portway, and *above* the thick series of dark-olive schists which are seen so well at Church Stretton, All Stretton, &c., and which are the lowest portion of the Longmynd series. See Section, fig. 1. The fossiliferous beds, therefore, are fairly packed in with strata which are not only distinct in mineral character from any of the Llandeilo flags or Lingula-beds to the west of them, but are unlike the upper portions even of the Longmynd rocks themselves.

The transverse valleys or "gutters" on the east side of the mountain afford excellent sections. Of these, the brooks at All Stretton, Church Stretton, Little Stretton, Minton, and Batch are the principal; and along these rivulets the following succession may be everywhere observed, in ascending order*.

1. Dark-olive schists, with very rare lines of crystalline limestone. Church Stretton, All Stretton, Brocards Castle, &c.

2. Harder beds, often rippled, some felspathic, alternating with thin courses of dark-greenish shale. All Stretton Quarries, the Burway, and Minton.

3. A thick series of hard and greenish sandstones, generally very fine-grained, except near the top where they are flaggy, rippled, and micaceous, and contain the *fossils* hereafter noticed. These sandstones form the hills of Synold's Coppice and Bodbury Ring, are seen at the Carding Mill, the Devil's Mouth, Winter Hill, and the ridge between Round Hill and Callow Hill, and have been traced as far as the Packet Stone, above Minton.

4. Red slates and harder beds. Conspicuous above the Carding Mill, Church Stretton, W. of Yearling Hill, Little Stretton.

5. Alternating grey and red slaty beds and sandstones.

6. Hard grey beds like No. 3. Light-spout Waterfall, above Church Stretton.

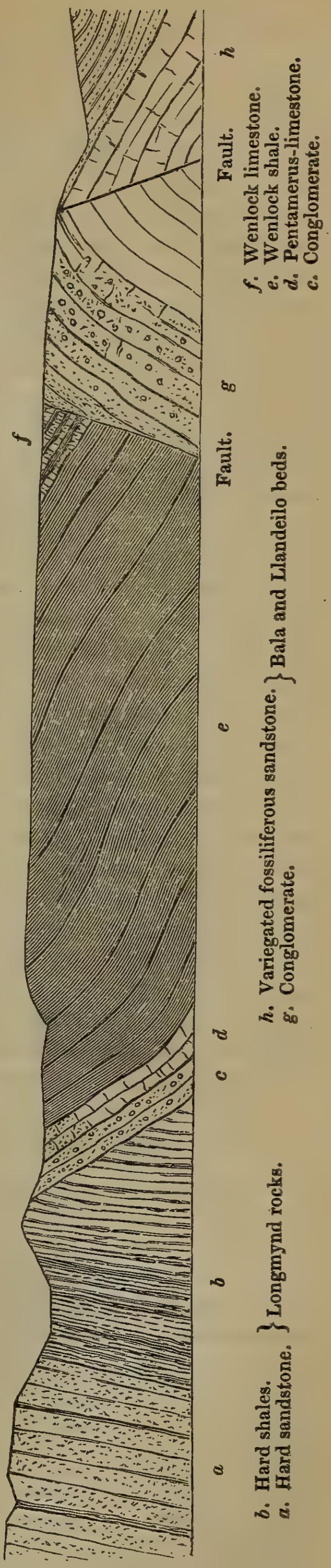


Fig. 1.—*Section of the Eastern Slope of the Longmynd, near Church Stretton.*
(Reduced from the Horizontal Sections, Sheet 34, of the Geological Survey of Great Britain.)

* See also Silurian System, 1839, chap. xxi. p. 255, and p. 717. pl. 32. fig. 1.

7. Alternating reddish and grey slates and sandstones succeed.

8. And these are overlaid by red sandstones, which form a band three miles broad, extending from the Portway about three and a half miles to the westward, chiefly vertical, or with a westerly high dip; they include thick bands of conglomerate; the principal band is 120 feet thick*.

It is only in the grey sandstones, No. 3, that the fossils were found, and these sandstones are so interstratified with the red shales, alternating with them and dipping in the same direction, that it is impossible to regard them as anything but a part of the Longmynd series, and rather low down in it.

The olive shales, Nos. 1 and 2, were searched vainly for any fossils, and the greater portion of the next series, No. 3, which forms the first considerable ridge, is of too fine and homogeneous a texture to promise much. At the upper part, however, the beds are coarser and more flag-like, and show considerable variations of surface.

Organic Remains†.—On the beds last mentioned, at the Carding Mill, Church Stretton Brook, are numerous double impressions, not a line long, but covering in quantities the surface of the slabs (Pl. IV. fig. 1). They are elongated in one direction, and appear nearly always parallel to each other,—a circumstance that at first suggests their being merely mechanical marks, such as minute ripples or ridges. But, when closely examined, they are found to be regular in size, constantly double, and distinctly of two kinds, viz. one set consisting of strongly impressed holes, as if recently made,—and others faint, as if subsequently effaced. I do not know anything to which these markings can be properly referred, unless it be the holes of marine worms, something like the Lob-worm of our own coasts. It will be remembered that Mr. Binney‡ first described such markings as the burrows of Annelides: they occurred in the flaggy sandstones of the lower division of the Lancashire coal-field; and he had ample reason for believing his conjecture to be a correct one, by finding the holes connected by a loop-like tube beneath the surface.

We may call ours, from analogy with these,

ARENICOLA DIDYMA. Pl. IV. fig. 1 *a*, 1 *b*.

A. fodinis didymis, minutis, approximatis, ellipticis, sæpissimè parallelis.

The most remarkable point, indeed, about these markings, whether the deep, or the obliterated ones, is their parallelism. They never deviate more than a degree or two from it; and, that this is not due to lateral pressure, is clear from the fact that the position of the

* This conglomerate, recently cut through by the new road to Ratlinghope, is of a very soft texture, easily worn away, and therefore not conspicuous except in brook- or road-sections. Quartz-rock is its chief constituent; syenite is very rare.

† The fossils described in this paper are in the Museum of the Geological Survey.

‡ Mem. Lit. Phil. Soc. Manchester, 2nd Ser. vol. x. p. 191. pl. 1. fig. 2.

pairs of holes themselves is always the same, and a line connecting them would be at right angles to their long diameter.

The only reason I can assign for this arrangement is, that it may have been determined by the current, which in the direction of the dotted lines might keep the holes clear from sediment, but in a contrary direction might tend to choke them. I do not know enough of the habits of the recent worms to explain it more fully.

Localities. Carding Mill, Stretton, in beds No. 3, north end of Callow Hill, Little Stretton, and other places; very common.

Annelide tubes. Pl. IV. fig. 2.

Besides the above, which may be doubtfully referred to Worms, there are occasional tracks of the Worm itself, in the form of shallow furrows on the surfaces. Only a couple of these tracks, preserved because of their greater sharpness, are represented in Pl. IV. fig. 2. But on the surfaces of the slabs I saw several undulating impressed lines, which I could refer to nothing else than the trails of such creatures.

Locality. Callow Hill.

The most interesting, however, of these few fossils is one which I cannot consider doubtful as belonging to a Trilobite, though differing from any species yet described, and probably referable to quite a new genus. I call it

PALÆOPYGE RAMSAYI. Pl. IV. fig. 3.

We have three or four specimens, the best of which is represented in Pl. IV. fig. 3. It is $2\frac{1}{4}$ inches broad, and $\frac{5}{8}$ of an inch long. Its forward edge is slightly curved downwards in the middle, but is otherwise nearly straight, and has an angular ridge running along its whole length just within the margin. The outer angles are rounded off, and the sides are a little oblique, and appear as if they had been produced, for the basal edge which follows the same line as the front margin is a little curved downwards as it runs to meet the side (at *c*).

The centre is occupied by a parabolic axis, obscurely defined by furrows. It is $\frac{1}{2}$ an inch broad, or nearly one-fourth of the whole width, and appears to extend nearly to the basal edge. In another specimen, however, it is shorter, and leaves a space 2 lines broad; but in this specimen the segment itself is somewhat broader and the base more strongly ridged; it may be the cephalic shield.

At first, indeed, all the specimens (four or five have been collected) were supposed to be the *heads* of a new trilobite; and the axis (*a*) was taken for the glabella. But the rounded outer corners (*b*, *b*) in the figured specimen negative this idea; the straight base and the apparent production of the posterior angle, *c*, remind us most nearly, among primordial fossils, of the new genus *Dikelocephalus*, proposed by Dale Owen* for the oldest known Trilobites of America, which were found in the Potsdam sandstone of St. Croix, Minnesota.

The far more transverse form of our fossils, and the entire want of annulation on the axis or side-lobes, are sufficient to indicate a distinct genus; and I dedicate the species to Prof. Ramsay, who has done so much to clear up the history of the Longmynd.

Locality. Ridge north of Callow Hill, Little Stretton. This fossil occurs with the next described.

Marks of ——— ? Pl. IV. fig. 4.

There are numerous hollows on the surfaces of the beds, which greatly resemble the impressions of Rain-drops. But they are less regular, less equal in size, and, although generally oval and lying in the same direction, have no ridge thrown up in front of them. It is impossible, however, to say they have *not* been caused by primeval rain; and Sir Charles Lyell, who examined them, was much struck by their resemblance to those he has figured and described.

Across the same surfaces run very frequently raised thread-like lines (Pl. IV. fig. 4, *a*) in the same direction as the longer diameter of the spots. Sometimes these lines are simply parallel, at others they are branched, at others interrupted and fading off. But they are sufficiently parallel and uniform in their direction over the bed to make it probable that they are lines of mineral structure, rather than anything organic, and I believe, too, that the drop-like hollows may be due to gaseous bubbles, or to the decomposition of small concretions, rather than that they indicate the marks of ancient showers.

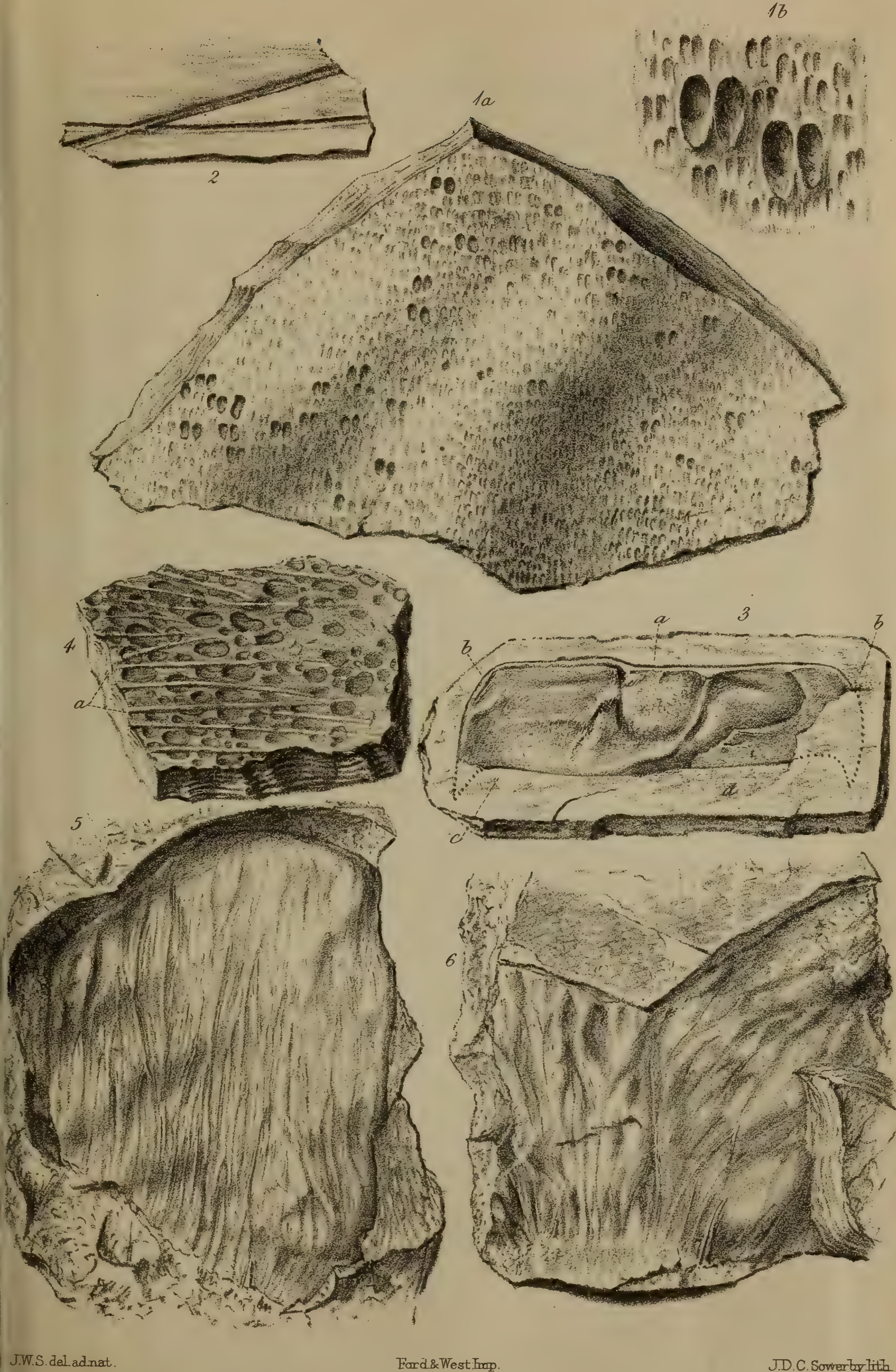
Locality.—Carding Mill, in the base of the red or purple sandstone (No. 4).

Ripple Marks (*with thin mud-coating?*). Pl. IV. figs. 5 & 6.

The surfaces of very many of the beds are, as above noticed, covered with ripple- or current-marks; this is particularly well seen about the small Waterfall called Light-spout, above Church Stretton.

Dark grey micaceous flags are there easily split into thin layers; and on these the ripple-hollows are generally stained with a thin film of protoxide of iron. Numerous radiating furrows, in the form of very fine branched lines, run from the margin toward the centre of these hollows or across them; the smaller ones near the edge running into the larger, just as brooks run into rivers. The lines are always *impressed* on the upper surface of the bed (*i. e.* in the faces dipping westward), so far as this could be ascertained, and are *elevated* threads on the casts of these hollows upon the *lower* surfaces; the edge of the hollow (Pl. IV. fig. 5) being concave or convex in each respective case. These ripple-marks have suffered, of course, all the contortions of the beds; and hence are puckered (*c*), flat-

* Report of Geol. Survey of Wisconsin, Iowa, and Minnesota. Philad. 1852, p. 573, pl. 1.



J.W.S. del. ad nat. Ford & West Imp. J.D.C. Sowerby lith.

FOSSILS FROM THE LONGMYND.

tened (*a*), folded (*b*), and very often obliterated. All these various conditions are represented in one figure (woodcut, fig. 2), which thus gives an average idea of the appearance of the markings when perfect. The furrows themselves either slightly impress a plain surface, as at *a*; or run between convex ridges, as at *c*, when they are closer and more branched.

Fig. 2.—*Diagram of the restored form of peculiar Ripple-marks on the Surfaces of the Flagstones near Church Stretton.*

All these circumstances and the great irregularity of outline convinced me, after careful search, that these were not fucoidal impressions*, but mechanical markings produced by the minute drainage of the surfaces when the water retired; and hence that they afford proofs of quiet littoral action.

Had the surface been merely sand, however fine, it is probable that no such marks would have been produced, but that simple percolation would have taken place. But if a thin film of ochreous mud, now a mere stain, were deposited on the surface, or washed into the ripple-hollows, such a surface, being more retentive, might show the tracks of the minute runnels of water as they flowed towards the lowest part of the hollow before they were absorbed.

This seems but a slender datum on which to found a belief of the proximity of land in these old Cambrian deposits. Their arenaceous character, however, and the conglomerates which occur a little higher up in the series, are better indications.

The conglomerates themselves, 120 feet thick to the W. of the Portway, are well deserving study. They are chiefly round pebbles of quartz-rock and vein-quartz; but there is an occasional stray pebble of syenite among them, as well as a great deal of felspathic matter derived no doubt from the degradation of still older volcanic shores.

* Such as those described under the name of *Dædalus* by Marie Rouault, Bull. Soc. Géol. France, 2de Sér., 1850, vol. vii. p. 736.

March 19, 1856.

Capt. W. S. Sherwill, the Rev. H. H. Wood, and D. T. Evans, Esq., were elected Fellows.

The following communications were read :—

1. *On some* Organic Remains *from the* Bone-bed *at the base of the* Lias *at* Lyme Regis. By the Rev. Mr. Dennis. Communicated by Sir C. Lyell, V.P.G.S.

[This Paper was withdrawn by the Author by permission of the Council.]

(Abstract.)

In this communication the author drew attention to some peculiar bones and teeth from the Bone-bed which occurs between the Trias and the Lias. Mr. Dennis considered that some of these fossils presented mammalian structure under the microscope. Among the specimens from the Lyme Regis bone-bed, Prof. Owen determined the remains of *Lepidotus* and *Saurichthys*, and also of a fish, *Placodus*, which had not previously been recognized among British fossils.

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2. *On the* Valenciennes Coal-basin. By MM. Degousée and Laurent, Civil Engineers.

[In a letter to, and communicated by, A. Tylor, Esq., F.G.S.]

(Plate V.)

We are enabled to give you some particulars relative to the works in the coal-basin of the Departments of the "Nord" and the "Pas de Calais," on the prolongation of the Belgian coal-basin of Mons. At the end of the last century, France in the north possessed only the mines of Anzin, which were first worked in 1716. This state of things lasted until 1832, when the workings had only extended to Denain. In 1839, the concessions of Douchy, Bruille, Vicoigne, Aniche, Azincourt, and Thivencelles were made. The works of research went on until 1841, at which period the adventurers, discouraged by the numerous fruitless attempts made in the supposed direction of the basin—towards Arras, abandoned them. Six years later, the works undertaken towards the north-west of Douai, in the direction of the present concessions of the "Pas de Calais," indicated the true direction of the coal-basin, and up to 1854 numerous trial-sinkings, of which many passed through the coal, led to the establishment of nine new concessions. A tenth on the border of the basin is in progress. Two more also have been made this year, one to the north of Douai, the other to the north of Bethune, above Choques, where it is supposed that the bands of dry coal (*faisceau maigre*) end, the coal-basin beyond this place becoming narrower, and representing only the seams of caking-coal in all the concessions to the west. Many works have, moreover, been undertaken in the course of the last three years in search of a widening of the basin by the series of the seams of caking-coal, and of an extension of the dry-coal-band, which disappears at Choques. With the exception of those made by the "Vendin Company," these sinkings have as yet given only negative results.

In all the sinkings which have been made from Valenciennes to the furthest of these researches, the Chalk forms the "head" (*mort terrain*) with a varying thickness. As far as Aire the Chalk alone forms the rock which has to be passed through before reaching the Coal, from which it is separated by a bed of green sand from 1 to 3 metres in thickness, known under the name of "tourtia." On the north of Aire it is, in addition, covered up by tertiary deposits, alternations of sands and clays, with a thickness in places of 100 to 150 metres, and which render it necessary to line the sinkings as the work advances. This formation is found even in Belgium, at St. Ghislain, near Mons, with a thickness of 60 metres.

The average thickness of the overlying beds is 140 metres. It seldom exceeds 180 metres, and was found to be only 85 metres at Marles, near Bethune. It is near this town that the depth to the base of the Chalk is the greatest; the sinkings which have been conducted on the south gave a result at a smaller depth.

Nearly 2,000,000 fr. have been expended by various companies, all formed of private persons, in more than 150 sinkings, and numerous workings have resulted, which have increased beyond all expression the wealth of these two Departments, have opened up a portion of the coal-field of France, and enriched, on a grand scale, the fortunate adventurers.

The small basin of Fiennes and Hardinghen, near Guines, is independent of this large one; it is a coal-deposit in the Mountain Limestone, and has been worked for some time past for local consumption; the coal is found at a slight depth, but the quantity of water renders the workings both difficult and expensive.

Similar works are progressing in the Dep. of the Moselle, where they are tracing the prolongation of the Sarrebruck basin, beneath the New Red Sandstone. Eight companies have already met with the coal between 200 and 300 metres in depth, and are applying for concessions. It is in this quarter and in the Dép. du Nord that the principal search is now being made, and where we have the greatest number of establishments.

As to the explorations between Douai and Valenciennes, where only shafts, and perhaps a few sinkings for the study of the ground, have been made, we are unable to give you such information as we have with respect to the new companies, whose recent works present much more interest.

Herewith we send you a tracing, according to scale, of the works done to the west of Valenciennes, together with an indication of the concessions which have been obtained in the "Département du Nord" and the "Pas de Calais," as also the names of the villages where the most important sinkings have been made. (See Plate V.) We have marked with a red line all those places where the sinkings have hit the Coal or the "coal-measures"; with a green line those where the Mountain Limestone is reached, and with a blue line those where the sinkings are in the Silurian formation. We have indicated the extent of the several concessions, and have marked, by two red lines, the limits, as they are at present approximatively known, of the coal-basin of the "Pas de Calais." Lastly, we give you separately the number of the sinkings which we know have been made by various companies in the course of the last few years.

Paris, December 26th, 1855.

Note.—Several errors in the names of places occur in Plate V. MM. Degousée and Ch. Laurent, having seen a copy of the lithographed Map, which was prepared from the tracing forwarded to Mr. Tylor, have kindly transmitted another sketch-map (containing several new features of interest), with the local names very distinctly written. The following is a list of the more important *errata*:—

For Marquises	*read* Marguise.	*For* Harnes	*read* Hasnes.
— Hardinghem	— Hardinghen.	— Sollan	— Sallau.
— Nottinghen	— Lottinghen.	— Baches	— Raches.
— Fouquenottes	— Foucquexolle.	— Eupin	— Erchin.
— Vizernes	— Wizernes.	— Marchicourt	— Emerchicourt.
— Ellinghem	— Eblinghem.	— Menchicourt	— Monchecourt.
— Lapagnoy	— Lapuignoy.	— Auiche	— Aniche.
— Gounay	— Gesnay.	— Rilloy	— Tilloy.
— Bally-grenay	— Bully-grenay.	— Auzin	— Anzin.
— Anhay	— Annay.		

—Ed.

3. *On the* Sandstones *and* Breccias *of the* South *of* Scotland * *of an age subsequent to the Carboniferous Period.* By R. Harkness, Esq., F.G.S., Professor of Geology and Mineralogy, Queen's College, Cork.

In a memoir "on the New Red Sandstone of the Southern Portion of the Vale of the Nith," published in vol. vi. of the Quart. Journ. Geol. Soc. (p. 389), I have given in detail the names of the localities where sections of these strata are exposed, also their dip at the several localities, and the connexion which exists between the different deposits composing what is termed the "New red sandstone" in this neighbourhood.

In describing the area occupied by this sandstone, I have been in error in supposing that, in the locality under notice, there is a connexion between the sandstone-beds of the Vale of the Nith and those of that portion of the Vale of the Annan in which the Corncockle-muir strata occur. A more perfect examination of the Dumfriesshire sandstones induces me to believe that there are five, if not seven distinct areas occupied by these deposits; and that the beds which appear in these several districts have an intimate connexion with each other, and are, for the most part, referable to the same geological age.

* See also Mr. E. W. Binney's paper "On the Permian Character of some of the Red Sandstones and Breccias of the South of Scotland," Quart. Journ. Geol. Soc., No. 46, p. 138.—Ed.

List of Concessions and Borings

Order	Companies	Concessions	Superficial Area: Square Kilometres	Superficial Area: Hectares	Number of Borings: Reaching the Coal	Number of Borings: Negative	Concession granted
1	Anzin	Vieux Condé (Nord)	39	62			.
		Fresnes .	20	73			.
		St Saulve .	22	.			.
		Odometz .	3	16			.
		Raismes .	48	20			.
		Hasnon .	14	88			.
		Anzin .	118	52			.
		Denain .	13	44			.
2	Fresnes-Midi	St Aubert .	4	55			.
		Thivencelles .	9	81			.
		Escaupont .	1	10			.
3	Crespin-3 bis Marly	Crespin .	28	42			.
		Marly .	33	13			.
		Château l'Abbaye	9	16			.
4	Vicoigne	Bruille .	4	3			.
		Vicoigne .	13	20			.
		Nœux (Pas de Calais)	65	28	(Nœux) 8		.
5	Douchy	Douchy (Nord) .	34	19			.
6	Aniche	Aniche .	118	52			.
7	Azincourt	Azincourt .	8	70			
8	Lascarpe	l'Escarpelle (Nord & Pas de Calais)	47	21	8	1	
9	Dourges	Dourges (Pas de Calais)	37	87	6		.
10	Courrières	Courrières do	45	97	8	1	
11	Lens	Lens .	60	31	6	2	.
12	Bethune	Grenay .	57	61	5	1	
13	Bruay	Bruay .	—	—	6	1	
14	Lillers	Marles .	—	—	2	3	
15	Ames & Ferfay	Ferfay .	—	—	6	1	
16	Auchy-au-Bois	Auchy .	—	—	3	4	
17	Lys Supérieure	. .	—	—	2	3	Concession applied for
18	Vendin-les-Bethune	. .	—	—	4	.	
19	Douaisiene	. .	—	—	3		
20	Fiennes & Hardinghem	Fiennes & Hardinghem	—	—	.	.	Concession granted

Topography of the Sandstone areas.—To commence with the eastern side of the county, we have, occupying the S.E. extremity, a portion of the great deposit of sandstone which covers so large a surface of Cumberland. This has the usual aspect of the deposits in the latter county; and, if we regard the sandstone of the country around Carlisle as Triassic, we have no alternative but to adopt the same nomenclature for this portion of the Dumfriesshire sandstones.

This area, commencing on the Solway Frith, in the parish of Cummertrees, and running in an E.N.E direction to the Liddle at Canobie, I regard as Trias, and newer than the deposits to be more fully alluded to.

In the Vale of the Annan, about six miles to the north of the above-mentioned area, the country is occupied by another area of sandstone, to which the name of the "Corncockle area" may be applied. Whether this can be connected with the deposits which occur on the east side of the River Annan, to the south and north of Moffat, is doubtful; and I am at present disposed to consider that in the higher portion of the Vale of the Annan there are three distinct areas, viz. the Corncockle,—the one which is seen in the form of a breccia in the streams immediately to the E. of Moffat, and to the S.E. at Bellcraig Linn, in the state of both sandstone and breccia,—and the third, filling up the head of the Annan in the district called the "Marquis of Annandale's Beef-tub."

To the N.W. of the north-western extremity of the Corncockle area, beyond several ridges of Lower Silurian mountains, there is found another spot where the sandstone presents itself, viz. to the S. of the farmhouse of Mitchell-Slack, in the course of the Capple Water. The area occupied by this is very small, probably not exceeding half a mile, if so much, in diameter; and the beds here have a brecciated character.

Westward from this last, we have another patch, of considerable size, occupying the east side of the Nith, from the Drumlanrig tunnel on the Glasgow and South-western Railway, to near Blackwood, having more than six miles in a N. and S. direction; and exceeding two miles in its greatest breadth.

To the south of this the "Dumfries area" appears, which has been already described. If the higher portion of the Vale of the Annan contains three areas of sandstone, we have scattered over the face of Dumfriesshire seven distinct patches of this substance; and these areas are well and widely separated from each other. If the higher portion of the Vale of the Annan contains only one patch, then we have five areas occurring under like circumstances.

Each of these several areas, with the exception of the one regarded as Trias, and the one which appears in the course of the Glasgow and South-western Railway immediately south of the tunnel (which may be termed the "Thornhill area"), has so far as can be determined Lower Silurian rocks for its margin. The other two are surrounded by Carboniferous rocks.

Sandstones and breccias of an age posterior to the Carboniferous are not confined in the South of Scotland to Dumfriesshire; we meet with deposits having the same characters, and apparently belonging to the same age, at and about Mauchline in Ayrshire; and, if we add this to the number, it gives us either six or eight patches of sandstones, covering several widely remote areas in the South of Scotland.

Physical Geology of the Sandstone-areas.—Besides the question as to the geological age of these patches, their position and isolation are matters of some importance, and there are certain circumstances connected with the physical geology of these strata which render them interesting.

As the Dumfries area has been already described, any matters of detail connected with this may be found in the memoir already alluded to. There are, however, certain phenomena or physical characters which are not there mentioned, and which should be noticed.

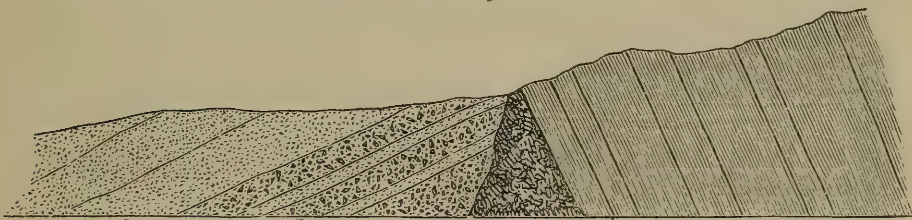
Corncockle Sandstone-area.—To commence with the Corncockle area,—this presents us with sandstones and breccias, but they have not the same relative arrangement as deposits of this nature have in the district around Dumfries. In the latter area we have a considerable thickness of sandstones, forming the lower portion of the deposits; these are succeeded by thick breccias (Craigs breccias); and above all we have sandstones, which are not extensively developed (Castledikes sandstone). In the Corncockle area there appear to be no equivalents of the breccias, nor the higher-lying sandstones; and the same remark, so far as I can ascertain, applies to all the other areas both in Dumfriesshire and Ayrshire. Breccias do occur in the other areas, but not under such circumstances as are presented in the Dumfries district.

In the most southern portion of the Corncockle area, at Dalton Hook, we have breccias exposed; and these possess some features which are peculiar in Dumfriesshire. Here they were formerly wrought for lime; the calcareous matter occurring in the form of angular fragments of Carboniferous Limestone, characterized by the usual fossils: these angular fragments are associated with others derived from the Lower Silurians. Both the Carboniferous and the Lower Silurian formations are met with at about a quarter of a mile from the spot where this breccia has been worked. In this locality the strata dip N.N.W., at a slight angle.

Breccias of a somewhat similar nature are seen in the course of the Water of Milk, about two miles east from Dalton Hook; and at the northern end of the Lockerby railway-cutting the breccia also makes its appearance; but here the fragments seem to be exclusively of Lower Silurian origin, and the inclination is more towards the west. Beds of sandstone are met with in the course of the Dryffe Water; and in the small burn which runs from the N.E. near Nether Cleugh station, on the Caledonian Railway, beds of a similar nature are likewise found. In the course of the Upper-Cleugh Burn, immediately as the newer beds come in contact with the Lower Silurians, the former assume a brecciated character, like the deposit which is seen at the north end of the Lockerby Cutting; but at Upper Cleugh the matrix is of a softer nature. In the Ryecastle Burn, about two miles from Nether Cleugh station, where the two formations come in contact, the newer is found resting on the older, and consisting of sandstones, which dip toward the W.S.W. Here, at the junction of the two formations, breccias do not make their appearance.

At the north-eastern extremity of the Corncockle area the sandstones are well exposed. They occur in the course of the Annan at Johnston Bridge, and have a south inclination; and when we go west from this, we find them well developed in the course of the Kinnel Burn, about half a mile below St. Ann's Bridge. See Section, fig. 1. In this neighbourhood the best section of the sandstones and breccias is seen which this area affords.

Fig. 1.—*Section in the course of the Kinnel Water, Parish of Johnstone, Dumfriesshire.*



c. False-bedded sandstones. *b.* Breccias and sandstones. *a.* Silurian rocks.

A short distance above the foot-bridge over the Kinnel, near Elizatown, the Lower Silurians are seen with the sandstones almost in contact. These latter consist of thin beds of red sandstone, false-bedded, associated with breccias, the latter abounding to a greater extent than the former. The total thickness of these strata exceeds 100 feet; and they have above them deposits of false-bedded red sandstone, devoid of breccias; the whole dipping south at an angle of about 30°. Red sandstones of the same character occur in the course of the Mollin Burn. They are seen also on the road leading from the Moffat Road to Courance, and have a S.E. inclination. They also present themselves in the Burrans Burn, with a S.S.E. dip. And at the western extremity of this area the conglomerate occurs immediately under Kirkmichael Manse, abutting against the Lower Silurians*. To the south-east of this locality, immediately below the Water of Ae bridge, the sandstone likewise occurs; it is flaggy, and dips N.N.E.; and near Trailflat, in the course of the Ae, it is also seen. From this last locality, I am not aware that the sandstones or breccias are anywhere exhibited until we reach Rammerscales; and here we have the strata dipping north; and at Smallholm the sandstone was formerly worked to a small extent, but the quarry is now filled up. Here likewise the northern dip obtained.

In the interior of this area the sandstone is well seen at Corncockle quarry, Templand Village quarry, Red Hall, and Lochbrow; the two latter quarries being now abandoned. In none of these four localities are the breccias seen; but the sandstones of the two quarries now

* See Section, Quart. Journ. Geol. Soc. vol. xi. p. 469.

wrought, viz. Corncockle and Templand, differ materially from each other. The former consists of very regularly bedded red sandstone, easily worked; the latter of a hard red flag, coarser than the Corncockle beds, and remarkably durable. I know of no red sandstone which at all approaches the Templand flags in respect of hardness. In these two localities the strata dip to the W., at an angle exceeding 30°; and, as Templand lies a short distance to the S.W. of Corncockle, the beds which occur at this spot occupy a higher position than the Corncockle sandstone.

I learn from Sir William Jardine, that, like the Corncockle strata, the deposits which occur at Templand afford fossil footsteps.

There are some circumstances in connexion with the Corncockle area which are matters of interest. One of these is the directions of the inclinations of the strata in the several localities where the sandstones and breccias are exposed.

Whenever we find the newer and the older formations near each other, the former in all cases dips from the latter. On the eastern margins of the area we have a westerly dip, on the western an easterly dip, on the northern a southerly, and on the southern a northerly dip; and in the intermediate positions the same circumstances occur.

Had the area been circular, we should have had the dips converging to a central point; but, as the form of the area is irregular, we have an approximation to this mode of arrangement. The Lower Silurian margins do not appear to present any evidence of the operation of those causes which have given to the sandstones and breccias their inclination; for we have either a continuous N.N.W. or a continuous S.S.E. dip occurring all through the Silurians of Dumfriesshire. The cause of this peculiar mode of arrangement in the Corncockle area seems to have been local; and I can attribute it to no other circumstance than a subsidence in a small area, which has dragged down the strata towards it in all directions, and so produced a series of inclinations which always dip from the older formation.

Another circumstance of interest is the sequence of the deposits which form the sandstones and breccias. As concerns the latter, we have seen that it only occurs in certain spots along the margins of the area. When we have higher beds, these are seen to be false-bedded sandstones, as in the Kinnel Section; and in no case do we meet with any thick deposits of sandstone beneath the breccias, as is the case with the breccias of the Craigs in the Dumfries area. The mode of occurrence of the breccias would therefore lead to the inference, that these are the lowest deposits,—that they are succeeded by a series of sandstones to which those wrought at Corncockle appertain, —and that the highest beds consist of the hard flags of Templand. We have therefore three groups,—1st, and lowest, breccias, with sandstones, more than 100 feet thick; 2nd, sandstones, the thickness of which has not been ascertained, but which must be considerably thicker than the breccias; and 3rd, hard flags, the thickness of which is not determined, but is probably less than that of the breccias.

The age of these several strata is also a matter of great interest;

but this at present we are hardly in a position to discuss. At one time I was disposed to regard them as triassic, resting the conclusion on the character of the sandstones and the nature of the footprints found on them.

With regard to the latter, which are principally chelonian, I find these differ in the relative length of the toes from those which occur in the Trias sandstones of Western Point, Runcorn, Cheshire; and, as Chelonians have existed during several geological epochs, too great importance may be attached to impressions of this Order. Under these circumstances, therefore, the triassic age of these strata is doubtful.

Sandstone-areas of the upper part of the Annan.—With regard to the two areas which occupy the east side of the River Annan, to the north of the Corncockle area, these consist of breccias with false-bedded sandstone; and beds of these characters are best seen in the Bell-Craig Linn, about four miles S.S.E. of Moffat. They appear to appertain to the lower strata of the more southern patch; and the inferior-lying conglomerates are well seen in the course of the Well Burn, from below Heathery Haugh to above Arch-bank. In the most northern area, the sandstone is well exposed at Newton; and this is probably the lower portion of the false-bedded sandstone which rests upon the breccias, as seen in the course of the Kinnel Burn. It is on the eastern margin of these two areas that we have the beds exposed; and here they are seen dipping from the Silurians. The western extremity of these patches is not seen, as the low ground is occupied by drift, and by gravel deposited by the River Annan. Where we have the newer strata exposed, they manifest themselves under the same circumstances as in the more southern area, viz. dipping away from the older deposits.

Sandstone-area of Mitchell-Slack.—As regards the little patch in the course of the Capple Water, below the farm-house of Mitchell-Slack, this is so small that little can be made of it, except that, from its brecciated nature, it appears to have affinity to the lower portion of the Corncockle series. It has a southerly inclination, dipping from the high hills which lie to the north. Its area cannot be made out owing to the drift which covers it, except in the spot before alluded to. This patch is, however, so closely surrounded on all sides by Lower Silurians, that the area occupied by it must be very small. Such a small isolated patch, surrounded on all sides by Silurian hills from 1000 to 2000 feet high, is a matter of considerable interest in connexion with physical geology.

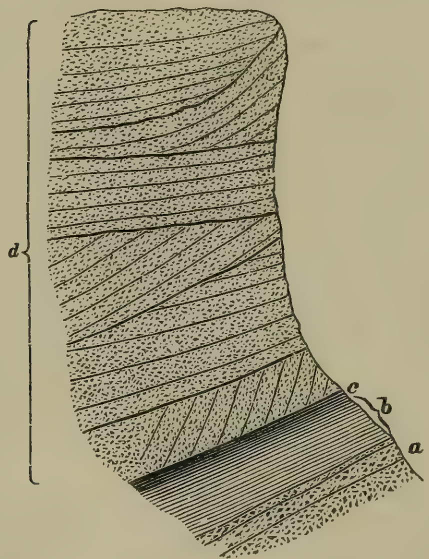
Thornhill Sandstone-area.—The sandstone-area on the east side of the River Nith, around Thornhill, and occupying the lower portions of the parishes of Morton and Closeburn, is of considerable importance as concerns size; and its being, for the most part, surrounded by Carboniferous rocks renders this area different in its boundaries from the patches before-described.

We have better sections exposed here than in some of the other localities occupied by sandstones and breccias; and we can derive some information from this area which the others do not afford.

The spot where we have the best sections of the strata of the

Thornhill area is in the course of the Creechope Burn, at Creechope Linn, the scene of the retreat of Balfour of Burley in 'Old Mortality.' Here a small rapid streamlet has cut itself a deep channel among soft sandstones, leaving steep cliffs on either side. At the entrance of the Linn, a short distance above where the Creechope joins the Cample Burn, we have purplish flagstones, which belong to the Carboniferous age, dipping at N. 4° S.E. at an angle of 15°; and the same flagstones are seen in the bed of the stream higher up the Linn, at a spot called the Sutor's Seat. The deposits, which at this spot occur immediately above the Carboniferous flagstones, cannot be seen owing to debris; but at about 9 feet above the flagstones purple clays make their appearance, with cream-coloured spots, devoid of lamination, and fracturing very irregularly. These have a thickness of about 6 feet; and above them are seen the soft red sandstones, attaining a considerable thickness, and very much false-bedded. See Section, fig. 2. In the purple clays I was unable to detect any

Fig. 2.—*Section at Sutor's Seat, Creechope Linn, near Thornhill, Dumfriesshire.*

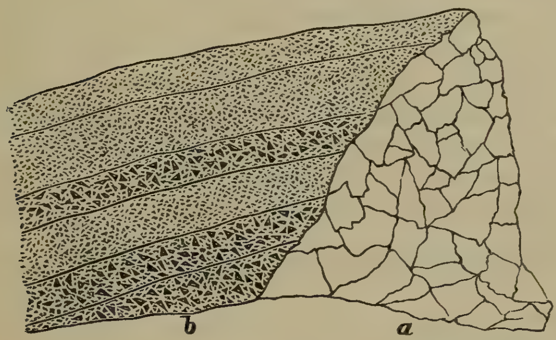


d. False-bedded sandstones.
c. Purple clays.
b. Not seen.
a. Carboniferous grits.

fossils. The sandstones extend through the whole of the Linn, and present the same false-bedded aspect, so much so that their apparent directions and dips are not to be depended on. At Gatelaw Bridge, about a mile north from Creechope Linn, the sandstone is extensively worked; and is here also false-bedded, but not to the same extent as at the latter locality. Where the inclination is regular the dip is N.N.W., at an angle of 15°; and at a short distance, higher up the Cample Water, breccias are seen, which seem to underlie the sandstone of Gatelaw Bridge. Columnar basalt, with layers of amygdaloid, occurs further to the east than the breccias, and has furnished the latter with a considerable portion of their contents.

In the course of the Glasgow and South-western Railway, we have the sandstones exposed twice in the cutting between the Thornhill and Carron Bridge Stations, and one of these exposures presents a troughing of the beds. North of Carron Bridge Station, in the cutting at the south entrance of the Drumlanrig tunnel, we have the sandstones and accompanying strata well exposed. The beds here dip south, at an angle of about 12° ; and besides sandstones we have breccias of an interesting character. The south end of the tunnel consists of amygdaloidal trap ; and on the south side of this we have the breccias composed of fragments of the igneous rocks in great abundance ; and these, with the associated sandstones, dip from the amygdaloids. See Section, fig. 3. At the north end of the tunnel,

Fig. 3.—*Section at the South Entrance of Drumlanrig Tunnel, Carron Bridge Station, Dumfriesshire.*



b. Sandstones and Breccias.
a. Trap-rock.

we have variegated Carboniferous grits, dipping S.S.E., at an angle of 25° ; and through these grits the igneous rock has burst.

The occurrence of igneous rocks here, and the relations which these bear to the Carboniferous beds, as well as their connexion with the newer sandstone strata, are subjects of interest, as we are enabled, to some extent, to derive information concerning the age of the latter ; and this is more important as we shall find in another district the sandstones and breccias occurring under like circumstances. The relations which exist between these several rocks show that the outbursts of trap were anterior to the deposition of the sandstones and breccias ; and this does not appear to be a mere local occurrence, but tends to support the inference that the Coal-fields of the centre of Scotland had not only been deposited, but had been subjected to all those violent disturbances, and outbursts of igneous matter, which are so prevalent among them, before the deposition of the sandstones and breccias.

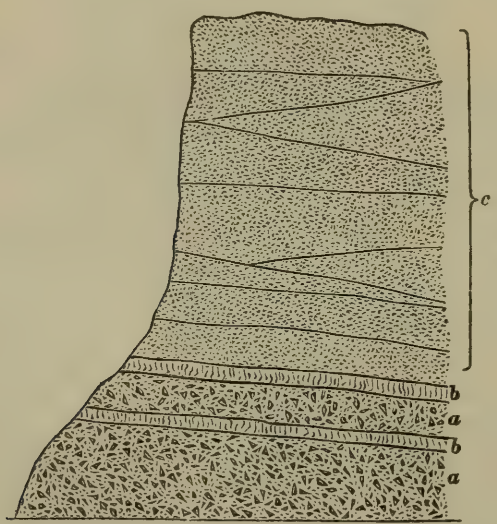
As in the other areas of sandstone which are found in Drumfriesshire, we have no proofs that the causes which disturbed them have affected the Silurians surrounding this area ; but the intermediate Carboniferous strata partake to a great extent of the influences of the forces which have disturbed the newer formation. From the appearance of the breccias in the lower portion of these deposits, I am disposed to consider them as the equivalents of the lower and middle portion of the Corncockle series.

Sandstone-area of Mauchline, Ayrshire.—We have now to leave Dumfriesshire and go to near the centre of the adjoining county Ayrshire. In this district, around Mauchline, there is another patch of red sandstone and breccias exhibited. About a quarter of a mile to the south of the Mauchline Station this sandstone is worked. It possesses all the features which characterize the false-bedded sandstones above the breccias in the several Dumfriesshire areas, and seems to be of considerable thickness. About half a mile further south, at Ballochmoyle, in the course of the Water of Ayr, we have a beautiful section exhibiting these sandstones and the strata upon which they repose.

Immediately above the bridge over the Railway the red sandstones dip N. 50° W., at an angle of 15°; and as we go up the Water of Ayr, from newer to older beds, we see a great change taking place in the nature of the deposits.

The lowest strata of the sandstones are soft, and rest upon a thick series of breccias, which in appearance are like those at the south entrance of the Drumlanrig tunnel, and consist of angular fragments of amygdaloid, in the cavities of which are nests of zeolitic minerals. In the highest portions of these breccias there are thin beds of a siliceous limestone, of a purplish colour, but in these I found no organic remains. See Section, fig. 4. In going up the stream, from

Fig. 4.—*Section near Ballochmoyle, Water of Ayr, Ayrshire.*



c. False-bedded sandstones.
b, b. Impure limestone.
a, a. Breccia.

the higher to the lower beds of the breccia, we come upon a trap-dike which cuts off the beds, and from which the fragments entering into the composition of the breccias have been obtained; and on the eastern side of the dike we have Carboniferous grits, similar to those which surround the sandstones of the Thornhill area.

The association of the several rocks here is intimately connected with what is seen at the entrance of the Drumlanrig tunnel, the only difference being that at Ballochmoyle we have a more perfect section presented to us. As regards the thickness of the sandstones, there are more than 200 feet exposed in the Water of Ayr; and the portion of the breccias which is seen must be nearly 50 feet in thickness. The newer strata here exposed appear to me to be most probably the representatives of the low breccias and overlying sandstones of the typical area, Corncockle.

Sandstone-area of Dumfries.—We have now to return to the area already described*,—the Dumfries area; not for the purpose of alluding to it in detail, but to endeavour to find out its relation to the several patches which have been noticed. In the memoir referred to, the Locharbrigs quarries are noticed (*loc. cit.* p. 391). These are the quarries which are nearest to the Corncockle quarry; and some of the strata seen in them are identical with those at the latter locality, afford the same chelonian footsteps, and have even the same angle of dip and direction. Like the Corncockle strata, they have no breccias covering them, and any person examining the two localities would arrive at the conclusion that they are the same, not only in nature, but position. We have in the Dumfries area no exposures of the beds which are subjacent to these sandstones, and consequently the breccias which support these are not seen.

If the sandstones of the Corncockle quarry and the Locharbrigs strata are the same (which I believe to be the case), then we become possessed of a clue which enables us to judge of the connexion existing between the other beds of the Dumfries patch and those already alluded to.

The Craigs quarry, south-east from Dumfries, is in the line of the strike of the Locharbrigs sandstones. It is similar in its nature, and it affords the same footprints. As we go from Locharbrigs to this quarry, the breccias come on, and are well seen occupying a position above the sandstone at Craigs (see Section, fig. 5, p. 264); and, consequently, we have in some portions of the Dumfries area certain breccias which have no equivalents occupying the same relative positions in any of the other Dumfriesshire areas, nor in that of Mauchline in Ayrshire.

These higher breccias differ from the lower ones in their nature;—they have fewer beds of sandstone interstratified in them, and they are much harder in their composition than the inferior breccias.

It is by no means improbable that the hard flagstones of Templand quarry, which overlie the beds of Corncockle quarry, may be the equivalents of the lower portion of the Craigs breccias, which are fully described in the memoir above referred to†. If such be the case, and if the sandstones of Locharbrigs, Craigs, and other localities in the Dumfries area be the equivalents of the beds at the Corncockle quarry, then it follows that the sandstones and breccias newer than the Carboniferous formation can be divided into four distinct groups;—1st, and lowest, breccias and sandstones, best seen in the course of the Kinnel Water and at Ballochmoyle in Ayrshire; 2nd, sandstones, for the most part false-bedded, well seen in

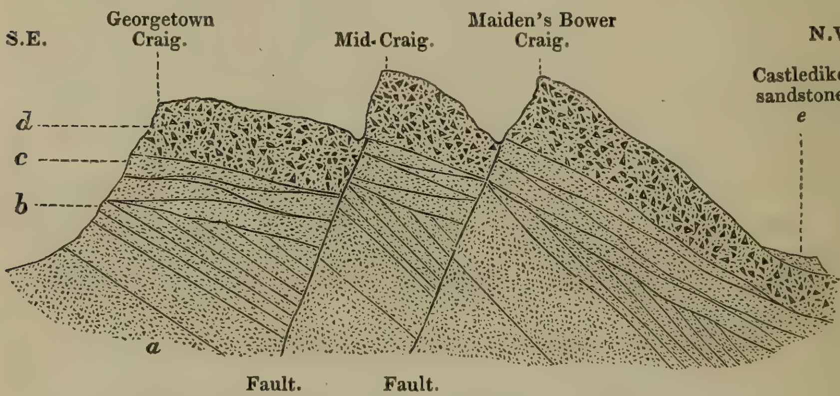
* Quart. Journ. Geol. Soc. vol. vi. p. 389.

† *Loc. cit.* p. 394.

the Corncockle area, the Thornhill district, at Mauchline, and in the neighbourhood of Dumfries; 3rd, hard thick breccias, best seen at the Craigs, Dumfries; and 4th, thin-bedded sandstone, only slightly developed; occurring at Castledikes, Dumfries, above the breccias*. The Dumfries area presents, so far as can be seen, the same physical geology as the other patches; it appears to dip from the higher hills, and forms a trough through which the River Nith flows.

Since my memoir on the New Red Sandstone of the southern portion of the Vale of the Nith was written, there has been another quarry opened immediately under the south-eastern end of the Maiden-Bower Craigs. See Section, fig. 5. Among the sandstones of

Fig. 5.—*Section near Dumfries, from Lochar Moss (S.E.) to the River Nith (N.E.).*



e. Castledikes sandstone.
d. Breccias.
c. False-bedded sandstones.
b. Flaggy beds with footprints.
a. False-bedded sandstones.

this quarry, which occupy a higher position than those in which the footsteps occur, there are seen features which, so far as I am aware, are peculiar to this spot. The lithological characters of some of the strata here show their intimate connexion with the overlying breccias, since some of the beds have fine breccias mixed up among them. On the surfaces of a few of the higher of these sandstones we have singular markings, which, at first sight, are so remarkable that there is a difficulty in knowing what to make of them. They consist of sunken impressions on the upper faces of the beds. These markings are in some cases somewhat rhomboidal in form, with sharp angles. In other cases they have a rib-like appearance; sometimes they are sinuous, and at other times they are cylindrical; and might be taken for either portions of stems of trees, or fragments of large *Orthocerata*. I was at one time disposed to regard them as the result of a peculiar mode of rippling, such as would arise from the action of a small rill over a muddy beach; but the angular character of some of the markings is hostile to this opinion; and the cylindrical form which they sometimes present is also opposed to this idea. I am indebted to my friend Sir William Jardine for the correct explanation as to

* *Loc. cit.* p. 396.

the nature of these singular markings; some of the most beautiful having been sent to him and being now in his possession. They are a unique form of desiccation-cracks, produced on mud which, in consequence of exposure to solar rays after the cracking, has curled up at the edges in some instances; and this curling has sometimes proceeded so far as to cause the mud to assume almost the form of a hollow cylinder, into which the sand has been afterwards poured; and in consequence we have the stem-like forms which occur in these sandstones. Sir W. Jardine informs me that he has seen modifications of the same circumstances which produced these singular markings take place on the banks of the River Annan among the muds which have been deposited during freshets.

These markings are not the only impressions which the sandstones of the Maiden-Bower afford. We frequently find on the upper surfaces of the strata pitted hollows; and we have natural casts of these on the under side of the overlying beds. On an average, the length of these impressions is about $\frac{3}{4}$ of an inch, and their breadth about $\frac{5}{12}$ of an inch, so that they have a form approaching to oval. They have a deeper impression on one end than the other, which gradually thins out; and these deeper impressions are all in the same direction on one surface. I was at first inclined to regard them as resulting from rain-drops; but they are larger and more irregular than the pittings produced by either rain or hail; and Sir Charles Lyell, who had an opportunity of examining this quarry with me, suggested that they might be caused by the splashing of spray driven almost horizontally on a muddy shore. Their elongated form shows that the force causing them had a less perpendicular direction than rain, and spray driven by the wind from the sea appears to have been their origin*.

If the singular markings already alluded to be the result of desiccation, and if these irregular oval markings owe their occurrence to spray, then we have on these ancient shores proofs of a hot sun's rays falling on a muddy beach, and proofs of the lashings of the sea by a violent wind which drove the tops of the foam-crested waves in the form of spray on this old beach.

Isolation of the Sandstone-areas.—The isolated position of the several sandstone-areas is a subject which next presents itself. Looking at these patches on the map, and knowing that some of them are surrounded by lofty mountains, it will at once be perceived that they could not have been deposited singly in the several areas which they occupy.

The intimate connexion which exists in the lithological characters of the series of beds forming these patches, shows that they have had a much more intimate union than they now possess; and all the circumstances lead to the inference that they are the relics of a large mass of sandstones and breccias which at one time covered a great portion of the South of Scotland; and which has been to a very great extent removed from the surface of the upturned Silurians by denuda-

* Original sketches of these markings and of the desiccation-cracks are deposited in the Society's Library.—Ed.

tion. At what period this denudation took place we have no means of determining; but a considerable amount of destruction must have occurred during the pleistocene period; for the beds which represent this formation in some portions of the South of Scotland consist almost exclusively of sand and gravel, the former of which has been derived from the abraded sandstone, whilst in the latter we have sometimes fragments of the higher breccia. It is, however, on the whole probable that the sandstones and their accompanying strata had suffered a great amount of denudation at a period antecedent to the glacial epoch.

Previously to this denudation, it would appear that there existed over an area which is now exclusively occupied by Silurians and Carboniferous rocks, thick deposits of a newer age, having their lower beds composed of breccias and intercalated sandstones; above which were red sandstones greatly false-bedded; succeeded by hard breccias; the only remains of which in Scotland are to be found in the neighbourhood of Dumfries, and thin-bedded sandstones, of which only slight traces now remain. The preservation of the isolated patches seems to have resulted from subsidences which have dragged down into hollows these newer strata, the harder Silurians on their margins protecting them from total destruction.

Age of the Sandstones and Breccias.—With respect to the age of the sandstones and breccias of the South of Scotland newer than the Carboniferous formation,—we have as yet obtained from them no fossils which will enable us to co-ordinate them with deposits of a like nature elsewhere. Such evidence of the existence of animals as they possess is not capable of affording us much assistance, since the footsteps obtained from the sandy strata seem to be unique among sedimentary deposits; therefore no definite conclusions can be drawn from them. We are consequently under the necessity of adopting lithological evidence in this matter. Red sandstones similar in all respects to those described are common to many parts of the Trias of England; but we do not find these red sandstones succeeded by thick beds of breccia, as is the case with those under consideration. Breccias are rare among the Trias, while conglomerates abound in some of the middle and lower beds. We have, however, no conglomerates in the Scotch red sandstones; the absence of conglomerates and the presence of breccias show that the lithological characters of the strata will not support the conclusion that these deposits are of the Triassic age.

We are therefore under the necessity of comparing them with another formation which affords red sandstones. In the Permian series we have sandstones which bear resemblance to those of the South of Scotland. Here likewise we have breccias; and Mr. Binney has shown * that in the neighbourhood of Brough and Kirkby Stephen, in Westmoreland, the associations and composition of the strata closely resemble those of the deposits in the neighbourhood of Dumfries, so much so, that he concludes the deposits of Westmore-

* Memoirs of the Literary and Philosophical Society of Manchester, vol. xii. p. 257 & p. 267.

land and the Craigs near Dumfries to be of the same age. Sir Charles Lyell and myself had an opportunity of examining the Westmoreland strata above referred to, and can acquiesce in the conclusions concerning relative position and mineral character. Sir Roderick Murchison had some years before adopted the opinion of the Permian age of the Dumfries series*, and was the first to announce this view. Mr. Binney also, when he accompanied me several years ago to the Craigs, seemed disposed to question the Triassic age of the strata there exposed; and on this occasion, when we visited the quarry at Green Mill in the parish of Caerlaverock, where beds similar to those of the Craigs quarry, and occupying the same position, are worked, he was the first to detect footprints. These impressions he stated were different from any found by him in the Trias of Cheshire.

Resting the conclusions therefore on the mineral evidence, it would appear that the sandstones which have hitherto generally been regarded as of Triassic age must be referred to the Permian; and probably the only portion of Triassic sandstone which occurs in the South of Scotland is that extending from Cumberland into the south-east of Dumfriesshire, the association of the strata of which is entirely different from that in the several areas described.

The existence of animal life, in the form of Reptiles, during the period of the deposition of these Permian beds must have been abundant, since we meet with numerous impressions caused by Chelonians, Lizards, and Batrachians, which walked over the shores of the Permian Sea when its sandstones were sandy beaches with mud-patches scattered over them.

* Quart. Journ. Geol. Soc. vol. vii. p. 163.

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————. No. 23. April 1856. Vol. vi. pt. 3.

Athenæum Journal for January, February, and March 1856. *From W. Dilke, Esq., F.G.S.*
- Notices of Meetings.

Basel, Verhandlungen der Naturforschenden Gesellschaft in. Zweites Heft. 1855.
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G. Jeusch.—Amygdalophyr, ein Felsit-gestein mit Weissigit, iii. Nachtrag, 798.

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———. Parallèle entre les Dépôts Siluriens de Bohême et de Scandinavie.

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Jones, T. Rupert. Notes on Palæozoic Entomostraca: No. 3. On some species of Leperditia.

King, W. On Anthracosia, a fossil genus of the family of Unionidæ.

King, W. On Pleurodictyum problematicum.

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Webster, T. The case of Josiah Marshall Heath, the inventor and introducer of the manufacture of welding Cast Steel from British Iron.

Yates, James. Narrative of the Origin and Formation of the International Association for obtaining a uniform Decimal System of Measures, Weights, and Coins.

Zepharovich, V. R. von. Der Jaulingit, ein neues Fossiles Harz aus der Jauling nächst St. Veit a. d. Triesting in Nieder-Österreich.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

April 9, 1856.

T. H. Huxley, Esq., F.R.S., was elected a Fellow.

The following communications were read:—

1. Notes *on the* Geology *of the Neighbourhood of* Sydney, Newcastle, *and* Brisbane, Australia. By Mr. James S. Wilson, Geologist to the North Australian Expedition.

[Communicated by Sir R. I. Murchison, F.G.S.]

(Abstract.)

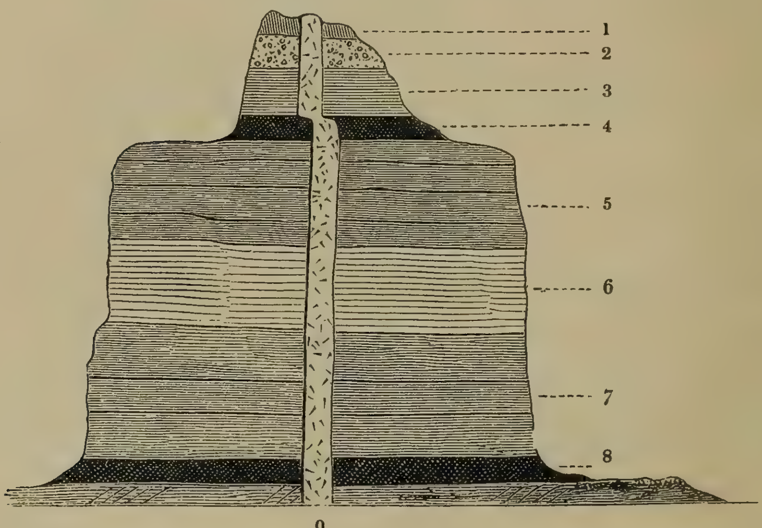
The country about Sydney is composed nearly altogether of sandstones belonging to the Carboniferous era, and similar in appearance to those of the same age in the north of England. Although in the vicinity of Sydney no coal has been found, with the exception of a few very thin seams, seldom exceeding a quarter of an inch in thickness, yet a thin seam of coal-shale of small extent occasionally occurs.

The sandstone-rocks about Sydney are generally white, consisting of a clear quartz-sand united by a white earthy cement; there are, however, two principal exceptions, viz. the top bed, which is a red conglomerate, principally pebbles of trap, cemented with oxide of iron,—and one of the lower beds, containing iron; but in whichever matrix the sand is found, it appears, when examined with a microscope, to consist of minute crystals of quartz, partially rounded by abrasion.

The coal-shales of the Hunter River district are full of fossil leaves, and some of them consist of a mixture of coal and clay, and contain such an amount of bituminous matter that Mr. Beaumont (Mineralogist to the Australian Agricultural Company) has expressed an opinion that gas might be manufactured from them. Two seams of coal only are being worked in this district; a third is known to exist, but is supposed to be too thin to pay for working at present. It is two feet thick where seen, and is situated considerably below the sea-level. The other two seams are from four to six feet thick, but contain seams of carbonaceous shale which deteriorate the quality of the coal.

At the entrance of Newcastle Harbour is a perpendicular rock (called Nobby's Island), once separated from the main land, but now united by a breakwater that has been thrown across for the protection of the harbour. The island exhibits a good section of the rocks of the coal-field. The accompanying section shows the arrangement of the strata.

Section of Nobby's Island, Newcastle Harbour.



1. Mould.
2. Trap-conglomerate.
3. Shales with plant-remains.
4. Coal.
5. Earthy sandstones and shales.
6. Chert.
7. Imperfect sandstones and shales.
8. Coal.
9. Trap-dyke.

The island is intersected by a trap-dyke, 9 feet thick, running in a direction nearly S.E. and N.W., and completely decomposed from the top down to the sea-level, presenting only a greenish-white greasy clay; but beneath the water the dyke is perfectly sound and hard; about low-water-level it crops up through the beach, and may be seen at some little distance running out into the sea. A bed of coal (the second in the series), that formerly extended far beyond the present limits of the island, and through which the dyke passes, has been washed away by the waves, with the exception of a few feet on each side of the dyke, looking like a great half-consumed log; this portion is so hard that it resists the action of the water with greater firmness than the trap-dyke itself to which it seems united.

The upper seam of coal, where it comes in contact with the dyke, has been altered in the same manner; but the alteration extends only a few feet on each side. A similar dyke passes through Beacon Hill, where I saw a number of prisoners working a seam only a few feet from the dyke, to obtain coal for the Beacon-fire.

At the top of the island, on the south side, the rocks have parted from the dyke to the extent of about one inch, and the space has been filled with clay and gravel, washed in from the shale and conglomerate above, as far down as the first coal-seam. This mixture is highly impregnated with the oxide of some metal (supposed by Mr. Stutchbury to be nickel), and is of a yellowish-green colour. Nobby's Island is about 100 feet high; but the top, as far down as the first coal-seam, is being cut down to form a level base for the erection of a light-house.

At a promontory called Red Head, six miles southward from Newcastle, Mr. Beaumont showed me the remains of a fossil forest on a broad bed of shale that was generally covered at high-water. Roots of trees, evidently in the situation where they had grown, now consist of rich ironstone. Some of the trees, broken off by the roots, and lying in the place where they first fell, are similarly fossilized. Some of the trunks are about 2 feet in diameter.

At a place three miles nearer to Newcastle, several tree-trunks, of more than one kind, are exposed to view, all of which consist of ironstone. Near the same place, in the face of the cliff, but in several beds higher in the series, a part of the trunk of a fossil tree, about 4 feet in length and 1 in diameter, stands erect in a bed of decomposed shale; but this tree has nothing of the ferruginous character of the trees of the lower bed.

In crossing the range of hills between Maitland and Singleton, I met first with a porphyritic dyke, containing fragments of quartz and crystals of felspar; next was a shelly limestone, corresponding to the mountain-limestone; and afterwards a hard conglomerate, at a cutting west of the point where the Black Creek crosses the road. It is of a bluish colour, and contains marine shells and water-worn pebbles of the crystalline rocks.

From six to eight miles N.W. from Singleton are large quantities of angular ironstone-gravel, without any appearance of having been waterworn; and soon afterwards I found the source from which it had descended,—namely, the remains of a fossil forest, similar to that on the coast at Redhead. One large stem, that lay extended from a wide-spreading root from which it had fallen, measured 12 feet in length. It appeared to me, that the rock in which these trees are imbedded is the same in age as that containing similar fossils at the water's edge near Newcastle.

About five miles from Muswell Brook I saw an edge of old slate-rocks standing vertically through the carboniferous rocks. A great portion of the country between Muswell Brook and Mooroorundi is comparatively level, and is generally excellent land. At the latter place conical hills, of a trappean character, rise abruptly from the plain-like valleys. One range, however (Wailand's Range), crosses within a few miles of Mooroorundi, and is rendered remarkable by the constant burning of a coal-seam in one of the hills, called Mount Wingen.

Mooroorundi is beautifully situated on the River Page, at the foot of the Liverpool Range, having in view several tall peaks of basaltic or trappean character, which may be seen ranging along the flank of the hills, and rising above the rocks in which they had once been enclosed.

From Mooroorundi I began to ascend the Liverpool Range, and to pass over crystalline rocks. Soon after crossing the Page River I found a fragment of granite that had been brought down by that stream; a little higher slate-rocks began to appear; and about four miles from the Page, in a deep cutting made for the road, trap is overlaid by slate at an angle of 15°.

For a distance of thirty miles from this place, in a north and westerly direction, I had been crossing a country of slate-rocks, but they were so broken and deranged that I could not determine satisfactorily any general angle of inclination; but here I found a trap-dyke between the slates inclined at an angle of 60°, and dipping to the westward. A portion of the dyke seemed disposed to part into polygonal blocks, similar to columnar basalt. Five miles further on, quartz began to appear, and the slate-rocks presented a decided strike and dip; the former N. by W. and S. by E. (magnetic); the dip 60° to west.

Having reached the Hanging Rock, at Hookanville, I went through the diggings there, and examined the rocks of the locality. I found a quartz-vein near the top of the rock, from which the drift-gold in the neighbouring creeks and gullies has, without doubt, been derived. The strike of the quartz-vein corresponds with that of the slate—north and south. Following down the Peel River to the Peel River Company's Works, a distance of six or seven miles, the hills and cliffs on each side of its course show very distinctly the position of the rocks. They all stand vertically, and the strike is the same as at the Hanging Rock. Dykes of porphyry and green-stone frequently occur rising between the strata; and serpentine occurs in considerable variety.

I was shown the works on the Peel River Company's property by the captain of the mines, who kindly endeavoured to give me all the information that I required. There has not been much done yet, nor are the indications very promising. Several small quartz-veins have been opened; they all run east and west; but range in a line north and south of each other, and may probably be connected. They are not perfect quartz-veins, but mere incrustations of crystals. They lean over a few degrees to the north, and the gold is found on that side; sometimes in the quartz, but more commonly in a coating of clay between the quartz and the imbedding rock. I learned also that the veins were richest near the surface; and were found to be poorer in sinking.

Mr. King, at Goonoogoonoo Creek, showed me some specimens of minerals of his own collecting, amongst which were sapphires, rubies, and gold in quartz*, also some fossil plants. Conducted by Mr. Moss (residing at Mr. King's), who volunteered to be my guide, I went to the rock from which the fossils were taken, and found it to be a shale belonging to the carboniferous series, and containing fine specimens of *Lepidodendron*; but the rock was too brittle to allow specimens of large size being taken from it.

According to Mr. Odernheimer†, "The dioritic and syenitic rocks with their breccias, are in the gold-fields of the Peel the exclusive bearers of the gold-quartz-veins, and are to be regarded as the main source of the gold. They occupy the greatest area of that district east and west of the Peel, from the Hanging Rock to the north."......"The dioritic rocks prove to be the constant source of gold, even at a distance north and west of the metamorphosed area of the gold-fields."

I would not here oppose my observations (made during one week) of the district to those of Mr. Odernheimer, extending through fifteen months, had not my former experience of the geology of gold districts led me to differ in opinion from the statements made in the report above quoted from. In the first place I would remark, that, as above stated, in this district there are imperfect quartz-veins only; and that the little gold that occurs (excepting the drift-gold) is all found in these imperfect veins.

If dioritic rocks be the source of gold, there is a much greater abundance of such rocks nearer the Dividing Range; but no gold has been found in them; and as to the extent of such rocks, I can only say, that I have travelled down the bed of the river on foot, and forded it twelve times between the Hanging Rock and the Peel River Company's Works, a distance of about seven miles, crossing the strata angularly, and I very much doubt that the igneous rocks passed over in that space would amount to a fourth part of a mile.

On our passage from Sydney to Moreton Bay we could see from the ship that the rocks of the carboniferous formation were continuous along the coast; and we several times saw what appeared to be lines of coal in the sea-cliffs.

The town of Brisbane is built on crystalline rocks. These extend uncovered a few miles to the eastward; and in the western direction include Sir H. Taylor's Range. On the central part of this range,

* See also Quarterly Journ. Geol. Soc. vol. x. p. 303; and vol. xi. p. 402.—Ed.

† Report on the Minerals and Geology of the Peel River District; Catalogue of the Natural and Industrial Products of New South Wales, &c. (Australian Museum and Paris Exhibition.) [See also Quart. Journ. Geol. Soc. vol. xi. p. 399.]

at a place called the Pass, I found a hill of felspar-granite, containing crystals of quartz and felspar. From the vast quantities of quartz in thin veins imbedded in the slate-rocks, I suspected that common granite with a quartz-base might be found somewhere in the range, and therefore went a second time to search for it, and found it at the southern extremity of the hills, where it had apparently been forced up in the solid state, and afforded a section of the rocks as they appeared in their order above it. This granite seemed to pass by imperceptible degrees into the felspathic granite, and then into gneiss. From where the granite appears upward to the top of the range, a height of about 1500 feet, the gneiss and other rocks of which the range is formed, have no appearance of having been disturbed. They dip at an angle of 15° to E.S.E., while outside the rent, from the range, the strata have an inclination of 45°, which increases, until at Brisbane they dip to the eastward at an angle of 60°, with a north and south strike.

I observed that the disturbed portion of the strata had innumerable small quartz-veins, while that portion of the range that had not been disturbed had apparently no quartz-veins, though quartz enters largely into the composition of some of the rocks.

The rocks in their ascending order are granite with a quartz-base, granite with a felspar-base, gneiss, massive felspar, mica-slate, chlorite-slate, and clay-slate.

Traversing the town of Brisbane, there is a large dyke of flesh-coloured porphyry, containing crystals of quartz and felspar and many fragments of the slate-rock through which it has been erupted. These fragments show no indication of having been fused or altered. The dyke is 200 feet thick; it rises up between the slates, and is parallel to them in direction and dip.

The country between Brisbane and Sir H. Taylor's Range is such as at first sight I should suppose to be auriferous, but on closer examination the quartz-veins are too small and too numerous. I found one quartz-vein at the eastern end of South Brisbane, in which I suspected that traces of gold might be found; and, seeing symptoms of its having been searched for, I made inquiries, and was credibly informed that a small quantity of gold had been found there.

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2. *On the* Lowest Strata *of the* Cliffs *at* Hastings. By S. H. Beckles, Esq., F.G.S.

The strata of which this communication is intended to be a very brief notice form the base of that range of cliff* which extends from Hastings to Cliff End.

* Accumulations of recent mud and drift always more or less obscure some details of this coast-section. The accumulations of mud are sometimes many feet thick, and are often the result of only two or three tides: but in some places they remain so permanently, that I have not yet at those spots had an opportunity of seeing the Wealden rocks. After a long calm the appearance of some of these deposits is so questionably recent, that casual visitors have mistaken them for ancient strata.

The group that I am about to describe consists of sandstone and clays, remarkable for their great diversity of hue, and are subordinate to those beds of conglomeratic shale and ironstone which Mr. Webster has described as the lowest strata visible in the series. They are supplemental, therefore, to the strata comprised, or intended to be comprised, in that author's notice*. At the date, however, of his Memoir they were partially disclosed, although perhaps not at those detached points where he traced his lowest strata.

Mr. Webster, in speaking of the strata to the east of Hastings, remarks, that "the lowest strata visible in this series consist of a dark-coloured shale (*m, m*), which is seen at the Govers and at Cliff End, and contain small roundish masses of sandstone, together with several layers (two of them from two to three inches thick) of rich argillaceous iron-ore." On the west of Eaglesbourne this last bed rises, in an arch, to the height of about twelve feet and then descends to the east. At Cliff End it reappears, and may be traced at low-water, forming a ledge.

In Mr. Webster's paper the "shale with its courses of argillaceous iron-ore," described as the lowest beds, are noticed to the west of the Govers and at Cliff End; and the occupation of the intermediate space (about four miles in extent) is ascribed to superior strata. In the stratigraphical section† annexed to that communication, the exposure of these, as well as of the substrata about midway between the Govers and Cliff End, is clearly indicated by an arched line from Lee Ness to Hook's Point; but in the Explanatory Memoir the succession here is mistaken, and the lower strata are identified by the author (who at this point did not recognize his lowest bed) with strata lettered by him *l, l*,—supposed to be much higher in the same series.

The shale, with its associated ironstone (*m, m*, in the annexed sketch-section), first emerges from the beach immediately on the east of Hastings, gradually rising into the cliff; it reaches the height of about 20 feet, and describes a curve, which, continuing on the eastern side of the picturesque valley of Eaglesbourne, descends to the beach at about 440 yards to the east of Eaglesbourne After passing under the present beach at the Govers, it reappears at the foot of that place, and so continues until it reaches Lee Ness Point, when it rises again into the cliff, forming another and more extended arch from Lee Ness to Hook's Point, when it returns a second time to the beach, and continues to Cliff End, where it forms the ledge described by Mr. Webster‡.

The most elevated points of all these beds have long been conspicuous in the vertical face of the cliff; while in the intervening depressions they have either sunk below the sea-level, or have been obscured by the ruins of the superior strata.

Although the stratum lettered *m, m*, is continuous through the section, yet it does not retain its mixed character of shale and iron-

* Trans. Geol. Soc. 2nd Series, vol. ii. p. 31 *et seq.* † *Loc. cit.* pl. 5.

‡ When Mr. Webster wrote, these beds were about 12 feet above the beach at this place; they are now nearer 20 feet.

Cliff-section from Hastings to Cliff End, Sussex. Length about 5 miles.

n n. Upper member of the lowest beds.

m m. Mr. Webster's "Shale and Ironstone."

stone throughout; in some places the ironstone dies out and leaves the shale as the sole representative of the stratum; in others the shale passes into iron, the band becoming ferruginous in its entire thickness.

The strata (*n*, *n*, of the sectional sketch) underlying the shale and ironstone are conformable to them, and occur in the same irregular undulating lines: they are also continuous, and at present more or less visible, through the entire section, with the exception of the neighbourhood of Lee Ness. They may be studied also with advantage on the beach under East Cliff, particularly on the east of Eaglesbourne, where they occur in the following descending order:—

1st. A band of sandstone; about 4 feet thick.
2nd. Slate-coloured compact clay; 7 feet thick.
3rd. Light-coloured clay; 4 feet thick.
4th. Dark clay; thickness unknown.

At Cliff End these beds have been so far removed from their original position (and, as it were, are so thrown over on their sides), that the present surface of the shore is formed of their edges, or by a section transverse to the plane of stratification.

At a distance of nearly 2000 yards to the east of the Lovers' Seat, several hundred square yards of the upper surface of the sandstone or superior member of this subgroup are exposed, and form the promontory or projection known as Lee Ness Point, the preservation of which may be attributed to the greater hardness and durability, as well as the peculiar position, of the upper members of this subgroup. On the east of Lee Ness these strata increase considerably in thickness; the clays below the sandstone (which is here about 9 feet thick) being intersected by arenaceous deposits, and the band of sandstone separated from the shale and ironstone above by layers of clay, which gradually diminish in thickness to the east and west, and thin away at the extremities of the arch, where the ironstone and sandstone may be seen in contact. At that point, between Lee Ness and Hook's Point, where the elevation of these strata is greatest, the height from the beach to the top of the sandstone is more than 30 feet, and to the top of the ironstone more than 50 feet. It may be further remarked, that these strata are the only members of the series that seem to extend uninterruptedly through the entire section from Hastings to Cliff End,

Organic Remains.—The organic contents of the strata above-described all indicate their deposition in fresh water; but many of them differ specifically from the Wealden fossils hitherto known. It may be well to observe, with reference to the distribution of *Unionidæ* in the Wealden strata, that, although interesting as affording additional evidence of the fluviatile or lacustrine origin of the formation, yet the species, and even the individuals hitherto discovered, were few in number and scarcely available as stratigraphical indices. I have now found these fossils, however, in considerable numbers in the Hastings rocks, where they afford good characteristics for certain strata. While those fossils of the Wealden which are of terrestrial origin are distributed promiscuously through the strata, the *Unionidæ*, like other *Testacea* which are indigenous to the element in which they were included (and which do not, like Fish, enjoy a great power of locomotion), occur for the most part in groups, each species being confined almost universally to one stratum or set of strata.

The superior members of the group, or the conglomeratic shale and ironstone (*m, m*, of the section, p. 290), contain *Cyrenæ, Unionidæ*, Insects*, and bones of Saurians. The ironstone abounds with vegetable remains†, for the most part in a fragmentary condition: from some parts of the deposit, however, I have taken very fine specimens, and others that are rare and valuable.

From the sandstone below (*n* of the Section, and No. 1 of the list at p. 290), I have taken small varieties of *Unio*; but, like the majority of fossils enclosed in the arenaceous deposits of the Wealden, they are badly preserved, and in only one or two instances have I secured instructive specimens. The most interesting traces of organic existence are the casts of Foot-prints, which occur in relief on its under surface, and which have formed the subject of my former communication in the tenth volume of the Society's Journal (p. 456).

The stratum, however, that I have found most interesting with reference to its organic remains is perhaps the next below (No. 2 of the list at p. 290). The *Zamia* occurs here in finer condition than I have seen it from any other part of the Wealden of England. In the same bed at least two other plants are deposited; together with a large *Anodon* (?) and a small *Paludina* (?); as well as small coprolitic bodies of only occasional occurrence. The Univalve occurs so

* See Notice of the Insectiferous Strata at Hastings by Messrs. Binfield, Quart. Journ. Geol. Soc. vol. x. p. 171.

† I have also detected fossil gum in a carbonaceous deposit much higher in the series.

sparingly, that I have not found more than one or two specimens; but of the *Anodon* (?) I have taken not fewer than fifty specimens, varying from less than three-quarters of an inch, to six inches in length; and, although some of the specimens exhibit a slight difference of form, yet a general uniformity of character and contour seems to refer them all to one species*.

The last and lowest deposit (No. 4, p. 290) does not appear to be rich in fossils; but this apparent destitution may result rather from an imperfect examination than from inherent barrenness. This bed consists principally of mottled clays, such as are usually supposed to be unfossiliferous. By the discovery of the dorsal rays of *Hybodus* in these clays†, however, I have satisfactorily proved that this opinion is erroneous; although the almost total exemption of these red-stained clays from organic remains which are distributed through the strata both above and below them, seems to support this general impression.

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3. *On the* Palæontological *and* Stratigraphical Relations *of the so-called* "Sands *of the* Inferior Oolite." By Thomas Wright, M.D., F.R.S.E.

[Communicated by Prof. Ramsay, F.G.S.]

Contents.

Introduction.—The calcareous sands which lie between the limestone-beds of the Inferior Oolite, above, and the clays of the Upper Lias, below, have from the time of Dr. William Smith until now been referred to the Oolitic group, and described in books as "the sands of the Inferior Oolite." These sands exhibit a very uniform lithological character throughout their entire range in England, although they differ much in thickness in different localities, thinning out or even altogether absent in some places, but attaining a considerable development in others; in this respect they do not differ from the great oolitic limestone-beds themselves, forming so important a feature in the geology of Gloucestershire; as those bold mural escarpments of freestone which impart such a picturesque effect to

* This *Anodon* (?) is one of at least twenty species of *Unionidæ* in my collection from the Hastings rocks, of which the majority are new.

† At Bulverhithe.

Leckhampton, Birdlip, and Painswick Hills thin out and almost disappear in a run of less than twenty miles from these typical sections. If we trace the so-called "Sands of the Inferior Oolite" from Cheltenham southwards, we find them gradually thickening as we proceed by Crickley, Cooper's, and Painswick Hills, to Beacon, Frocester, and Wotton-under-Edge, where fine sections are exposed. The oolitic limestones, including the pea-grit, upper and lower freestones, and the intervening oolite marl, which are about 190 feet thick at Leckhampton, gradually diminish in thickness near Stroud, and in the neighbourhood of Bath are represented by about 60 feet of freestone, the pea-grit and oolite-marl having entirely thinned out.

The upper ragstones, including the Gryphæa-bed and the Trigonia-bed, have a more constant and uniform development throughout the tract of the Inferior Oolite, and present a similar suite of fossils wherever they are exposed; being always well characterized by *Ammonites Parkinsoni*, Sow., *A. Martinsii*, d'Orb., *Trigonia costata*, Sow., *Perna rugosa*, Goldf., *Clypeus sinuatus*, Leske, *Collyrites ringens*, Desml., *Holectypus hemisphæricus*, Desor, *H. depressus*, Klein, *Terebratula globata*, Sow., *T. sphæroidalis*, Sow., *Rhynchonella plicatella*, Sow., and *R. spinosa*, Sow.

The Fuller's Earth is represented by a thin band of clay near Cheltenham; it is 70 feet thick near Stroud, 128 feet near Wotton-under-Edge, and forms a conspicuous bed, 150 feet thick, near Bath.

In Somersetshire and Dorsetshire the Sands attain a great thickness, and form an important feature in the physical geography of the oolitic districts of these counties. Wherever they are well exposed, as in the sections about to be described, they are overlaid by a bed of coarse, brown, marly limestone, full of small, dark, ferruginous grains of hydrate of iron, imparting an iron-shot aspect to this rock, which in general contains an immense quantity of individuals of several species of *Ammonites*, *Nautili*, and *Belemnites*, with a few shells of other *Mollusca*. Beneath this fossiliferous band, or "Cephalopoda-bed," are the so-called "Sands of the Inferior Oolite," consisting of very fine, brown and yellow, calcareous sands, often micaceous, and well adapted for foundry-purposes, as they receive sharp impressions of bodies pressed upon them. They contain in their upper part inconstant layers of siliceo-calcareous sandstone, and sometimes in their lower part large inconstant concretionary masses of coarse sandstone, the lowest beds becoming blue and marly, and passing insensibly into the clays of the Upper Lias. The line of junction is easily detected by the springs of water which burst out immediately above the clays. The sands themselves are not fossiliferous, but the nodules sometimes lying near their base often contain organic remains.

As it is the object of this memoir to show, that the Cephalopoda-bed contains a number of well-known Upper Liassic *Ammonites*, *Nautili*, and *Belemnites*, and that the weight of palæontological evidence is in favour of the supposition, that it belongs to the Lias, rather than to the Oolite-formation, I purpose to describe five sections in Gloucestershire and two in Dorsetshire to prove the stratigraphical relations of the Cephalopoda-bed and Sands to the limestones of the Inferior Oolite above and the clays of the Upper Lias below.

My friend the Rev. P. B. Brodie, in his valuable paper "On the Basement-beds of the Inferior Oolite *," has already shown how distinct the Cephalopoda-bed (called by him "the Ammonite and Belemnite bed") is in two of the sections hereafter to be described; but, in common with all local geologists, myself then among the number, he considered these beds as the lowest of the Oolitic series, and "the greater number of the *Belemnites* and *Ammonites* from this division of the Cotswolds as unnamed †." About two years ago I had the pleasure of submitting my collection of *Ammonites* from the Cephalopoda-bed, now placed before the Society, to the inspection of M. Sæmann, the well-known palæontologist of Paris, who pronounced them to be the species to which they are referred in this paper; and I afterwards made an excursion to Frocester Hill with M. Sæmann, who was anxious to see a section that had yielded so many Upper Lias Ammonites, which at that time were not known to have been found in England.

During last summer I accompanied Dr. Oppel, of Stuttgart, to Frocester Hill for the purpose of examining the Cephalopoda-bed *in situ*. This gentleman, who is well acquainted with the Oolitic formations of France and Germany, was clearly of opinion that it belonged to the Upper Lias, and that it was a good representative of a rock of the same age, "die harten Steinmergel voll *Ammonites Jurensis, insignis, radians, Germanii* (*hircinus*)," which he had described in his memoir ‡.

In September last I visited Scarborough and Whitby, and was fortunate to find in the museums of those towns, and in the collection of my friend Mr. Leckenby, several *Ammonites* from the Upper Lias of Whitby identical with those collected from the bed at Frocester, as *Ammonites opalinus*, Rein., *A. variabilis*, d'Orb., and *A. striatulus*, Sow. These facts removed all further doubts from my mind, and convinced me that the Cephalopoda-bed and its underlying sands belong to the uppermost part of the Superior Lias, and not to the Inferior Oolite as formerly supposed.

Section at Leckhampton Hill.—As the magnificent section of the Inferior Oolite at Leckhampton Hill, near Cheltenham, has been already described in detail in the pages of the Geological Society's Journal §, it will be unnecessary now to do more than to enumerate the upper beds of that section, and briefly to mention the lower strata which are in more immediate relation with the Upper Liassic sands. The following section has been kindly drawn by my friend Mr. E. Hull, F.G.S., and exhibits very accurately the different beds here so admirably exposed.

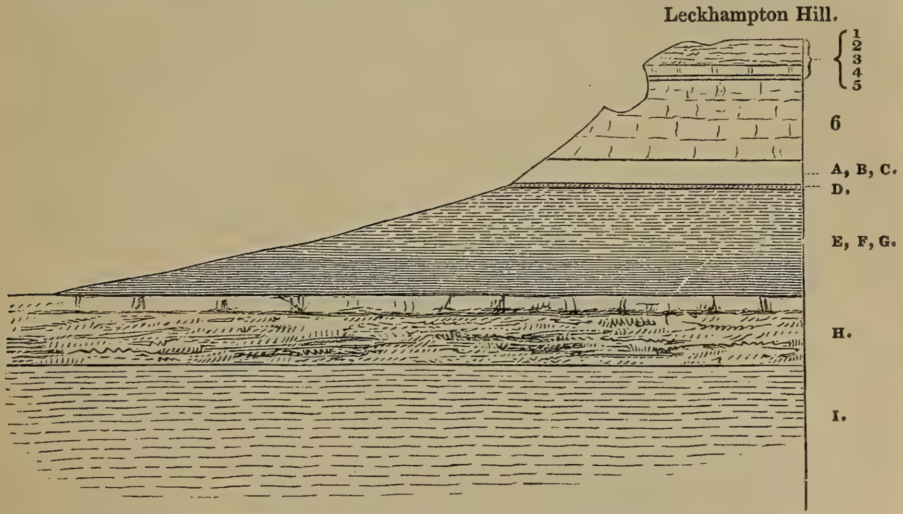
* Quart. Journ. Geol. Soc. vol. vi. p. 208.
† *Op. cit.* p. 210.
‡ Der mittlere Lias Schwabens, p. 3.
§ vol. vi. p. 239.

SECTION I.—*Leckhampton Hill, near Cheltenham.*

Nos. 1 and 2 form the upper ragstones, consisting of the "Trigonia-grit" (No. 1), and the "Gryphæa-grit" (No. 2).

No. 1. The *Trigonia-bed* is a coarse brown ragstone, containing many impressions of *Trigonia costata*, Sow., *T. decorata*, Lyc., *Lima cardiiformis*, Sow., *Rhynchonella concinna*, Sow., *Ammonites*

Fig. 1.—*Section through Leckhampton Hill, near Cheltenham.*



1. Trigonia-bed.
2. Gryphæa-bed.
3. Brown rubbly oolite.
4. Flaggy freestone.
5. Fimbria-bed or oolite-marl.
6. Freestone.

A, B, C. Pea-grit and ferruginous oolite.
D. Cephalopoda-bed.
E, F, G. Upper Lias sand and Upper Lias clay.
H. Marlstone.
I. Lower Lias clay.

Parkinsoni, Sow., *Echinobrissus clunicularis*, Lhywdd, *Holectypus depressus*, Leske, and *Clypeus sinuatus*, Leske; in thickness it is about 7 feet.

No. 2. The *Gryphæa-bed* is an ancient oyster-bank, and is composed in great part of *Gryphæa Buckmani*, Lyc., with many other shells, as *Myacites dilatata*, Buck., *Terebratula impressa*, v. Buch, *Tancredia donaciformis*, Lyc., *Gervillia tortuosa*, Phil., *Lutraria ovalis ?*, Phil., *Cypricardia cordiformis*, Desh., *Ammonites Murchisonæ*, Sow., and many other shells; but the dominant shell is the *Gryphæa*: this bed is about 8 feet in thickness.

No. 3. A coarse, brown, shelly, rubbly oolite, well exposed to the east of Leckhampton Hill, where it forms a mural cliff; and between the inclined planes at the Leckhampton quarries it contains many fossils; but, as the bed is not in general quarried, they cannot be extracted: it is about 24 feet thick.

No. 4. Upper flaggy bastard-freestone, well seen above the oolite-marl: 26 feet thick.

No. 5. The *Oolite-marl* or *Fimbria-bed*, is a cream-coloured mudstone, not unlike chalk-marl; the dominant shell is *Terebratula fimbria*, Sow.; but it contains likewise *Lucina lyrata*, Phil., *Lima* *cardiiformis*, Sow., *L. læviuscula?*, Sow., *Natica Leckhamptonensis*, Lyc., *Natica adducta*, Phil., *Mytilus pectinatus*, Sow., *Astarte elegans*, Sow., *Nerinæa*, sp., *Chemnitzia*, sp., and masses of Coral, chiefly *Thamnastræa Mettensis*, Edw. This bed was deposited under different conditions to that of the freestone on which it rests, as its lower portion is slightly brecciated; and the surface of the freestone on which that breccia was deposited had been for some time exposed to aqueous action and made smooth thereby. The marl measures about 7 feet in thickness, and passes upwards into a marly limestone, becoming oolitic in the uppermost layers. This division of the bed is about 10 feet thick. The Fimbria-bed is a constant feature in the Inferior Oolite of the Cheltenham district.

No. 6. The *Freestone* is a compact light-coloured oolitic limestone; the uppermost beds are the best for building-purposes; the middle beds are of an inferior quality, and are stained in part with the peroxide of iron; the lower beds contain large oolite-grains, and are called "roestone": the freestone in all is about 110 feet in thickness.

	Ft.	in.
The Pea-grit (Inferior Oolite).		
A. A brown, coarse, rubbly oolite, full of flattened concretions cemented together by a calcareous matrix. When the blocks weather, the concretions, which resemble flattened peas, form a very uneven surface. It contains many fossils in good preservation	12	0
B. A hard, cream-coloured, pisolitic rock, made up of flattened concretions, with a thickness about similar to those in A	10	0
C. A coarse, brown, ferruginous rock, composed of large oolitic grains; it is readily disintegrated by the frost, and is of little economical value. About	20	0
The Cephalopoda-bed (Upper Lias).		
D. A brown marly rock, full of small dark oolitic grains of the hydrate of iron, which are strewed in profusion in a calcareous paste. About	2	0
D′. A thin seam of yellowish sand	0	1½
E. A dark-grey crystalline limestone, extremely hard, and resembling some beds of the carboniferous limestone; it is bored in different places by *Fistulana?*, the shells of which remain in the excavations	0	9
F. A brown, argillaceous, sandy bed, full of micaceous particles; passing downwards into fine brown and yellow sands. Thickness unknown.		
G. Upper Lias Clay, of a dark blue colour. Thickness probably	160	0

Fossils of the Pea-grit (Inferior Oolite)—A, B, C.

As this bed is very much the same, lithologically and palæontologically, as the Pea-grit of Cleeve, Crickley, and Birdlip Hills, I shall give a list of its most abundant fossils in my next section of Crickley Hill.

Fossils of the Cephalopoda-bed—D, E, F.

The lower part of bed D contains many fossils, which are not well preserved; they are sufficiently characteristic, however, to prove the identity of this rock with "the Cephalopoda-bed" in other parts of the Cotteswold Range.

Cephalopoda.

Ammonites opalinus, *Reinecke* (primordialis, *Schlotheim*), *d'Orbigny, Terr. Jurass.* pl. 62.
A. hircinus, *Schlotheim, Zieten, Württemberg*, pl. 15. fig. 3.
Nautilus inornatus, *d'Orbigny, Terr. Jurass.* pl. 14. fig. 1.
Belemnites compressus, *Blainv., Voltz, Observations sur les Bélemnites*, pl. 5. figs. 1, 2.
B. breviformis, *Voltz, ibid.* pl. 2. figs. 2–4.

Gasteropoda.

Pleurotomaria }
Turbo } interior moulds only.

Conchifera.

Myacites abductus?, *Phil.*
Pholadomya fidicula, *Sow.*, small var., very distinct from the large type-form of this shell.
Gervillia Hartmanni, *Münst., Goldfuss, Petr. Germ.* tab. 115. fig. 7.
Fistulana?, sp.
Trigonia Ramsayii, *Wright*, nov. sp. (Palæontological notes appended to this memoir.)
Trichites; species indeterminable, as the specimens are all fragmentary.
Cucullæa, nov. sp.

Brachiopoda.

Rhynchonella cynocephala, *Richard, Davidson, Monogr. Oolitic Brach.* pl. 14. fig. 10.

Anthozoa.

Montlivaltia; species indeterminable.

SECTION II.—*Crickley Hill near Cheltenham.*

The Pea-grit (Inferior Oolite).

	Ft.	in.
A. A coarse oolitic limestone, with large grains and numerous concretionary bodies; exceedingly hard and crystalline in parts .... about	25	0
B. A coarse pisolitic limestone, composed of flattened concretionary bodies which are round, oval, or flattened like crushed peas .... about	19	8
C. A coarse brown rock, very ferruginous and full of large oolitic grains .... about	10	0

The Cephalopoda-bed (Upper Lias).

D. A brownish marly matrix very full of large oolitic grains of hydrate of iron, which impart a speckled appearance to this bed	2	6
E. A dark-greyish limestone, very hard and crystalline	1	6

F. Brownish sands, micaceous in parts, and passing downwards into brown marls and ferruginous clay. Thickness not ascertained.

G. Upper Lias Clay, darkish blue.

Fossils of the Pea-grit and other Limestone-beds of the Inferior Oolite—A, B, C.

The beds A and B contain many fossils, which in general are not well preserved. The *Echinodermata* are sometimes found tolerably perfect with the test in a good state of preservation. The *Mollusca* are usually denuded of the shell; but when they happen to be preserved in clayey or sandy seams of the Pea-grit, the sculpture of the shell is sharp and perfect. The following list contains only the most prevailing species :—

Cephalopoda.

Ammonites corrugatus, *Sow.* Juvenile state of *A. Murchisonæ,* Sow. Min. Conch. pl. 451. fig. 3.
Nautilus truncatus, *Sow.*
Belemnites giganteus, *Schloth.*

Gasteropoda.

Pleurotomaria ornata, *Defrance.*
Patella rugosa, *Sow.*
—— inornata, *Lycett.*
Nerita costata, *Sow.*
Natica adducta, *Phil.*
Cirrus nodosus, *Sow.*
Trochotoma carinata, *Lyc.*
Chemnitzia, nov. sp.
Rimula tricarinata, *Sow.*
Nerinæa, nov. sp.

Conchifera.

Lima duplicata, *Sow.*
—— notata, *Goldf.*
—— semicircularis, *Goldf.*
—— læviuscula, *Goldf.* (non *Sow.*).
—— sulcata, *Münster.*
—— lyrata, *Münster.*
—— ovalis, *Sow.*
Lima, nov. sp., allied to *L. punctata.*
Pecten, nov. sp. (non *vimineus*).
Pecten lens, *Sow.*
—— demissus ?, *Phil.*
—— clathratus, *Rœmer.*
Goniomya angulifera, *Sow.*
Hinnites abjectus, *Phil.*
—— tuberculosus, *Goldf.*
——, nov. sp.
Plicatula, sp.
Placuna Jurensis, *Rœmer.*
Mytilus bipartita, *Sow.*
—— pectinatus, *Sow.*
—— pulcher, *Sow.*
—— striatulus, *Münst.*
—— cuneatus, *Sow.*
Modiola plicata, *Sow.*
Pinna cuneata, *Sow.*
Pinna fissa ?, *Goldf.*
Myoconcha crassa, *Sow.*
Ostrea costata, *Sow.*
Avicula ? complicata, *Buck.*
Cypricardia cordiformis, *Desh.*
Lucina despecta, *Phil.*
Psammobia lævigata, *Phil.*
Ceromya plicata, *Agass.*
—— Bajociana, *d'Orbig.*
Macrodon Hirsonensis, *d'Archiac.*
Myacites punctata, *Buck.*
—— dilatata, *Buck.*
—— oblonga, *Buck.*
Trichites, sp.
Cardium striatulum, *Phil.*
—— lævigatum, *Lycett.*
Trigonia costatula, *Lycett.*
—— exigua, *Lycett.*
—— v-costata, *Lycett.*
—— decorata*, *Lycett.*
—— clavo-costata*, *Lycett.*
—— costata, *Sow.*
—— striata, *Sow.*
—— duplicata*, *Sow.*
Avicula echinata, *Sow.*

* Those marked with an asterisk occur in the upper ragstones only.

Brachiopoda.

Terebratula simplex, *Buck.* (trigonalis, *Lhwyd.*).
—— plicata, *Buck.*
—— submaxillata, *Davidson.*
Rhynchonella Wrightii, *Davidson.*
Rhynchonella decorata, *Davidson.*
—— tetrahedra, *Sow.*
—— angulata, *Sow.*
—— concinna ?, *Sow.*
—— oolitica, *Davidson.*

Annelida.

Serpula grandis, *Goldf.*
—— convoluta, *Goldf.*
—— plicatilis, *Münst.*
—— quadrilatera, *Goldf.*
Serpula socialis, *Goldf.*
—— sulcata, *Sow.*
—— filaria, *Goldf.*
—— flaccida, *Goldf.*

Echinodermata.

Cidaris Fowleri, *Wright, Monogr. Oolitic Echinoderms,* pl. 1. fig. 4.
—— Bouchardii, *Wright, ib.* pl. 1. fig. 2.
—— Wrightii, *Desor., ib.* pl. 1. fig. 3.
Rabdocidaris Wrightii, *Desor., ib.* pl. 1. fig. 5.
Acrosalenia Lycetti, *Wright, ib.* pl. 15. fig. 1.
—— spinosa, *Agassiz, ib.* pl. 17.
Diadema depressum, *Agass., Wright, ib.* pl. 6. fig. 2.
Echinus germinans, *Phil. ib.* pl. 12.
—— bigranularis, *Lamarck, ib.* pl. 12.
Polycyphus Deslongchampsii, *Wright, ib.* pl. 13.
Hemipedina Bakeri, *Wright, ib.* pl. 10. fig. 1.
—— tetragramma, *Wright, ib.* pl. 10. fig. 4.
—— perforata, *Wright, ib.* pl. 10. fig. 2.
—— Bonei, *Wright, ib.* pl. 10. fig. 5.
Pygaster semisulcatus, *Phil. M. G. S.* decade 5.
—— conoideus, *Wright, M. G. S.* decade 5.
Hyboclypus agariciformis, *Forbes, M. G. S.* decade 5.
—— caudatus, *Wright, Ann. Nat. Hist.* vol. ix. pl. 3.
Goniaster; a portion of a ray only.
Extracrinus, nov. spec.

Anthozoa.

Montlivaltia Delabechii, *Edw. & Haime.*
—— Waterhousei, *Edw. & Haime.*
—— cupuliformis, *Edw. & Haime.*
Axosmilia Wrightii, *Edw. & Haime.*
Latomeandra Flemingii, *Edw. & Haime.*
—— Davidsoni, *Edw. & Haime.*
Thecosmilia gregaria, *Edw. & Haime.*
Thamnastræa Defranciana, *Edw. & Haime.*
—— Terquemi, *Edw. & Haime.*
Isastræa tenuistriata, *Edw. & Haime.*
Thamnastræa Mettensis, *Edw. & Haime.*
—— fungiformis, *Edw. & Haime.*

Bryozoa.

Stromatopora dichotomoides, *d'Orbig.*

Fossils from the Cephalopoda-bed—D, E, F.

This bed is not so well exposed at Crickley Hill as in many other localities, no new surface having been laid bare for upwards of twenty years; the fossils are for the most part fragmentary and not well preserved.

The bed D contains—

Cephalopoda.

Ammonites opalinus, *Rein.*
—— insignis, *Schübler.*
Nautilus inornatus, *d'Orbig.*
Belemnites breviformis, *Voltz.*

Gasteropoda.

Turbo capitaneus, *Münst.*

Conchifera.

Myacites abductus, *Phil.?*
Gervillia Hartmanni, *Münst.*

Brachiopoda.

Rhynchonella cynocephala, *Rich.*

F contains many fossils in a fragmentary state, with a profusion of small teeth of fishes. The limestone is bored by *Fistulanæ* (?). *Belemnites* abound in the bed. *Belemnites breviformis,* Voltz, and *Belemnites compressus,* Voltz, are the prevailing forms.

E contains shells in a fragmentary state; but the specimens are indeterminable; many fragments of the spines of Echinoderms are likewise strewed throughout this bed.

G. The Upper Lias Clay is indicated by the outburst of springs along the line of its junction with the sands: although this bed was lately exposed in consequence of the falling away of a mass of debris, still very few fossils were found; I collected *Ammonites bifrons,* Brug. (*Walcotii,* Sow.), small specimens, *Ammonites serpentinus,* Schloth., *Ammonites communis,* Sow., *Ammonites annulatus,* Sow.

SECTION III.—*Beacon Hill near the Haresfield Station on the Bristol and Birmingham Railway.*

Inferior Oolite.

	Ft.	in.
A. A close-grained freestone; resembling the same bed at Leckhampton, but becoming rather flaggy in the upper part	15	0
A'. A close-grained yellow oolitic limestone, quarried for road-mending; much speckled with dendritical patches of the peroxide of iron, and containing few fossils; it measures about	12	0
B. A yellowish sandy rock, separating into large blocks which contain fossiliferous nodules; the fossils are in general well preserved in this bed; it is not used for any economic purpose, and heaps of blocks lie close to the brown micaceous sands*	1	8

* In consequence of the position of these blocks, many supposed that they came out of the so-called "Sands of the Inferior Oolite;" and, as they contain numerous fossils, it was said that such species had been collected from the sands. The true position of these sandy stumbling-blocks is that now given in the section.

	Ft.	in.
c. A brown sandy oolite, passing into a coarse ferruginous oolite; containing many fossils not well preserved; oolitic grains of the hydrate of iron are scattered through the brown calcareous matrix: it measures from 8 to	10	0

Cephalopoda-bed.—Upper Lias.

D. A coarse brown ferruginous bed, extremely hard where it is weathered, and containing an abundance of small oolitic grains of the hydrate of iron; many fossils are collected from this rock, but they are not in general well preserved; a thin seam of clay divides the bed into two portions; in the clay-seam nearly all the *Brachiopoda* are found: the entire bed measures from 2 feet to	2	6
E. Fine yellow micaceous sands, passing downwards into brownish sands mixed with marly bands; this bed is non-fossiliferous; its thickness is not accurately ascertained, it may be from 60 to 100 feet	80?	0
F. The blue clays of the Upper Lias are not exposed near the section; but their position is shown by the outburst of springs on the glacis of the hill.		

Fossils from the Inferior Oolite beds—A, B, C.

A. The freestone-beds are flaggy and not fossiliferous.
B. The fossiliferous nodules contain—

Cephalopoda.

Ammonites, nov. sp., resembling *A. Garantianus*, d'Orbig., Terr. Jurass. pl. 123.

Conchifera.

Pholadomya fidicula, *Sow.*
Modiola plicata, *Sow.*
Pinna fissa, *Goldf.*
Myacites dilatatus, *Buck.*
Ceromya Bajociana, *d'Orbig.*
Lima bellula, *Lyc.*
Pecten, nov. sp., allied to *P. demissus*, Phil.

Fossils from the Cephalopoda-bed—D, E, F.

Cephalopoda.

Ammonites opalinus, *Rein.*; very fine specimens.
—— insignis, *Schübl.*
—— variabilis, *d'Orbig.*
Nautilus inornatus, *d'Orbig.*
Belemnites breviformis, *Voltz.*
—— compressus, *Voltz.*
—— irregularis, *Schloth.*

Gasteropoda.

Turbo capitaneus, *Münst.*
Pleurotomaria, sp.

Conchifera.

Cucullæa, nov. sp.
Myacites abductus?, *Phil.*
Modiola plicata, *Sow.*
Astarte lurida, *Sow.*

Brachiopoda.

Rhynchonella cynocephala, *Richard.*
—— furcillata, *Theod.*
Terebratula subpunctata, *Davidson.*

M. Richard * thus describes the locality and bed of his *Rhynchonella cynocephala*:—" Un calcaire marno-ferrugineux, placé au-dessus des marnes supérieures du Lias, et au-dessous d'un calcaire appartenant à l'oolite inférieure, qui lui-même est recouvert non loin de là (Bourmont, Haute-Marne) par le calcaire à entroques. Les couches qui la contiennent doivent sans doute être rapportées à l'oolite ferrugineuse inférieure, car on a tenté à plusieurs reprises d'en extraire du minerai de fer pour le haut-fourneau de Vrécourt; mais ce minerai ne s'est point trouvé assez riche, ni peut-être assez abondant."

Mr. Davidson, after having examined a series of *Terebratula subpunctata*, David., from the Cephalopoda-bed at Beacon Hill and Frocester Hill, informs me that it is "a well-known form and occurs abundantly in the Liassic beds, and in the beds just above the Upper Lias (the equivalent of the Cephalopoda-bed) in France," where he collected it with *Rhynchonella cynocephala*; and that it may probably be a variety of *Terebratula punctata*, Sow., which is a well-marked species belonging to the Marlstone; many shells from the Marlstone near Ilminster closely resembling those from the Frocester Cephalopoda-bed.

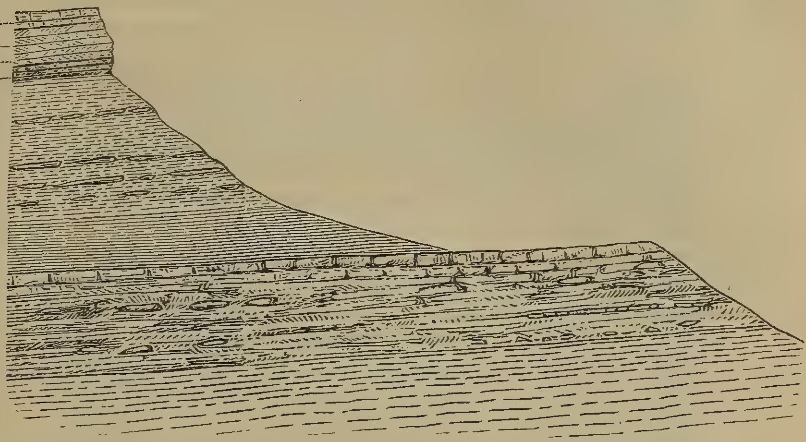
At the Horspools near Painswick the Cephalopoda-bed and Brown Sands are finely exposed in a lane near the hotel, where their relation to the other Lias beds may be satisfactorily made out; I collected here *Ammonites variabilis*, d'Orb., fragments of *Ammonites opalinus*, Rein., *Rhynchonella cynocephala*, Rich., *Terebratula subpunctata*, Davidson, and many other Lias shells in a fragmentary state.

Section IV.—*At Frocester Hill, near Stonehouse, Gloucestershire.* Fig. 2.

This fine section and the one near Wotton-under-Edge are the most typical of the beds now under consideration. The palæontological and stratigraphical relations of "the Cephalopoda-bed," in particular, to the Oolitic limestones above, and to the Upper Liassic sands below, are admirably shown in both. I had lately the pleasure of making an excursion to Frocester Hill with my friends Professor Ramsay, Local Director of the Geological Survey, and Mr. Edward Hull, F.G.S., who has surveyed a considerable part of the oolitic district of Gloucestershire. At my request Mr. Hull has prepared the accompanying diagram from a sketch made on that occasion, which exhibits very clearly and faithfully the relation of the beds so well exposed in this locality. The thickness of the strata indicated in the section is only approximatively true, as it would be a tedious process to level them all accurately.

* Bulletin Soc. Géol. de France, vol. xi. p. 263, 1840.

Fig. 2.—*Section of Frocester Hill, near Stonehouse.*



a, b, c. Inferior Oolite; 70 feet.
D, E. Calcareo-ferruginous sandstone (Cephalopoda-bed); 6 feet } "Upper Lias Sands."
F. Yellow and brown sands, with inconstant and concretionary bands of calcareous sandstone; 150 feet? } "Upper Lias Sands."
G. Upper Lias shale; 80 feet.
H. Marlstone; hard calcareous sandstone, resting on brown and grey sands, with bands and nodules of ferruginous sandstone; 150 feet.
I. Lower Lias shale.

Inferior Oolite.

	Ft.	in.
a. A fine-grained oolitic limestone, similar to the freestone of Birdlip, Painswick, and Leckhampton Hills; the upper beds exhibit a most remarkable example of oblique bedding, the flaggy layers of which rest horizontally on inclined beds of freestone: thickness about............	50	0
b. A coarse, light-cream-coloured, gritty, crystalline oolite, traversed at intervals by shelly layers extremely crystalline; a great part of the rock appears to be composed of the fragments and plates of *Crinoidea*, the plates and spines of *Echinidæ*, and comminuted fragments of the shells of *Mollusca*. This white rock has a most remarkable lithological character, and glistens brilliantly when lit up by the sun's rays. The shelly and pisolitic seams which traverse this bed resemble those in the Pea-grit. The surface of weathered slabs discloses numerous microscopic objects; the rock is in fact almost entirely composed of organic debris. It measures about......	10	0
c. A hard, fine-grained, oolitic, sandy limestone, of a light-brown colour, lithologically different from *b*. It contains many fossil shells, which are extracted with difficulty; and passes into a hard yellow oolite with few fossils: thickness from 8 to	10	0

[The lithological character of this rock is very different to that of *d*, on which it rests.]

The Cephalopoda-bed—Upper Lias.

d. A coarse, dark-brown, calcareo-siliceous rock, full of small, dark, flattened grains of hydrate of iron. It contains an immense quantity of fossils, but *Ammonites* and *Be-*

	Ft.	in.
lemnites are the dominant forms; some of the bivalve shells are well preserved, but the matrix adheres to the surface with such tenacity that they can seldom be cleaned without injury. The *Ammonites* and *Nautili*, for the most part, want the shell. *Rhynchonella cynocephala* lies in the upper part of the bed, and the *Ammonites, Belemnites, Nautili*, and other *Mollusca* in the middle part; the lower part is not so fossiliferous: this bed measures	4	6
e. A hard, coarse, brown mudstone, with hard irregular nodules of a calcareo-siliceous sandstone, highly micaceous and ferruginous, and passing downwards into the sands	0	9
f. Fine, brown and yellowish, micaceous sands, passing into dust-coloured, grey and slate-coloured, micaceous sands, with inconstant and concretionary bands of highly calcareous sandstone; nodules of various size occur in these bands, which are sometimes fossiliferous, containing chiefly *Ammonites* and *Belemnites*	150?	
g. Blue clay and shale, marked by the outburst of springs and by pools of water on the terrace formed by the Upper Lias Clay, which is about	80	0
h. Marlstone; a hard calcareous sandstone, resting on brown and grey sands, with bands and nodules of ferruginous sandstone: about	150	0
i. The shales of the Middle and Lower Lias, sloping down into the valley.		

Fossils of the Inferior Oolite.

A. Very few fossils in the Freestone; those which are observed are mostly fragmentary.

B. The fossils are so fragmentary in this bed that I have not been able to determine them. Stems and column-plates of *Extracrinus*, portions of the tests of *Pygaster* and *Acrosalenia*, plates of *Cidaris*, and quantities of spines in fragments are seen on the slabs.

C. The following shells were observed, but could not be extracted from the upper part of the bed:—

Pholadomya fidicula, *Sow.*	Trichites, sp.; large fragments only.
Modiola plicata, *Sow.*	Serpula socialis, *Goldf.*

The frond of a Fern was found in this bed by the Rev. P. B. Brodie. The lower part of the rock resting on the Cephalopoda-bed is sparingly fossiliferous.

In very few localities, where the sands are exposed along the escarpments of the Cotteswolds or in the beautiful valleys intersecting these hills, are they found to contain fossils; at present I only know two localities, Frocester Hill and Nailsworth: the former I have already noticed; the latter I must now briefly describe, as I shall include the Palæontology of both localities in my list of species from the Frocester district.

The fossiliferous vein at Nailsworth is found at the base of the sands 4 or 5 feet above the Upper Lias clay. The bed consists of a fine soft ferruginous marly sandstone, of a deep brown colour, containing much peroxide of iron, and many shells, mostly of the same species as those found in the Cephalopoda-bed at Frocester. The difference between these two beds is important, and deserves to be noticed, as the Cephalopoda-bed at Frocester overlies the sands, whilst the fossiliferous vein at Nailsworth is found at their base, clearly proving that the sands and Cephalopoda-bed form only one stage.

Fossils of the Sands and Cephalopoda-bed (D, E, F) *of the Frocester district* *.

Reptilia.

Vertebræ of *Ichthyosaurus.* F.

Pisces.

Teeth of *Hybodus.* F.

Cephalopoda.

Ammonites opalinus, *Reinecke* (primordialis, *Schloth.*). F.
—— bifrons, *Brug.* (Walcotii, *Sow.*). F.
—— insignis, *Schübler.* F. and Newmarket and Ozleworth.
—— hircinus, *Schloth.* F.
—— Jurensis, *Zieten.* F. N.
—— striatulus, *Sow.* (radians, *Schloth.*). F.
—— Thouarsensis, *d'Orb.* F.
—— radians, *d'Orb.* F.
—— —— Dewalquianus. F.
Ammonites Mooreii, *Lycett, MS.* nov. sp. F.
—— discoides, *Zieten.* F.
—— Raquinianus, *d'Orb.* F. N.
—— Levesquei, *d'Orb.* F.
—— concavus, *Sow.* F.
—— Leckenbyi, *Lyc. MS.*, n. sp. F.
—— variabilis, *d'Orb.* F. N.
Nautilus inornatus, *d'Orb.* F.
Belemnites compressus, *Voltz.* F. N.
—— tripartitus, *Schloth.* F. N.
—— irregularis, *Schloth.* F. N.
—— Nodotianus, *d'Orb.* F.

Gasteropoda.

Pleurotomaria.
Chemnitzia lineata?, *Sow.* N.
*Turbo capitaneus, *Münst.* F. N.
Trochus; allied to T. duplicatus, *Sow.* N.

Conchifera.

*Lima bellula, *Lycett.* F. N.
*Pholadomya fidicula, *Sow.* F. N.
*Gervillia Hartmanni, *Münst.* F. N.
*Modiola plicata, *Sow.* F. N.
*Trigonia striata, *Sow.* F. N.
*Perna rugosa, *Goldf.* N.
*Hinnites abjectus, *Phil.* F. N.
*Pecten articulatus, *Goldf.* F.
*Gresslya adducta, *Phil.* F. N.
*—— conformis, *Agass.* F. N.
*Myacites tenuistriatus, *Agass.* F.N.
*Goniomya angulifera, *Sow.* F.
*Astarte excavata, *Sow.* F. N.
*Myoconcha crassa, *Sow.* N.
*Astarte modiolaris. N.
*Cypricardia cordiformis. F.

* This list has been prepared from specimens collected by Mr. Lycett and myself during many years, and I beg to thank my friend for the valuable aid he has given me in making my list of *Conchifera* as complete as it now is; the specimens have all been determined with much care, and I believe every confidence may be placed in the accuracy of our conclusions. The letters F. N. indicate that the species has been found at Frocester or Nailsworth.

*Pecten comatus, *Goldf.* N.
Opis carinata, *Wright*, nov. sp. (see Appendix). F.
Cypricardia brevis, *Wright*, nov. sp. (see Appendix). F. N.
Cardium Hullii, *Wright* (Buckmani, *Lycett*). F. N.
—— Oppelii, *Wright*. N.
Cucullæa; allied to C. inæquivalvis, *Goldf.* N.
Lima electra, *d'Orb.* F. N.
Unicardium, nov. sp. N.
Tancredia, nov. sp. N.
Trigonia Ramsayii, *Wright*, nov. sp. (see Appendix). F.
Pecten textorius?, *Goldf.* F.
Pholadomya; allied to P. media, *Ag.* F.
——, nov. sp. F. N.
Astarte complanata, *Rœmer.* N.
Lima ornata, *Lyc. MS.*, nov. sp. N.
Astarte lurida, *Sow.* N.
Gervillia fornicata, *Lyc. MS.*, nov. sp. N.
Astarte rugulosa, *Lyc. MS.*, nov. sp. N.
Arca; allied to A. olivæformis, *Lyc.* N.
Nucula ovalis?, *Ziet.* N.
Pholadomya ovulum?, *Agass.* N.

Brachiopoda.

Terebratula subpunctata, *David.* F. N.
Rhynchonella cynocephala, *Richard.* F.
——, nov. sp. N.

The species marked with an asterisk in the above list are found likewise in the Inferior Oolite; but the specimens from the Sands are nearly all dwarfed forms of the species, and lead one to the conclusion that they lived under conditions unfavourable to their development. The stinted growth of the stationary *Conchifera* forms a striking contrast with the size and number of the *Cephalopoda* interred with them in the same bed; in fact the dawning existence of these *Conchifera* appears to have been a struggle for life, whilst the conditions of the closing scene of the *Belemnites, Nautili,* and falciferous *Ammonites*, were favourable to their continuance in time, but abruptly brought to a termination by some great physical change which took place about the commencement of the deposition of the oolitic formations.

Section V.—*At Wotton-under-Edge, near Bradley Turnpike, Gloucestershire**. Fig. 3.

The lower beds in this section are almost a repetition of those at Frocester Hill; but the relations of the Cephalopoda-bed to the Inferior Oolite, Fuller's Earth, and Great Oolite are so admirably exhibited in this locality, that I cannot omit a brief description of them. I am indebted to my friend Professor Ramsay for the accompanying diagram, which shows the succession of the strata between Symonds-Hall Hill and Wotton-under-Edge. The hill is capped by the Great Oolite; beneath this is the Fuller's Earth, here attaining a considerable thickness, and overlying the

* For this and the Frocester Hill district, see Map of the Geological Survey of Great Britain, Sheet No. 35.

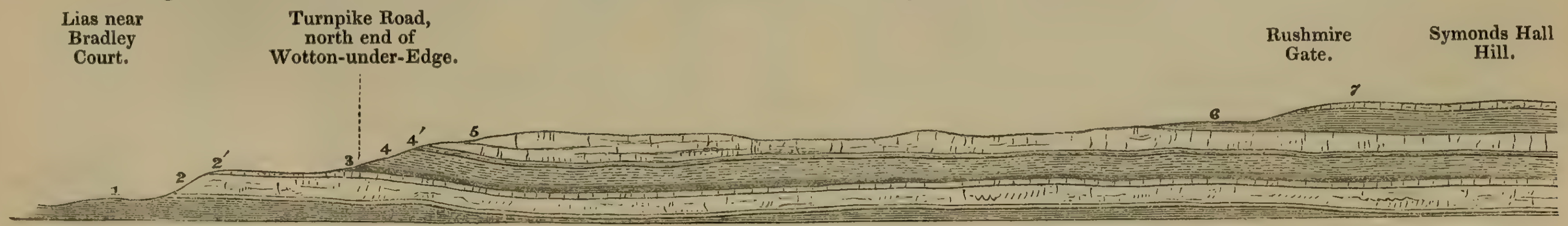
Inferior Oolite.

	Ft.	in.
A. The limestones of the Inferior Oolite, which form an excellent freestone very similar to the same rock at Birdlip, Frocester, Painswick, and Leckhampton, have a thickness of	80	0
B. Is not well exposed in this section; the Inferior Oolite limestone quarry is about half a mile from the section of the lower beds, and the intervening escarpment is covered over by vegetation	?	
C. Is represented by a yellow, loose, rubbly oolite, resting on the Cephalopoda-bed; it contains *Ammonites*, shells, and *Serpulæ*.		

The Cephalopoda-bed—Upper Lias.

	Ft.	in.
D. A hard, brown, coarse ferruginous, oolitic, sandy limestone, speckled with large flattened grains of hydrate of iron; the hard sandy bands are interstratified with softer sand, which contains many fossils, and passes into		
D′. A coarse oolitic rock, not so ferruginous as the upper division, but with fossils of the same species, and passing into thin bands of a ferruginous oolite like D.		
E. A coarse oolitic rock, similar to D′; the same bed occurs at Ozleworth and Sudbury. These three beds measure about	16	6
F. The Upper Lias Sands are yellow and micaceous, and contain inconstant and irregular layers of hard, sandy, lenticular concretions, some of which are fossiliferous: these sands measure	123	0
G. The Upper Lias Clay is very thin, and contains nodules of limestone at the top; it nearly thins out here, and its thickness is only	10	0

Fig. 3.—*Diagram showing the succession of strata between Symonds Hall Hill and Wotton-under-Edge.*



7. Great Oolite.
6. Fuller's Earth; 128 feet.
5. Inferior Oolite limestone; 80 feet.
4′. Calcareous hard sandy bands (with specks of silicate of iron), interstratified with softer sand; *Ammonites* and *Belemnites*; 16 feet.
4. Sand of the Upper Lias, with hard sandy lenticular concretions; 123 feet.
3. Upper Lias shale, very thin, with nodules of limestone at the top; about 10 feet.
2′. Hard brown rock capping the terrace; 12 feet } Marlstone.
2. Marlstone; 186 feet.......................... } Marlstone.
1. Lower Lias shale and limestone.

The Marlstone—The Middle Lias.

	Ft.	in.
H. The upper bed of the Marlstone is a hard, brown, calcareous sandstone, which forms the capping of the Marlstone terrace *	12	0
H'. The Marlstone is well developed, and consists of fox-coloured sandstone, more or less ferruginous, with grey impure sandy limestone containing oolitic grains : thickness	186	0

I. The Lower Lias Shales and Limestone : thickness unknown.

Fossils of the Inferior Oolite—A, B, C.

A. The Freestone-beds are not fossiliferous: the upper ragstones contain the common species found therein; but they are not abundant.

B. Is not sufficiently exposed to be worked for fossils.

C. Contains—

Ammonites corrugatus, *Sow.* (=*Ammonites Murchisonæ*, Sow.).
Ostræa costata, *Sow.*
Serpula socialis, *Goldf.*

Fossils of the Cephalopoda-bed—D, E.

D contains—

Ammonites insignis, *Schübler.*
—— variabilis, *d'Orb.*
—— opalinus, *Rein.*
—— Jurensis, *Zieten*; only fragments with the rounded back were obtained.
Belemnites breviformis, *Voltz.*
—— compressus, *Voltz.*
—— irregularis, *Schl.*
Nautilus inornatus, *d'Orb.*; fragments of this species.

E. The upper beds contain nearly all the fossils: I saw few in this layer of rock.

F. The nodules are not so well exposed as in Frocester Hill: some fragments of *Ammonites* and *Belemnites* only were observed.

G. The characteristic Upper Lias *Ammonites* are here found:—

Ammonites communis, *Sow.*
—— serpentinus, *Schloth.*
Ammonites bifrons, *Brug.* (*Walcotii*, Sow.).

H contains many well-known Marlstone forms, such as—

Ammonites margaritatus, *Montfort.*
—— spinatus, *Brug.*
Pecten æquivalvis, *Sow.*
Gryphæa gigantea, *Sow.*

I. The Lower Lias beds were not examined with reference to their palæontological characters.

It has been stated by my late lamented friend Mr. H. E. Strickland† that the bed herein described as the *Cephalopoda-bed* "is the precise equivalent of the well-known Oolite of Dundry, near Bristol, which may be recognized as far off as Bridport on the Dorset coast,"

* See Hull on the Marlstone Platforms of the Cotteswolds, Quart. Journ. Geol. Soc. vol. xi. p. 485.

† Quart. Journ. Geol. Soc. vol. vi. p. 250.

—an opinion in which I cannot concur. It is true that lithologically the beds resemble each other, but palæontologically they are entirely distinct; "the Dundry Ammonite-bed" appertains to the Inferior Oolite, and represents a higher zone than the Cephalopoda-bed of Frocester, Beacon, and Wotton. The prevailing *Ammonites* at Dundry are

Ammonites Humphriesianus, *Sow.*	Ammonites Sowerbyii, *Miller.*
—— Brongniartii, *Sow.*	—— Blagdeni, *Sow.*
—— Gervillii, *Sow.*	—— dimorphus, *d'Orb.*
—— Brocchii, *Sow.*	—— Browni, Sow.

I have already shown that not one of this list is found in "the Cephalopoda-bed," and I am assured by my friend Mr. Etheridge, of the Bristol Institution, who is well acquainted with all the fossils that have been and are collected at Dundry, that (with the exception of *A. variabilis* and *A. concavus*, which lie at the base of the bed, and a small *A. bifrons* from the Upper Lias Marl) not one of the species of *Ammonites* found in the Cephalopoda-beds of Frocester and Wotton have ever been collected at Dundry.

The Dundry Ammonite-bed, however, does occur in Somersetshire and Dorsetshire with the same species of *Ammonites, Pleurotomaria,* and other characteristic Dundry shells; but in these places it occupies a higher stratigraphical position than the Frocester Cephalopoda-bed.

Between Yeovil and Sherborne the Cephalopoda-bed is well developed, and extensively exposed; and at the Halfway House its relations to the Sands below, and the Limestone of the Inferior Oolite above, may be satisfactorily made out. Here it contains a great many large *Ammonites, Nautili,* and *Belemnites,*—as

Ammonites Dorsetensis, *Wright,* n. sp.	Nautilus inornatus, *d'Orb.*
—— Jurensis, *Zieten.*	Belemnites breviformis, *Voltz.*
	—— compressus, *Voltz.*

Section VI.—*At Bradford Abbas, near Yeovil, Dorsetshire.*

Inferior Oolite.

	Ft.	in.
A. Coarse, hard, brown ragstone, slightly oolitic, very irregularly bedded, and containing few fossils: about	2	0
B and C. Absent.		

Cephalopoda-bed.

	Ft.	in.
D. A coarse, brown, oolitic ragstone, composed in part of hard, calcareous, sandy layers, grey and brown, and having softer marly sandy seams running through the rock; it breaks with an uncertain fracture, and sometimes has a flinty hardness: the ragstones are speckled with dark brown flattened oolitic grains of hydrate of iron, and contain many fossils: about	2	6

	Ft.	in.
E. A hard, greyish, crystalline limestone, raised and broken up for road-mending; it resembles carboniferous limestone, and contains shells in a fragmentary state: it is about	0	9
F. Fine brown and yellowish sands, very micaceous in parts, and containing hard, sandy, lenticular concretions: thickness considerable.		

Fossils of the Inferior Oolite—A.

A. Contains *Pholadomya fidicula, Modiola plicata,* and other Inferior Oolite shells (undetermined); the same bed near the Half-way House is overlaid by ragstones containing *Ammonites Parkinsoni,* Sow.; so that the upper and lower ragstones are here in conjunction, the intermediate freestone being exceedingly thin, or perhaps wanting. Fine large specimens of *Ammonites Truelli,* d'Orbigny, were likewise collected here.

Fossils of the Cephalopoda-bed—D, E, F.

Cephalopoda.

Ammonites Jurensis, *Zieten.*
—— concavus, *Sow.*
—— Dorsetensis, *Wright,* n. sp.
—— variabilis, *d'Orb.*
Ammonites striatulus, *Sow.*
—— insignis, *Schübl.*
Nautilus inornatus, *d'Orb.*
Belemnites compressus, *Voltz.*

Gasteropoda.

Turbo capitaneus, *Münst.*
Turbo spinulosus, *Münst.*

Sections in Dorsetshire.—The Cephalopoda-bed, with its underlying sands, is admirably developed in Dorsetshire. In several places near Bridport these beds are well exposed. Watton Hill, on the west side of Bridport Harbour, is capped with fossiliferous beds of Forest Marble, which form the extreme south-western extension of this formation on the English Coast. This rock consists here and at Bothenhampton of thick limestone-beds, composed of shelly fragments and interstratified with layers of a coarse oolitic sandy slate. It contains

Lima cardiiformis, *Sow.*
Pecten lens, *Sow.*
Avicula echinata, *Sow.*
Ostræa.
Terebratula obovata, *Sow.*
—— intermedia, *Sow.*
Apiocrinus rotundus, *Miller.*
Echinobrissus clunicularis, *Lhwydd.*
Holectypus depressus, *Leske.*
Acrosalenia hemicidaroides, *Wright.*
—— spinosa, *Agass.*

Economically it is used as a building-stone and is burnt for lime. The Forest Marble is underlaid by a thick bed of grey marl, the Fuller's Earth, which attains a thickness here of about 150 feet, and contains

Pholadomya carinata, *Münst.*
Terebratula ornithocephala, *Sow.*
Myacites.
Ceromya concentrica, *Sow.*
Ostrea acuminata, *Sow.*

The Fuller's Earth rests upon the sands. I found no *Ammonites* belonging to the Cephalopoda-bed at Watton Hill; but its western escarpment exhibits an interesting coast-section of the three beds *in situ*; the united thickness of the Sands, Fuller's Earth, and Forest Marble is here about 400 feet.

To the east of Bridport Harbour, there is a magnificent coast-section of the Liassic Sands, which there attain a thickness of probably 200 feet: and between Bridport Harbour and Burton Bradstock there are several good quarry-sections which exhibit the upper ragstones of the Inferior Oolite resting on the Cephalopoda-bed. These two rocks lithologically resemble each other very much; and, but for their palæontological characters, it would be almost impossible to separate them; fortunately the Inferior Oolite ragstones contain many *Ammonites* and other well-known Inferior Oolite Shells, Echinoderms, and Corals, and by them the line of separation can alone be traced.

The Inferior Oolite beds contain—

Cephalopoda.

Ammonites Parkinsoni, *Sow.*	Ammonites Gervillii, *Sow.*
—— dimorphus, *d'Orb.*	—— Humphriesianus, *Sow.*
—— Martinsii?, *d'Orb.*	—— Brongniarti, *Sow.*
—— subradiatus, *Sow.*	—— Brocchii, *Sow.*

Gasteropoda.

Pleurotomaria Proteus, *Deslong.*	Pleurotomaria punctata, *Sow.*
—— elongata, *Sow.*	—— ornata, *Defrance.*

Conchifera.

Lima notata, *Münst.*	Trigonia costata, *Sow.*
—— semicircularis, *Goldf.*	—— striata, *Sow.*
Astarte modiolaris, *Lamk.*	Opis trigonalis, *Sow.*

Brachiopoda.

Terebratula sphæroidalis, *Sow.*	Rhynchonella plicatella, *Sow.*
—— Phillipsii, *Morris.*	—— senticosa, *Von Buch.*

Echinodermata.

Collyrites ringens, *Agass.*	Holectypus hemisphæricus, *Desor.*
—— bicordatus, *Desor.*	Echinus bigranularis, *Lamk.*
Clypeus altus, *M'Coy.*	Cidaris Bouchardii, *Wright.*

Anthozoa.

Montlivaltia trochoides, *Edw. & Haime.*

The Cephalopoda-bed contains

Ammonites Dorsetensis, *Wright.*	Belemnites breviformis, *Voltz.*
—— variabilis, *d'Orb.*	Nautilus inornatus, *d'Orb.*

Echinodermata.

Ophioderma Egertoni, *Broderip.*

At Chideock Hill, three miles west of Bridport, the Inferior Oolite, which caps the hill, consists of a light-brown oolitic limestone, speckled with an abundance of dark, flattened, glistening grains of hydrate of iron; in some beds the oolitic grains are very large, and almost pass into a pisolite. A few years ago, when this rock was worked, a great many fossils were obtained from it. My kind friend Dr. Symes, of Bridport, who at that time collected the fossils obtained from Chideock, gave me fine specimens of the following species:—

Cephalopoda.

Ammonites Martinsii, *d'Orb.*	Ammonites subradiatus, *Sow.*

Gasteropoda.

Pleurotomaria Proteus, *Deslong.*	Pleurotomaria punctata, *Sow.*
—— elongata, *Sow.*	—— ornata, *Sow.*

Conchifera.

Trigonia costata, *Sow.*	Astarte trigonalis, *Sow.*, sp.
Astarte modiolaris, *Desh.*	Myoconcha crassa, *Sow.*

Brachiopoda.

Terebratula sphæroidalis, *Sow.*	Rhynchonella plicatella, *Sow.*
—— perovalis, *Sow.*	—— senticosa, *Von Buch.*

Echinodermata.

Clypeus Agassizii, *Wright.*	Collyrites bicordatus, *Desor.*
—— altus, *M'Coy.*	Hemicidaris Bouchardii, *Wright.*
Collyrites ringens, *Agass.*	Echinus bigranularis, *Lamk.*

Anthozoa.

Montlivaltia trochoides, *Edw. & Haime.*

Beneath the Inferior Oolite, there is a bed composed almost entirely of the fragments of *Pentacrinites*, and underlying this is the Cephalopoda-bed, with *Ammonites Dorsetensis*, Wright, *Ammonites hircinus*, Schloth., *Gervillia Hartmanni*, Münst., *Cucullæa*, *Modiola*, and large *Limæ*. As the Inferior Oolite beds were those chiefly worked, it was from that rock the fossils for the most part were obtained. The Cephalopoda-bed consists of a fine yellow micaceous sand, indurated in parts, and passing downwards into the loose sands of the Upper Lias. The same bed is exposed in two or three road-side quarries between Bridport and Chilcombe Hill, from which I collected many good specimens of *Ammonites Dorsetensis*, Wright, and where I saw many large *Nautili* and *Belemnites in situ*. The rock consisted of a coarse, brown, rubbly oolite, traversed by sandy seams, and was worked for road-mending.

Oolitic character of the Cephalopoda-bed.—From the facts above recorded, it is clear that the Cephalopoda-bed forms an important and well-marked feature in the lower division of the Oolitic group: although it contains sparingly a few species of Conchifera, such as—

Pholadomya fidicula, *Sow.*	Modiola plicata, *Sow.*
Gervillia Hartmanni, *Münst.*	Astarte excavata, *Sow.*
Myacites abductus, *Phil.*	Hinnites abjectus, *Phil.*
Pecten demissus, *Phil.*	Perna rugosa, *Goldf.*

with other species enumerated in the list of *Conchifera* from the Frocester district, and which are found in the limestones and sands of the Inferior Oolite, still it contains a suite of *Cephalopoda* which are only found in the Upper Lias, and characterize that formation in Germany, France, Belgium, and England: these are—

Ammonites opalinus, *Rein.*	Ammonites hircinus, *Schloth.*
—— insignis, *Schübler.*	—— Jurensis, *Zieten.*
—— variabilis, *d'Orb.*	Nautilus inornatus, *Sow.*
—— discoides, *Zieten.*	Belemnites breviformis, *Voltz.*
—— striatulus, *Sow.*	—— compressus, *Voltz.*
—— radians, *Schlotheim.*	—— Nodotianus, *d'Orb.*
—— Raquinianus, *d'Orb.*	—— irregularis, *Schloth.*

With these facts before us, I submit that the amount of palæontological evidence is in favour of our grouping the Cephalopoda-bed and its underlying sands with the Upper Lias, rather than with the Inferior Oolite, to which latter it has been considered to belong, and as the basement-bed of which it has been described.

In estimating the value of palæontological evidence, we ought to look at its *weight* as well as its *amount*. It is well known, for example, that many species of *Conchifera* and *Gasteropoda* have a much more extensive stratigraphical range than other *Mollusca*; thus, certain forms of these classes have lived in the seas that deposited the Inferior Oolite, as well as in those of the Oxford Clay and Coralline Oolite: of which, *Trigonia costata*, *Pecten lens*, *Myacites abductus*, *Ostrea Marshii*, *Myacites Jurassi*, and *Phasianella striata* are examples. But when we inquire what species of *Ammonites*, *Brachiopoda*, or *Echinodermata* are common to the Inferior Oolite and Coral-rag, the answer is *none*. These three classes are therefore of more value to the palæontologist than the *Conchifera* and *Gasteropoda*, seeing that their species have a more limited distribution in time.

Ammonites are in fact probably the best indicators of geological horizons; and this is the more remarkable, seeing that their Cephalopodous occupants lived in these fragile shells in the high seas, at a considerable distance from the shore. We know that the Lower, Middle, and Upper Lias contain species which characterize these divisions of that formation in the most satisfactory manner; and that even the different beds of these three divisions contain species peculiar to each. The species of *Ammonites* found in the lower ragstones of the Inferior Oolite are distinct from those of its upper beds. The same reasoning holds true when applied to the *Ammonites* of the middle and upper divisions of the Oolitic rocks, as well as those found in the different stages of the Cretaceous group.

Brachiopoda are likewise good stratigraphical indicators, as has been most clearly shown by Mr. Davidson in his magnificent 'Monograph on the British Brachiopoda.'

Echinodermata, although lower in the animal series in a zoological point of view, afford the palæontologist the largest amount of data on which to reason. The Silurian, Devonian, and Carboniferous rocks are all characterized by distinct forms of *Crinoidea*, most of which are limited to the different stages of these great groups. The Liassic *Crinoidea* and *Echinidæ* are all distinct from those of the Inferior Oolite, and its upper stages Great Oolite, Forest Marble, and Cornbrash. The *Echinidæ* of the lower division of the Oolitic group are all distinct from those of the middle; and the latter in like manner are distinct from all other Oolitic forms. If this be true of the stratigraphical distribution of the *Echinodermata*, it follows that the Pea-grit (of the prevailing species of which I have given a list in the description of Crickley Hill, p. 298) must be a very distinct formation from the Cephalopoda-bed, on which it rests, seeing that not one of the twenty species of *Echinoidea* and *Crinoidea* found in that rock alone have been discovered in the Cephalopoda-bed a few feet below it; nor, on the other hand, has one of the twenty species of *Ammonites*, *Nautili*, and *Belemnites* found in the Cephalopoda-bed been discovered in any of the stages of the Inferior Oolite; so that both our positive and negative evidence lead us to the conclusion that the Cephalopoda-bed marked the close of the Liassic, and not the commencement of the Oolitic formation.

Place of the Cephalopoda-bed on the Continent.—The Cephalopoda-bed * forms a very persistent fossiliferous band, occupying the same geological horizon, in France, Belgium, and Germany. My friend Charles Pierson, Esq., of this town, has shown me a small series of fossils which he collected at Croisilles, near Thury Harcourt, Calvados, from an Ammonitiferous bed which rests on the brownish marls of the Upper Lias; the series consists of *Ammonites variabilis*, *Am. Raquinianus*, *Am. striatulus*, *Am. radians*, and one or two species of *Belemnites*. This bed is overlaid by the Inferior Oolite, containing *Ammonites dimorphus*, *Am. Parkinsoni*, *Trigonia costata*, *Astarte modiolaris*, Desh., *Pleurotomaria ornata*, Def., *Pleurotomaria conoidea*, Desh., and *Terebratula sphæroidalis*; and is underlaid by the shaly marls, the Upper Lias, containing *Am. communis*, *Am. bifrons*, *Belemnites elongatus*, Mill., and many other shells which he has not preserved.

M. Terquem † has described the same bed as it occurs in the "département de la Moselle" under the name "Grès supraliassique ou marly sandstone." This sandstone, he observes, might lithologically be confounded with the "grès medioliassique," which appears to be equivalent to our Marlstone, if palæontology had not indicated the distinction to be made between them. This bed is found near the summit of Saint-Quentin, above Tignomont, in the environs of Thionville, at the summit of the hill of Guénetrange, Saint-Michel, in the environs of Longwy, at Mont-Saint-Martin, at Long-la-Ville, &c.

* M. Eugène Deslongchamps, in his "Notes pour servir à la Géologie du Calvados" (Bull. Soc. Linn. Normandie, 1856, p. 1), has described this bed as No. 9 of his section at Évrecy: it is there formed of a slightly coherent, argillaceous limestone, penetrated often with small, ferruginous, oolitic grains slightly adhering together. It contains many fossils, which are not well preserved, as *Ammonites opalinus*, *Modiola plicata*, *Gervillia contorta*, and the characteristic *Rhynchonella cynocephala*.

† Extrait de la Statistique de la Moselle, page 22.

Fossils of the Marly or Supraliassic Sandstone.

*Belemnites tripartitus, *Schl.*
—— compressus, *Sow.*
—— abbreviatus?, *Miller.*
*—— Nodotianus, *d'Orb.*
*Ammonites insignis, *Schüb.*
*—— radians, *Schl.*
* —— opalinus, *Rein.*
—— Normanianus, *d'Orb.*
Pholadomya lyrata, *Sow.*
—— Zietenii, *Ag.*
—— decorata, *Ziet.*
—— obtusa, *Ag.*
—— reticulata, *Ag.*
Corbula Voltzii, *Tqm.*
*Pleuromya unionides, *Ag.*
—— angusta, *Ag.*
—— æquistriata, *Ag.*
—— arenacea, *Tqm.*
Ceromya (Gresslya) anglica, *Ag.*
—— major, *Ag.*
—— striata, *Ag.*
—— pinguis, *Ag.*
—— donaciformis, *Ag.*
Ceromya rotundata, *Ag.*
*Cardium truncatum, *Phil.*
Hettangia dionvillensis, *Tqm.*
—— compressa, *Tqm.*
Psammobia.
*Isocardia (Ceromya) concentrica, *Sow.*
Trigonia navis, *Lamk.*
—— litterata, *Phil.*
—— pulchella, *Ag.*
Arca Munsteri, *Goldf.*
—— elegans, *Goldf.*
Nucula Hammeri, *Defrance.*
—— pectinata, *Zieten.*
*Pinna fissa, *Goldf.*
Mytilus gregarius, *Goldf.*
—— cephus, *d'Orb.*
*Gervillia Hartmanni, *Goldf.*
Inoceramus.
Pecten paradoxus, *Münst.*
Gryphæa Cymbium, *Lamk.*
Orbicula.

M. Terquem distinguishes from the marly supraliassic sandstone a bed which nearly resembles it in the forms of its organic remains. He describes it under the name of *Hydroxide oolitique ou fer supraliasique*; it contains a great quantity of littoral shells and *Belemnites,* and at Longwy an attempt was made to work the bed for its mineral contents. In some localities, as at Moyeuvre, *Ammonites* and *Nautili* of large size are found in this ferruginous rock. A small mine opened below Longwy was very fossiliferous, and the specimens were in a state of perfect preservation. The following list represents the contents of this bed :—

Fossils of the Hydroxide Oolite.

*Ichthyosaurus communis, *Conyb.*; vertebræ, ribs, and teeth.
*Belemnites abbreviatus?, *Mill.*
—— compressus, *Sow.*
—— exilis, *d'Orb.*
—— acuarius, *Schl.*
*—— Nodotianus, *d'Orb.*
—— incurvatus, *Quenst.*
*Nautilus inornatus, *d'Orb.*
*Ammonites opalinus, *Rein.*
—— Aalensis, *Ziet.*
*—— radians, *Schl.*
*—— variabilis, *d'Orb.*
*—— concavus, *Sow.*
*—— insignis, *Schl.*
*—— Jurensis, *Ziet.*
*Pholadomya fidicula, *Sow.*
Pholadomya decorata, *Ziet.*
—— obtusa, *Desh.*
Pleuromya angusta, *Ag.*
Ceromya (Gresslya) anglica, *Ag.*
—— striata, *Ag.*
—— pinguis, *Ag.*
—— major, *Ag.*
*—— concentrica, *Sow.*
*Cardium truncatum, *Phil.*
Hettangia dionvillensis, *Tqm.*
—— compressa, *Tqm.*
Cytherea.
*Astarte lurida, *Sow.*
Trigonia navis, *Lamk.*
—— tuberculata, *Ag.*
—— undulata, *Ag.*
—— costellata, *Ag.*

Mytilus gregarius, *Goldf.*
*Gervillia Hartmanni, *Münst.*
—— tortuosa, *Phil.*
—— lata, *Phil.*
*Pecten demissus, *Phil.*
*—— cingulatus, *Goldf.*
Pecten paradoxus, *Münst.*
*—— comatus, *Münst.*
Hinnites, sp.
Gryphæa gigantea, *Sow.*
—— sandalina, *Münst.*

I have marked with an asterisk all the species of the marly sandstone and the hydroxide oolite which have been found by me in the Cephalopoda-bed.

The equivalent of this bed occurs in the Province of Luxembourg, and is well described by Drs. Chapuis and Dewalque * as *Lias supérieur, 6me étage,—Schiste et Marne de Grand Cour*; and is regarded by M. Dumont as forming the superior part of the Lias. The schist is worked for the extraction of bitumen at Aubange, where numerous fossils have been found.

This bed is *la terre à foulon* of Boblaye,—*la marne supérieure* of Sauvage and Buvignier. It corresponds to the *Lias ζ* and to the *Brown Jura α* of Quenstedt; to the *Posidonien-schiefer* of Roemer; and to the *Upper Lias Shale* of Phillips. I regard it as constituting the upper stage of the "superior Lias." The authors found the following *Ammonites* and *Belemnites* in this bed:—

*Ammonites communis, *Sow.*
*—— concavus, *Sow.*
*—— heterophyllus, *Sow.*
*—— radians, *Rein.*
*—— Raquinianus, *d'Orb.*
—— serpentinus, *Schl.*
*Ammonites variabilis, *d'Orb.*
Belemnites acuarius, *Schl.*
—— compressus, *Voltz.*
*—— tripartitus, *Schl.* (elongatus, *Miller*).

Our Cephalopoda-bed and sands are equivalent to Professor Quenstedt's *graue Kalkstein-Bank mit Ammonites Jurensis*, forming the bed ζ, the uppermost of his *schwarzer Jura* † (Lias), together with the *schwarze Thon mit Ammonites opalinus* ‡, forming bed α of his *brauner Jura*.

Through the kindness of Dr. Fraas, of Stuttgart, I have before me a series of authentic specimens of *Ammonites* from these German beds, which I have compared with the *Ammonites* from the bed at Frocester Hill; and there cannot be a doubt as to the identity of the species: the specimens before me are—

Ammonites Jurensis, *Ziet.* Lias ζ, Balingen, Boll.
—— insignis, *Schl.* Lias ζ, Balingen.
—— radians, *Schl.* Lias ζ, Aalen.
—— torulosus, *Ziet.* Brown Jura *a*, Laufen.
—— opalinus, *Quenst.*, *Rein.* Brown Jura *a*, Laufen and Gmünd.

The Frocester Ammonite-bed is therefore undoubtedly the equi-

* Description des Fossiles des Terrains Secondaires de la Province de Luxembourg.

† See Fraas on the Jura Formation, Quart. Journ. Geol. Soc. vol. vii. Part 2. Miscell. p. 54 *et seq.*

‡ "Sehr mächtig im untersten Gliede findet sich *Ammonites torulosus*."—Handbuch der Petrefacten-Kunde, p. 11.

valent of the Jurensis-marl of Dr. Fraas, so well developed in Suabia, and described in his admirable memoir "On the comparison of the German Jura-formation with those of France and England*." This bed was hitherto supposed both by English and continental geologists to be wanting in England, but I have shown that it is probably as well developed in our island as on the continent.

A Table showing the Stratigraphical Distribution of the Fossils contained in the foregoing lists.

Names of Species.	England.					France.		Belgium.		Germany.	
	Marlstone.	Upper Lias Clay.	Upper Lias Sands.	Upper Lias Cephalopoda-bed.	Inferior Oolite.	Upper Lias.	Inferior Oolite.	Upper Lias.	Inferior Oolite.	Upper Lias.	Inferior Oolite.
Ammonites opalinus, *Rein.*	...	...	...	*	...	*	...	...	...	*	
—— insignis, *Schübl.*	...	*	*	*	...	*	...	...	...	*	
—— variabilis, *d'Orb.*	...	*	*	*	...	*	...	*			
—— discoides, *Ziet.*	...	...	...	*	...	*	...	*	...	*	
—— Thouarsensis, *d'Orb.*	...	...	...	*	...	*	...	*	...	*	
—— radians, *Rein.*	...	*	*	*	...	*	...	*	...	*	
—— Raquinianus, *d'Orb.*	...	*	*	*	...	*	...	*	...		
—— hircinus, *Schloth.*	...	...	...	*	...	*	...	...	...	*	
—— Jurensis, *Ziet.*	...	...	*	*	...	*	...	...	...	*	
—— Dorsetensis, *Wright*	...	...	...	*	...						
—— concavus, *Sow.*	...	*	*	*	..	*	...	*	...	*	
—— striatulus, *Sow.*	...	*	*	*	...	*	...	*	...	*	
—— heterophyllus, *Sow.*	...	*	...	*	...	*	...	*	...	*	
—— serpentinus, *Schloth.*	...	*	...	...	...	*	...	*	...	*	
—— bifrons, *Brug.*=Walcottii, *Sow.*	...	*	*	...	...	*	...	*	...	*	
—— communis, *Sow.*	...	*	...	...	...	*	...	...	...	*	
—— margaritatus, *Mft.*=amaltheus, *Schl.*	*	...	...	...	...			Lias moyen.			
—— spinatus, *Brug.*	*	...	...	...	...			Lias moyen.			
—— Truelli, *d'Orb.*	...	...	...	...	*	...	*				
—— corrugatus=Murchisonæ, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
—— Humphriesianus, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
—— Brongniarti, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
—— Gervillii, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
—— Brocchii, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
—— Sowerbyii, *Miller*	...	...	...	...	*	...	*	...	...	...	*
—— Blagdeni, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
—— dimorphus, *d'Orb.*	...	...	...	...	*	...	*				
—— Parkinsoni, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
—— Martinsii, *d'Orb.*	...	...	...	...	*	...	*				
—— subradiatus, *Sow.*	...	...	...	...	*	...	*				

* Quart. Journ. Geol. Soc. vol. vii. Part 2, Miscell. p. 42, &c.

TABLE (*continued*).

Names of Species.	England.					France.		Belgium.		Germany.	
	Marlstone.	Upper Lias Clay.	Upper Lias Sands.	Upper Lias Cephalopoda-bed.	Inferior Oolite.	Upper Lias.	Inferior Oolite.	Upper Lias.	Inferior Oolite.	Upper Lias.	Inferior Oolite.
Nautilus inornatus, *d'Orb.*	...	...	...	*	...	*					
—— truncatus, *Sow.*	...	...	...	...	*	...	*				
Belemnites breviformis, *Voltz*	...	...	...	*	...	*	...	*	...	*	
—— compressus, *Blainville*	...	...	...	*	...	*	...	*	...	*	
—— Nodotianus, *d'Orb.*	...	...	*	...	...	*	...	...	...	*	
—— giganteus, *Schloth.*	...	...	...	...	*	...	...	*	...	...	*
—— irregularis, *Schloth.*	...	...	*	*	...	*	...	*	...	*	
GASTEROPODA.											
Turbo capitaneus, *Münst.*	...	...	...	*	...	*	...	...	...	*	
Pleurotomaria ornata, *Defrance*	...	...	...	...	*	...	*				
Patella rugosa, *Sow.*	...	...	...	...	*	...	Gt.O.				
—— inornata, *Lyc.*	...	...	...	...	*						
Nerita costata, *Sow.*	...	...	...	...	*	...	*				
Natica adducta, *Phil.*	...	...	...	...	*	...	*				
Cirrus nodosus, *Sow.*	...	...	...	...	*	...	*				
Trochotoma carinata, *Lyc.*	...	...	...	...	*	...	*				
Rimula tricarinata, *Sow.*	...	...	...	...	*						
Chemnitzia, nov. sp.	...	...	*								
CONCHIFERA.											
Limea duplicata	*?	...	...	...	*	*	*	*	...	*	*
Lima notata, *Goldf.*	...	...	...	...	*	...	*	...	...	...	*
—— semicircularis, *Goldf.*	...	...	...	...	*	...	*	...	...	...	*
—— sulcata, *Münst.*	...	...	...	...	*	...	*	...	...	...	*
—— lyrata, *Münst.*	...	...	...	...	*	...	*	...	...	...	*
—— ovalis, *Sow.*	...	...	...	...	*	...	Gt.O.				
—— bellula, *Lyc.*	...	...	...	*	*						
—— electra, *d'Orb.*	...	...	*	*	...	*					
—— ornata, *Lyc.*	...	...	*	*							
Opis carinata, *Wright*, nov. sp.	...	...	...	*							
Trigonia costatula, *Lyc.*	...	...	...	...	Middle.						
—— exigua, *Lyc.*	...	...	...	...	Lower.						
—— V-costata, *Lyc.*	...	...	...	...	Lower.						
—— decorata, *Lyc.*	...	...	...	...	Upper.						
—— clavo-costata, *Lyc.*	...	...	...	...	Middle.						
—— costata, *Sow.*	...	...	...	*	*	...	*	...	...	...	*
—— striata, *Sow.*	...	...	...	*	*	...	*	...	...	...	*
—— duplicata, *Sow.*	...	...	...	...	Lower.	...	*				
—— Ramsayii, *Wright*	...	...	...	*							
Pecten articulatus, *Goldf.*	...	...	...	...	*	...	...	...	...	...	*
—— lens, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
—— demissus, *Phil.*	...	...	...	*	*	...	Kellow	*	*	*	*

TABLE (*continued*).

Names of Species.	England. Marlstone.	England. Upper Lias Clay.	England. Upper Lias Sands.	England. Upper Lias Cephalopoda-bed.	England. Inferior Oolite.	France. Upper Lias.	France. Inferior Oolite.	Belgium. Upper Lias.	Belgium. Inferior Oolite.	Germany. Upper Lias.	Germany. Inferior Oolite.
Pecten textorius?, *Goldf.*	...	...	*	*	...	...	...	*			
—— comatus?, *Münst.*	...	...	...	*	*	...	Gt. O.	...	...	...	*
Hinnites abjectus, *Phil.*	...	...	*	*	*	...	Oxf.	...	...	...	*
—— tuberculosus, *Goldf.*	...	...	...	...	*	...	*	...	...	...	*
——, n. sp., *Wright*	...	...	...	...	*						
Plicatula	...	...	...	...	*						
Trichites, sp.	...	...	...	...	*						
Placuna Jurensis, *Roemer*	...	...	...	...	*	...	Coral	...	...	...	*
Modiola plicata, *Sow.*	...	...	*	*	*	*	*	...	...	...	*
Mytilus bipartita, *Sow.*, sp.	...	...	...	...	*	...	*	...	...	...	*
—— pectinatus, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
—— pulcher, *Goldf.*	...	...	...	...	*	...	...	...	...	...	*
—— striatulus, *Münst.*	...	...	...	...	*	...	*	...	...	...	*
—— cuneatus, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
Pinna cuneata, *Phil.*	...	...	...	...	*	...	*				
—— fissa?, *Goldf.*	...	...	...	*	*	...	...	...	...	*	
Myoconcha crassa, *Sow.*	...	...	...	...	*	...	*	...	...	...	*
Ostrea costata, *Sow.*	...	...	...	...	*	...	*				
Avicula? complicata, *Buck.*	...	...	...	...	*						
—— inæquivalvis?, *Sow.*	...	...	...	*	*	*	*	...	...	*	*
—— echinata, *Sow.*	...	...	...	...	*	...	Gt. O.				
Lucina lyrata, *Phil.*	...	...	...	...	*	...	*				
Quenstedtia lævigata, *Phil.*	...	...	...	...	*	...	Oxf.				
Ceromya plicata, *Agass.*	...	...	...	...	*	...	*	...	...	...	*
—— Bajociana, *d'Orb.*	...	...	...	...	*	...	*				
Cucullæa, nov. sp.	...	...	*	*							
Macrodon Hirsonensis, *d'Archiac*	...	...	...	...	*	...	*				
Arca inæquivalvis?, *Goldf.*	...	...	*	...	...	*	...	...	...	*	
Myacites punctatus, *Buck.*	...	...	...	...	*						
—— oblongus, *Buck.*	...	...	...	...	*						
—— dilatatus, *Buck.*	...	...	...	...	*						
—— tenuistriatus, *Agass.*	...	...	...	*	*	...	*	...	...	...	*
Cardium Hullii, *Wright*	...	...	...	*							
—— Oppellii, *Wright*	...	...	...	*							
Pholadomya fidicula, *Sow.*	...	...	*	*	*	...	*	...	*	...	*
Gervillia Hartmanni, *Münst.*	...	...	...	*	*	...	...	...	...	*	
—— fornicata, *Lyc.*	...	...	*	*							
Perna rugosa, *Münst.*	...	...	*	*	*	...	*	*	*	...	*
Gresslya abducta, *Phill.*	...	...	*	*	*	...	*	...	...	...	*
—— conformis, *Agass.*	...	...	*	*	*	...	*	...	...	...	*
Goniomya angulifera, *Sow.*	...	...	*	*	*	...	...	...	...	...	*
Astarte excavata, *Sow.*	...	...	*	*	*	...	*				
—— modiolaris?, *Lamk.*	...	...	...	*	*	...	*	...	...	...	*
—— complanata, *Roem.*	...	...	...	*	...	...	...	...	...	*	

TABLE (*continued*).

Names of Species.	England.					France.		Belgium.		Germany.	
	Marlstone.	Upper Lias Clay.	Upper Lias Sands.	Upper Lias Cephalopoda-bed.	Inferior Oolite.	Upper Lias.	Inferior Oolite.	Upper Lias.	Inferior Oolite.	Upper Lias.	Inferior Oolite.
Astarte lurida, *Sow.*	...	...	*	*	...	*	...	...	...	*	
—— rugulosa, *Lyc.*	...	...	*	*							
Cypricardia cordiformis, *Desh.*	...	...	...	*	*	...	*	...	...	*	
—— brevis, *Wright*	...	...	*	*							
BRACHIOPODA.											
Terebratula simplex, *Buck.*	...	...	...	...	*						
—— plicata, *Buck.*	...	...	...	...	*						
—— submaxillata, *David.*	...	...	...	...	*						
—— subpunctata, *David.*	*	...	*	*							
Rhynchonella Wrightii, *David.*	...	...	...	...	*	...	*				
—— decorata, *David.*	...	...	...	...	*	...	*?				
—— angulata?, *Sow.*	...	...	...	...	*						
—— concinna, *Sow.*	...	...	...	...	*	...	*				
—— oolitica, *Sow.*	...	...	...	...	*						
—— cynocephala, *Rich.*	...	...	...	*	...	*	...	...	...	*	
—— furcillata, *Thiod.*	...	*	*	*	...	*	...	...	...	*	
Thecidea triangularis	...	...	...	...	*	...	*				
ANNELIDA.											
Serpula grandis, *Goldf.*	...	...	...	...	*	...	...	...	...	...	*
—— convoluta, *Goldf.*	...	...	...	...	*	...	...	...	...	...	*
—— plicatilis, *Münst.*	...	...	...	...	*	...	...	...	...	...	*
—— quadrilatera, *Goldf.*	...	...	...	...	*	...	...	...	...	...	*
—— socialis, *Goldf.*	...	...	...	...	*	...	...	...	...	...	*
—— sulcata?, *Goldf.*	...	...	...	...	*	...	...	...	...	...	*
—— filaria, *Goldf.*	...	...	...	...	*	...	...	...	...	...	*
—— flaccida, *Goldf.*	...	...	...	...	*	...	...	...	...	...	*
ECHINODERMATA.											
Cidaris Fowleri, *Wright*	...	...	...	...	*	...	Sarthe				
—— Bouchardii, *Wright*	...	...	...	...	*						
—— Wrightii, *Desor*	...	...	...	...	*						
Rabdocidaris Wrightii, *Desor*	...	...	...	...	*						
Acrosalenia Lycetti, *Wright*	...	...	...	...	*	...	Sarthe				
—— spinosa, *Agassiz*	...	...	...	...	*	...	Gt. O.				
Diadema depressum, *Agassiz*	...	...	...	...	*	...	*				
Echinus germinans, *Phil.*	...	...	...	...	*	...	*				
—— bigranularis	...	...	...	...	*	...	*				
Polycyphus Deslongchampsii, *Wright*	...	...	...	...	*						
Hemipedina Bakeri, *Wright*	...	...	...	...	*						
—— tetragramma, *Wright*	...	...	...	...	*						

TABLE (*continued*).

Names of Species.	England.					France.		Belgium.		Germany.	
	Marlstone.	Upper Lias Clay.	Upper Lias Sands.	Upper Lias Cephalopoda-bed.	Inferior Oolite.	Upper Lias.	Inferior Oolite.	Upper Lias.	Inferior Oolite.	Upper Lias.	Inferior Oolite.
Hemipedina perforata, *Wright*	...	...	...	...	*						
—— Waterhousei, *Wright*	...	...	...	...	*						
—— Bonei, *Wright*	...	...	...	...	*						
Pygaster semisulcatus, *Phil.*	...	...	...	...	*	...	Sarthe				
—— conoideus, *Wright*	...	...	...	...	*						
—— agariciformis, *Forbes*	...	...	...	...	*	...	...	...	...	...	*
—— caudatus, *Wright*	...	...	...	...	*						
Clypeus Agassizii, *Wright*	...	...	...	...	*						
—— altus, *M'Coy*	...	...	...	...	*						
Extracrinus, nov. sp.	...	...	...	...	*						
Ophioderma Egertoni, *Broderip*	...	...	*								
ANTHOZOA.											
Montlivaltia Delabechei, *Edw. & H.*	...	...	...	...	*						
—— Waterhousei, *Edw. & Haime*	...	...	...	...	*						
—— cupuliformis, *Edw. & Haime*	...	...	...	...	*						
—— Wrightii, *Edw. & Haime*	...	...	...	...	*						
Axosmilia Wrightii, *Edw. & Haime*	...	...	...	...	*						
Latromeandra Flemingii, *Edw & H.*	...	...	...	...	*						
—— Davidsoni, *Edw. & Haime*	...	...	...	...	*						
Thecosmilia gregaria, *Edw. & Haime*	...	...	...	...	*						
Thamnastræa Defranciana, *Edw. & H.*	...	...	...	...	*						
—— Terquemii, *Edw. & Haime*	...	...	...	...	*						
—— Mettensis, *Edw. & Haime*	...	...	...	...	*						
—— fungiformis, *Edw. & Haime*	...	...	...	...	*						
Isastræa tenuistriata, *Edw. & Haime*	...	...	...	...	*						
BRYOZOA.											
Stomatopora dichotomoides, *d'Orb.*	...	...	...	...	*	...	*				

Notes on some New Species of Mollusca collected from the Cephalopoda-bed, and included in the Lists of Fossils in the preceding Memoir.

AMMONITES DORSETENSIS, Wright, nov. sp.

Shell discoidal, compressed, not carinated. Each whirl in middle age ornamented with from forty to forty-five ribs, which commence at the umbilical margin, where they are most prominent, become flattened and almost disappear on the sides, and reappear bifid near the dorsal margin, each primary rib having apparently become bifurcated at the upper third of the whirl; the ribs and their bifurcations are all bent gently forwards, and each whirl exhibits three or four contractions at nearly regular intervals of growth. *Spire* formed of seven or ten whirls, according to age, which are all well exposed; their greatest diameter is near the umbilical border; from this point the sides slope gently towards the dorsal border. *Back*, in middle age, narrow, rounded, and smooth both in the shell and mould. *Mouth* oblong, compressed on the sides, and becoming narrow on the dorsal third; when entire, it terminates in two *f*-shaped processes. *Umbilicus* large, with stair-like sides; the whirls embracing the half-smooth part of the shell, and exposing the inner ribbed portions thereof.

The *septa* are symmetrical on the dorsal and lateral parts of the whirls, and consist of a dorsal lobe and five lateral lobes; the *dorsal lobe* is much larger than, but not so long as, the superior lateral lobe; it is divided by the median line into two parts for about one-third of its length, and is formed of six symmetrical, nearly equal-sized lobules, which are provided with three or four unequal digitate margins; the *superior lateral lobe* is smaller, but much longer than the dorsal; it is formed of eight unsymmetrical unequal-sized lobules; those on the upper side are more developed than those on the under side, and the terminal leaf is much the largest, with large lateral bifid ramifications; the *inferior lateral lobe* is small, and directed obliquely backwards; it is composed of two lateral lobules, and one terminal lobule, which are unequal in size and either trifid or quadrifid on the margins; the *three ventral lobes* decrease in size from above downwards; they are all directed obliquely upwards; the uppermost lobe is tridigite, the second is bidigite, and the third consists of a single lobule with jagged margins.

Up to the diameter of 6 or 8 inches the shell retains its ribbed character, as described; but when it grows beyond that size, it loses all its ribs, the whirls become more thick, the back more rounded, the shell smooth, and only marked with lines of growth and slight periodical constrictions.

Dimensions.—Usual size from 8 to 9 inches in diameter; the largest specimen known is in the British Museum, and measures 16 inches.

Affinities and differences.—This species, up to the diameter of 6 inches, resembles *Ammonites Parkinsoni*, and is frequently named as such in public collections: this may have arisen in part from the remark made by Sowerby in his description of *Ammonites Parkinsoni*, that "it is the Ammonite so frequently split, polished, and sold at Bath;" and again, "I suspect it may also be found in the lower beds of the Iron-shot Oolite, as the specimen figured is from near Yeovil." Now the fact is, that *Ammonites Parkinsoni* so well figured by Sowerby (Min. Conch. tab. 307. fig. 1) rarely exceeds 6 or 7 inches in diameter, and is not often either split or polished; whereas the specimens of *Ammonites Dorsetensis* selected by "the gothic hands of the mason," almost always exceed these dimensions. All the largest and finest specimens of *Ammonites Parkinsoni* which

I have collected retain their ribs in mature age, whilst *Ammonites Dorsetensis* as constantly loses them, the whirls in old specimens of this species being always smooth. The ribs in *A. Parkinsoni* are always more sharp and prominent than those of *A. Dorsetensis,* and the latter wants the small terminal tubercles which adorn the dorsal ribs in *A. Parkinsoni.* In the mould of *A. Parkinsoni* the middle of the back is slightly excavated, whereas in *A. Dorsetensis* it is rounded.

Locality and stratigraphical position.—This species characterizes the "Cephalopoda-bed" in Somersetshire and Dorsetshire; it is collected in abundance at the Half-way House between Yeovil and Sherborne, where the largest shells are obtained; I have found it near Bridport, and at Burton-Bradstock. In its stratigraphical position, therefore, it differs from *A. Parkinsoni,* which is always found in the upper ragstones of the Inferior Oolite associated with *Echinodermata, Brachiopoda,* and other fossils found only in that Oolitic zone.

TRIGONIA RAMSAYII, Wright, nov. sp.

Syn. *Trigonia signata,* Lycett, Annals and Magazine of Nat. Hist. ser. 2. vol. xii. p. 239.

Shell very inequilateral, flat, and elongated, the height being small in proportion to the length; umbones near the anterior side, small, nether prominent nor recurved; area well developed, lengthened, flattened, marked with transverse lines of growth; carinæ nearly obsolete, represented by smooth elevations.

Surface of the valves ornamented with twenty nearly equal-sized tuberculated costæ; the anterior and posterior series form concentric ridges, and the middle series are undulated; the tubercles of the costæ are nearly of a uniform size, and placed close together on thickened ridges of the shell.

Length $2\frac{13}{20}$ inches. Breadth $1\frac{15}{20}$ inch. Thickness $1\frac{5}{20}$ inch.

Affinities and differences.—This shell resembles *Trigonia angulata,* Sow., in the flatness of the area, and in the absence of prominent carinæ in that region; but differs from it in being more straight and elongated, and in its height being less in proportion to its length: the umbones are likewise smaller, less prominent, and nearer the border.

It differs from *Trigonia signata,* Agass., with which it was identified in the absence of tuberculated carinæ from the area, in being more compressed, more elongated, and not so high; the tuberculated costæ are more numerous, and their arrangement less regularly concentric. It is sufficiently distinct from all the other clavellated species of *Trigonia.*

Locality and stratigraphical position.—Collected hitherto only rarely in the Cephalopoda-bed of Frocester. The species is dedicated to my friend Professor Ramsay, Local Director of the Geological Survey.

Cypricardia brevis, Wright, nov. sp.

Shell triangular, inequilateral, ventricose, and cordate; posterior side short and sharply angular; anterior side bluntly rounded; umbones large, prominent, nearly central and much recurved, with an acute carina descending from them to the posterior side; surface nearly smooth, slightly marked with lines of growth; margin of the valves straight.

A. Frocester specimen.—Breadth $1\frac{5}{10}$ inch. Length $1\frac{8}{10}$ inch. Thickness $1\frac{2}{10}$ inch.

B. Sherborne specimen.—Breadth $2\frac{1}{20}$ inches. Length $2\frac{5}{10}$ inches. Thickness $1\frac{5}{10}$ inch.

Affinities and differences. — This shell resembles *Cypricardia Bathonica,* d'Orbigny, but it is a much shorter and straighter form; the carinæ on the posterior side are more prominent and acute; but it wants the graceful twisted slope which characterizes *C. Bathonica.*

Locality and stratigraphical position.—I have collected this species out of the fossiliferous nodules at the base of the Sands at Nailsworth, and in the Upper Lias Sands at Frocester Hill, *Ammonites bifrons* being associated with it in the same nodule; much larger specimens are found in the Upper Lias near Sherborne. It appears to be a very rare shell.

Opis carinatus, Wright, nov. sp.

Shell trigonal, its breadth nearly equalling its length; umbones large and incurved, bounded on their posterior borders by acute prominent carinæ which descend along the margin of the valves and bound the posterior side; anterior side rounded; surface of the valves ornamented with regular concentric ridges; posterior side concave, the surface marked with sharp oblique close-set lines; lunule small, nearly circular.

Length $1\frac{2}{10}$ inch. Breadth $1\frac{1}{20}$ inch. Thickness $\frac{15}{20}$ths of an inch.

Affinities and differences.—This shell resembles *Opis* (*Astarte*) *trigonalis,* Sow., in its proportionate length; but it is distinguished from it by the regular concentric ridges on the surface of the valves, those on *O. trigonalis* being waved, by its acute prominent carinæ, and by the general sharpness in the outline of the different parts of the shell. It differs from *Opis lunulatus,* Sow., in being a much longer and more compressed form, in having more prominent carinæ and a small shallow and nearly circular lunule, that of *Opis lunulatus* being large, deep, and cordate, with acute margins.

Locality and stratigraphical position.—Collected only from the Cephalopoda-bed of Frocester Hill; it is not an abundant shell, and is seldom well preserved.

Cardium Hullii, Wright, nov. sp.

Shell smooth, subtrigonal, inequilateral; breadth nearly equalling its length; the anterior side convex and rounded; the posterior side sloping obliquely from the umbo to the posterior border; the marginal fold of this side is slightly flattened, on which a series of concentric ridges are seen crossing the lines of growth at different angles; the umbones are small and placed near the centre; the surface is only marked with delicate lines of growth.

Length $2\frac{1}{8}$ inches. Breadth $1\frac{19}{20}$ inch. Thickness $1\frac{5}{10}$ inch.

Affinities and differences.—This shell resembles *C. lævigatum*, Lyc., in the smoothness of its surface, but is distinguished from it by the shortness of its posterior side, and the band of concentric ridges which extends from the umbones to the posterior border.

Local and stratigraphical position.—Collected only from the Cephalopoda-bed of Frocester Hill. The species is dedicated to my friend Edward Hull, Esq., F.G.S., of the Geological Survey.

CARDIUM OPPELII, Wright, nov. sp.

Shell smooth, convex, slightly inequilateral; umbones large, prominent, incurved, nearly central; anterior side rounded; posterior side slightly produced and gently truncated; on this more or less angular band numerous concentric ridges are seen.

Length 2 inches. Breadth $1\frac{6}{10}$ inch. Thickness $1\frac{4}{10}$ inch.

Affinities and differences.—This shell resembles *C. lævigatum*, Lyc., but it is a more elongated and compressed form: the posterior side is flattened and ornamented with concentric ridges which are absent in all the specimens of *C. lævigatum* which I have examined. It may prove to be only a variety of that Inferior Oolite shell when a larger number of specimens permit a more rigorous determination to be made.

Locality and stratigraphical position.—Collected from the base of the Sands at Nailsworth, where it is not common. The species is dedicated to my friend Dr. Oppel, of Stuttgart, well known for his extensive acquaintance with continental Oolitic Geology, and author of "Die Juraformation Englands, Frankreichs, und des südwestlichen Deutschlands."

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4. *On the Probable Origin of the* ENGLISH CHANNEL *by means of a Fissure.* By M. AMI BOUÉ, For. Mem. G.S.

[Abstract.]

THE author, having met with a published proposal to construct a submarine tunnel across the Straits of Dover, pointed out that it was highly probable that the English Channel had not been excavated solely by water-action, but owed its origin to one of the lines of disturbance which have fissured this portion of the earth's crust; and that, taking this view of the case, the fissure probably still exists, being merely filled with comparatively loose material, and would prove a serious obstacle to any attempt to drive a submarine tunnel which would have to traverse it.

April 23, 1856.

Lester Lester, Esq., was elected a Fellow.

The President read a Letter from the Directors of the New River Company, in answer to a Memorial, signed by many Members of the Society, relative to the Artesian boring at Kentish Town:—the Directors expressed their regret that they did not feel it to be their duty to the Proprietors of the Company to proceed further at present with the boring.

The following communication was read:—

On the Formation *of* Craters, *and the Nature of the* Liquidity *of* Lavas. By G. Poulett Scrope, Esq., M.P., F.R.S., F.G.S.

Contents.

Introduction.—It is now some thirty years since I published two works* upon the Phænomena of Volcanos, Active and Extinct. I described in them, as accurately as I could, by pen and pencil, what I had observed during a residence of some duration among the volcanic districts of France and Italy; and explained, in considerable detail, the laws which, from those observations, I believed to regulate the remarkable developments of subterranean energies usually called volcanic, which have played so important a part in the construction of the superficial crust of our planet.

The general principle on which I proceeded in the theoretical portion of these works was the same which had been previously employed by Hutton and Playfair, and was subsequently adopted, with signal success, by Sir Charles Lyell,—namely, to refer, so far as is possible, appearances the origin of which has not been witnessed, to such causes as are seen or known to produce analogous appearances in the present day,—instead of resorting for the purpose to imaginary hypotheses.

In the earlier volume of the two (the Considerations on Volcanos), however, I certainly overstepped this wholesome rule, by entering towards the conclusion of the work upon some rather crude speculations on a general theory of the globe; and this, together with defects of style and arrangement, and likewise of illustration, of which I became sensible only when it was too late to amend them,

* "Considerations on Volcanos," &c., 1825–6. "On the Geology of Central France," &c., 1826–7.

sufficiently accounts for the different reception these two works met with from geologists at the time. Neither, however, I presume to hope, were wholly without some beneficial result. At the period of their publication, the Wernerian theory of the precipitation from some aqueous menstruum, not merely of granite, and what were then called the primitive formations, but even of all the trap-rocks, still prevailed, and had the support of a large school of geologists in this country. I venture to think that the facts reported in my two volumes (especially those represented to the eye in the atlas illustrative of the volcanic remains of Central France) had some share in the final extinction of that German romance,—which some geologists as old as myself may remember to have been regarded almost in the light of a gospel-truth, and defended with all the acrimony of polemical controversy.

Some of the opinions, however, expressed in these works with respect to the laws that govern volcanic action, were severely criticised at the time. Others have been since opposed by rival theories. And, as these disputed questions have an important bearing on some of the most interesting problems of geology, I trust it may not be unprofitable to call the attention of our Society to the more prominent among them.

I will advert on this occasion to two subjects especially, viz.

I. The origin, or mode of formation, of volcanic cones and craters.
II. The nature of the liquidity of lava at the time of its protrusion from a volcanic aperture.

I. *Formation of Cones and Craters.*—In both of the works to which I have alluded, I referred the formation of those remarkable circular hollows, usually called craters, which are of such frequent occurrence in volcanic districts, to explosive aëriform eruptions, breaking their way through the superficial rocks; and that of the external more or less conical hill or mountain which generally, but not always, environs a crater,—and which, indeed, often occurs without a crater, but always characterized by the quâ-quâ-versal dip of its constituent beds of lava and conglomerates,—to the accumulation, round and above an eruptive vent, of its fragmentary ejections and the lava-streams poured out from it.

I considered this law to be without exception; attributing the differences in figure and structure apparent among volcanic cones to the greater or less number and violence of the eruptions to which they were owing,—some being the product of a single eruption, others of a vast number, often repeated through a series of ages,—to differences in the position of the orifices of discharge, whether from the summit of the cone, or its base, or any intermediate points, —and whether from under water, or in the air,—to the varying mineral character of the products,—and to the influences of subsequent degradation.

At the same time I remarked that the earthquakes which always more or less accompany volcanic eruptions render probable a certain amount of elevation in mass of the pre-existing superficial rocks; and moreover that the rents they cause in the solid substance of the cone of a volcano in repeated eruption, into many of which rents liquid lava will be injected from the column rising in the central chimney, and cool down afterwards into more or less vertical dykes of solid rock, must have added considerably to the bulk and elevation of such a mountain, by a sort of inward distension.

This was no closet-theory,—because, as respects the cone and crater of Vesuvius at least, I had the advantage, in the years 1818, 1819, and 1820, of watching with my own eyes the outward growth of that cone, through a series of almost continual eruptions of a comparatively tranquil character, which during those years added considerably to its height and bulk by external accretions of ejected scoriæ and lava-currents. These last, the lava-streams, issued from small cones and craters formed upon the solid platform which then composed the summit of the great cone, and dribbled slowly down its slopes, consolidating so rapidly there as in few instances to reach the base of the cone at all; although night after night they were to be seen flowing from the summit in streams of considerable breadth and bulk, and glowing with a bright light on its steep sides.

Afterwards, in the latter part of the year 1822, I had seen the upper portion of this solid cone blown into the air (by which it lost a full third of its height), and a crater of vast dimensions drilled through its axis by continuous eruptive explosions of twenty days' duration.

I had previously made a close examination of the cones and craters of Etna, the Phlegræan Fields, the Lipari Isles, Central France, and the Rhine district; and their appearances accorded so completely with the supposition of an analogous mode of formation in their instances, that, upon the principle of explaining the unknown by the known, it seemed impossible, or at least unnecessary, to imagine any other origin for them.

"Elevation," "Denudation," and "Engulfment" Theories of Crater-formation.—It was, therefore, with no small surprise that I have since found this simple and natural mode of production denied to all cones and craters—including those of Vesuvius itself; and an hypothesis substituted of their originating in some sudden elevation of previously horizontal beds around a centre,—not (it would seem) of eruption, but of maximum elevation. I allude, of course, to the "Elevation-crater theory" of MM. Von Buch and Elie de Beaumont.

Sir Charles Lyell, M. Constant Prevost, and others, have amply refuted this unphilosophical theory; which, however, still appears to hold its ground to some extent on the Continent, through the prestige of the great names attached to it. It may, therefore, not be wholly useless to adduce some additional proofs of its unwarrantable character. But I must first be permitted to remark, that even Sir Charles Lyell, while supporting the view indicated above, of the generally eruptive origin of volcanic cones, has had recourse, in the case of some craters, to another agency, the influence of which I am induced to think he over-rates;—I mean the excavating power of the sea in forming what he calls "craters of denudation." This phrase, I think, he first employed in a paper on the subject read before this Society in December 1849. It is not repeated in the latest edition of his "Principles," and I imagine, therefore, that he is no longer desirous of maintaining its propriety.

I by no means doubt, that in the case of craters formed beneath the sea, or in such close vicinity to it as to allow its waves and currents to enter and sweep round their interiors, these circumstances must have considerably modified the result. In the former case, that of subaqueous eruption, the resistance of the water above the vent would probably tend to throw off the ejected materials over a wider area. And thus, perhaps, we may account for the vast horizontal dimensions of the great crateriform basins of Italy,—Bolsena, Bracciano, Albano, and others, evidently of submarine origin. In the latter case, that of subaërial craters to which the sea has had access through some lateral opening, no doubt great degradation of their internal slopes and cliffs, as well as of the outside, will have often taken place. Many, indeed, will have had their enclosure reduced to a mere skeleton, like Santorin. Some, like Graham's Isle, have been entirely swept away. But the question being as to the *origin* of these crateriform hollows, not as to the cause of any subsequent alteration of figure, this, I believe, may in every instance, without exception, be most reasonably referred to volcanic explosive eruptions. And, therefore, the employment of such a phrase as "craters of denudation," in contradistinction to "craters of eruption," can only lead to a wrong conception of the originating forces.

Where, indeed, is to be found a crater, the formation of which cannot be accounted for (making allowance for the subsequent modifications already referred to) by eruptive phænomena of the same character as those which have before the eyes of trustworthy observers repeatedly drilled enormous craters through the axis of the cone of Vesuvius?

Is it the vast size of some craters which should render such an origin incredible in their instances? For example,—of the Val di Bué on the flank of Etna, the Caldera of Teneriffe, that of Palma, Santorini, or the external crater of Barren Island; which measure some three, five, or even six miles in diameter? But the crater of Vesuvius, formed in 1822, before my eyes, by explosions lasting twenty days, measured a mile in diameter, and was more than a thousand feet deep. The old crater of Somma, which half encircles the cone of Vesuvius, is about three times as wide as the crater of 1822. Are we, then, on that account alone, to believe that it could not have been produced by an eruption of proportionately greater violence,—when, too, such an eruption is known to have occurred about the time this crater must have been formed, namely in the year 79, and to have overwhelmed three cities at the base of the mountain beneath its enormous fragmentary ejections? Is it not, on the contrary, much more in accordance with sound philosophy to ascribe the excavation of the old concentric crater of Somma to the same cause which but the other day was seen to excavate the new crater of Vesuvius, through the heart of the same mountain, than to invent for the former a different and fanciful process? But if Somma be admitted, notwithstanding its extent, to be a true crater of eruption, the same origin cannot be denied to that of Palma, Santorini, or others, on the ground of their size, which scarcely, if at all, exceeds that of Somma.

Sir Charles Lyell seems to doubt the Val di Bué being a true crater of eruption upon two grounds. First, because the beds composing the surrounding cliffs do not show the usual quâ-quâ-versal dip, but generally slope towards the sea. This, however, is merely the result of the eruption having broken out on one side of the central axis of the mountain,—a circumstance of frequent occurrence; and naturally so, because the old central vent is apt to be sealed up by the consolidated products of former eruptions, and the point of least resistance to the subterranean eruptive force will often, therefore, be a little on one side,—probably on a fresh point of a fissure broken through the flank of the mountain.

In fact, there must be a contest between the resisting powers of the sides of the mountain and of its upper part; and the weakest part, whichever it is, will give way, and be blown up.

Sir Charles's second reason is, that a sufficient amount of conglomerates is not to be seen on the mountain-slopes around the Val di Bué, to account for the vacuity. But, besides that he himself speaks of "enormous masses of scoriæ on the flanks of Etna," it should be remembered that the aëriform explosions, when long continued, triturate the ejected matters, owing to their repeated fall into and rejection from the crater, to such a degree as to reduce the greater part at length to an impalpable powder, which is carried by the winds to a distance, sometimes of hundreds of miles, and spread in a thin layer over an enormous area of sea or land. And, moreover, the larger the dimensions of any crater, the more powerful and enduring will have been, in all probability, the explosions, and the more thoroughly triturated, during the process of its gradual enlargement, would be the fragments thrown up by them.

I remember being exceedingly surprised, after the termination of the Vesuvian eruption of 1822, forming a continual fountain of stones and ashes some miles in height, lasting through twenty days, and in the end completely gutting the mountain, to find that the prodigious amount of fragmentary matter thrown out from the crater had coated the outer slopes of the mountain only to an average thickness of a foot or two at most. But then the ashes which day by day were reduced to a finer and at length to an impalpable powder, so fine as to penetrate the closest rooms in the houses of Naples, were borne to vast distances by the winds. Much, too, was carried down into the plain, or the sea below the mountain, by the torrents of rain (producing *lave di fango*, or mud-lavas), such as overwhelmed Herculaneum, and which accompanied, as usual, the paroxysmal eruption of 1822.

Indeed, if we consider the statements adduced on good authority, of the prodigious distances to which ashes, and even large fragments of lapillo and of pumice, have been occasionally borne away from some of the volcanoes of South America and the Pacific (as, for example, in the eruption of Coseguina in 1835, and of Galongoon in 1822),—distances of more than a thousand miles (a large segment of the circumference of the globe), the whole of which intermediate space must have been strewn with them (and, in the first of these instances, it is said, to the depth of ten feet at the distance of twenty-four miles from the volcano), we may well conceive that eruptions productive of such an enormous amount of ejected matters may (nay, must) have blown into the air entire mountains of a magnitude far exceeding that of Vesuvius and Somma itself, or the bulk of matter wanting in the Val di Bué, and left in their place craters of corresponding dimensions.

Sir Charles Lyell suggests (as others have done before him), in regard to some of the largest known craters, another possible origin, which he calls *Engulfment*—that is, the subsidence of the upper part, or a large area, of a volcanic mountain into some abyss suddenly opened beneath. With respect to this supposition, without attempting to dispute its possibility, I must say that I am not aware of any such process having been ever witnessed by any credible observer so placed as to be able to distinguish between engulfment and ejection; and consequently that it were well to be cautious in admitting the occurrence of such a phænomenon, if the ordinary mode of action be sufficient to explain the facts really observed. We possess reports, it is true, of eruptions and earthquakes in Java, Sumatra, the Andes, and elsewhere, having caused the disappearance of the entire summit of a mountain, leaving a vast cavity in its place. But this is precisely the result that was observable after the eruption of Vesuvius in 1822. And in that instance we know there was no subsidence. The leading example usually adduced of such immense (supposed) engulfments is the truncation of the lofty cone of Papandayang, in Java, by an eruption in the year 1772. There, it is always said, a great area of the volcano "fell in and disappeared," swallowed up in the bowels of the earth, together with forty villages and their inhabitants. Such are the phrases usually made use of on these occasions, and very naturally so, by alarmed and unscientific observers. But recent explorers, especially Professor Junghuhn, have stated that these towns and villages of Papandayang were not swallowed up at all, but buried, like Pompeii, under the ejectamenta of the volcano; and Dr. Junghuhn, therefore, very properly refers the truncation of the mountain to eruptive explosions, rather than to subsidence.

It is, no doubt, quite conceivable, that within a volcanic mountain some internal reservoir, or subterranean lake of liquified lava, coated over by a crust of hardened rock or the accumulation of fragmentary matter, may be *tapped*, as it were, by an earthquake, and empty itself out of an aperture in the side of the mountain at a low level, leaving a cavity, which another earthquake, or the explosion of vapour and gases accumulated within it and increasing in temperature, may cause to burst, like a vast bubble,—the overlying crust of rocks falling inwards. But such a supposition is, in the present state of our knowledge, purely conjectural, and unwarranted, if, as I have endeavoured to show, the ordinary phænomena of eruption suffice to account for the formation of the largest known craters. If it is to be resorted to in any case, it would be, perhaps, in that of the very small pit-craters, occasionally met with in volcanic districts, such as the Gour de Tazana, and the lakes Pavin, Du Bouchet, and Servières in Central France. But even these show marks of explosive eruption in the scoriæ sprinkled around their banks. And the occurrence of even a single scoria is certain proof of some explosions having taken place from a body of liquid lava beneath; though, as I have said, this *may* have been accompanied or followed by engulfment. Perhaps the singular character of the crater of Kilauea, in Owyhee, may be thought to claim for it an origin in subsidence rather than eruption. It is described as a vast sudden depression in what would otherwise be almost a level plain, on the side of the gently sloping volcanic mountain of Mauna Roa. It has an irregularly oval form, from three to five miles in diameter, and is usually encircled by vertical cliffs some hundred feet high. Its bottom consists of a lake of lava, on some points (which occasionally change their situation) in continual ebullition, and at a white heat; but coated over for the most part by an indurated crust upon which it is often possible to walk. Sometimes, however, the incrusted portion is in the centre of the lake, forming a rough platform, surrounded by a circle of incandescent and seemingly fused lava,—sometimes the outer circle forms a solid shelf, within which an inner basin of lava boils at a greater or less depth below its edge. It is evident, from the interesting story of this crater given by Professor Dana, in the 'American Journal of Science,' as gathered from the relations of various observers during nearly a century past, that the surface of a vast boiling lake of subterranean lava existing here, rises and sinks at irregular intervals of several years in duration; sometimes filling the entire cavity, and even pouring over its outer margin sheets of a very liquid lava, —sometimes sinking to a depth of a thousand feet or more,—especially when some outburst from a lower vent, or chain of vents, has *tapped* the internal reservoir. But, however interesting the characteristic features of this crater, both from the facilities it affords for observation, and the great scale on which they are developed, they do not seem to me to prove the origin of the cavity other than that of ordinary craters. The phænomena of Kilauea are not so exceptional as, at first view, might be supposed. Visitors who looked down into the great Vesuvian crater for a few years after its formation in 1822, saw pools of liquid and incandescent lava at its bottom, and small cones of scoriæ thrown up by an almost constant ebullition. The difference in the violence of the explosions, and in the amount of ejected scoriæ, arises, no doubt, as Professor Dana very justly observes, from the difference in the relative liquidity of the lavas,—those of Kilauea being very liquid, those of Vesuvius much more viscid and unyielding*. So also during the Vesuvian eruption of 1753,

* Dana, 'American Journal,' 1850, vol. ix. p. 383.

persons who ventured to the summit of the cone observed jets of liquid lava thrown up from the surface of a mass which occupied the bottom of the crater, and conducted itself exactly in the manner of a liquid in ebullition. Spallanzani remarked a similar appearance within the great crater of Etna in 1788. In the volcano of the Isle of Bourbon, Bory de St. Vincent describes a source of very liquid and glassy lava ceaselessly and somewhat tranquilly boiling over in concentric waves from the summit of a dome-shaped hillock composed of its overflowings.

Circular form of Craters.—A consideration which has not, perhaps, been sufficiently adverted to by geologists speculating on the origin of volcanic craters, is the cause of their invariably circular or nearly circular figure. If I am right in attributing their formation exclusively to aëriform explosions, it follows that each is in fact simply the external orifice of a more or less cylindrical bore drilled through the pre-existent rocks by repeated discharges of highly expansive aëriform fluids (probably for the most part steam) forcing their way upwards at some weak point; and that it is to the equal pressure in all directions of the expanding fluid that the circular form of the section of this orifice is due,—the same cause, in fact, which gives a spherical form to a bubble of air or gas rising through water. Indeed the eruptive explosions must be considered as occasioned by the rise of a succession of enormous bubbles from a great depth in the fluid lava below. Each single explosion attests the bursting of such a bubble from the surface of the liquid mass of lava in the vent. In moderately tranquil eruptions these succeed each other at considerable intervals. In the case of Stromboli, I noted that about five minutes usually occurred between every two explosions. When the eruption assumes a violent character, as in the Vesuvian one of 1822, the eructations, for such they are, succeed each other so rapidly as to produce an almost continuous roar, like the blowing-off of a thousand steam-boilers. And each explosion gives birth to one of those great globular volumes of white vapour, which, rolling over and over each other as they rise in the air in a vast column, occasion one of the most remarkable and magnificent appearances of a paroxysmal volcanic eruption. In the midst of these clouds of snowy vapour, a black column of stones, scoriæ, and ashes may be seen to shoot up to a vast height, generally attended with copious discharges of electricity generated by the friction of the ejected fragments, and forming a singular contrast to the jet of aëriform matters.

In some rare cases it is possible to witness the actual rise and bursting of these great bubbles of vapour. Spallanzani on his visit to Stromboli in 1780 saw the liquid surface of lava at a white heat within the orifice of the volcano surge alternately upwards, and after bursting like a great bubble, fall back again out of sight. In 1819 I was myself able to witness the same interesting phænomenon probably from the same position, a high point of the external crater-rim which overlooks the vent. At each belch, a shower of tattered fragments of lava, torn from the surface of the bubble as it broke, rose into the air with a cloud of vapour and a fierce roar; while steam seemed to be at intervals blowing off from another neighbouring vent. Hoffman, who visited the same volcano a few years later, describes in minute detail precisely the same phænomena.

The vast size of some craters, already noticed, may afford a notion of the enormous volumes of gasiform matter that must have been discharged through them at the time of their formation by continuous explosions lasting for weeks and even months; since each individual bubble of vapour must have been of a magnitude to fill the entire horizontal section of the crater; and even for some time to aid in enlarging the area of this aperture by violent pressure against its rocky sides. The prodigious force with which they ascend, and therefore the great depth at which they are generated, may be judged from the vast vertical height, measured in miles, to which they have been seen to shoot up a continuous columnar fountain of ejections, consisting not merely of scoriæ and ashes, but often of rocky fragments of great size.

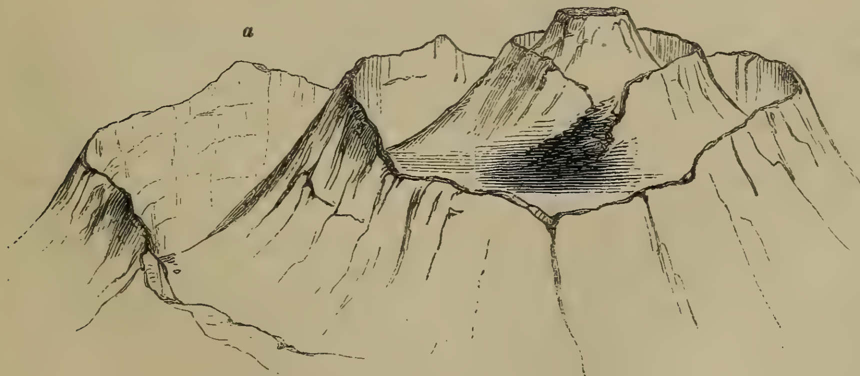
These, by their mutual friction, as they alternately fall back and are thrown up again, become, as already has been said, greatly comminuted; and the source of the explosive vapours having sooner or later exhausted its energies, the accumulation of these ashes in the vent at length appears to stifle their further development, and quiescence for a time ensues. [I am speaking here, of course, of the case of such a paroxysmal eruption as I had the advantage of witnessing in 1822.]

I have said that every crater is more or less circular in figure; but, since the orifice of discharge will almost necessarily be opened on the least resisting point of some fissure broken through the solid pre-existing rocks, we might expect its section to be often lengthened in the direction of this fissure, and consequently to be rather oval than strictly circular. And this expectation is justified by observation. Sometimes two orifices have been opened upon the same fissure so near together that their craters or cones intersect each other. In the range of Puys of Auvergne and the Velay such examples are frequent. And in the eruption of 1850 of Vesuvius two craters were formed on the summit of the cone divided only by a narrow ridge; their common horizontal axis coinciding with the line of the great fissure, which in the preceding year had been visibly broken through the side of the cone towards the north-east. Sometimes aëriform explosions take place from openings upon lateral fissures, and produce those minor, or (as they are often called) parasitic cones, of which several examples occur on the flanks both of Vesuvius and Etna. At other times, the explosions are confined to the central vent of the volcano, the lava alone welling out, perhaps, at some lateral orifice. This, indeed, is the normal character of these phænomena. And it is this habitual predilection (as it may be called) of volcanic eruptions for the same identical vent, that occasions in so many instances the heaping up of some vast mountain mass above and around it, subject to the occasional blowing up of the central portion, to be re-formed again and again by subsequent eruptions.

The result of the irregular alternation of these paroxysmal explosions and subsequent gradual expulsions of new matter is the appearance, so common in volcanic mountains, of a minor and central cone with its crater, rising within the circumference of some larger crater of earlier date, or in its immediate vicinity. The walls of the latter crater are of course often broken down on one or more sides (generally on the line of the original fissure);—perhaps reduced to a mere segment of its original circuit, by the combined operation of volcanic convulsions and aqueous erosions. Whoever will take the trouble to examine carefully an accurate map, on a sufficiently large scale, of almost any volcanic district (such, for example, as Vesuvius and the Phlegræan Fields, Etna and the Lipari Isles, the Roman Territory, the Grecian Archipelago, Madeira, Teneriffe, the Azores, Bourbon, St. Helena, Barren Island, the Leeward Isles, &c.), will see numerous unquestionable examples of this law by which crater is formed within crater, and new cones upon the ruins of old ones.

History of Vesuvius.—At the risk of repetition, I must be permitted to illustrate this law by the trite, but instructive, example of Vesuvius,—which only comes so often before us because from its proximity to Naples it has been open to more constant and accurate observations than any other known volcanic mountain. What, in brief, is the history of this volcano during the last century? Precisely one hundred years ago, in the year 1756, Vesuvius possessed no less than three cones and craters, one within the other, like a nest of boxes, besides the great encircling crater and cone of Somma (fig. 1). Sir W. Hamilton gives us a drawing of its appearance in this state.

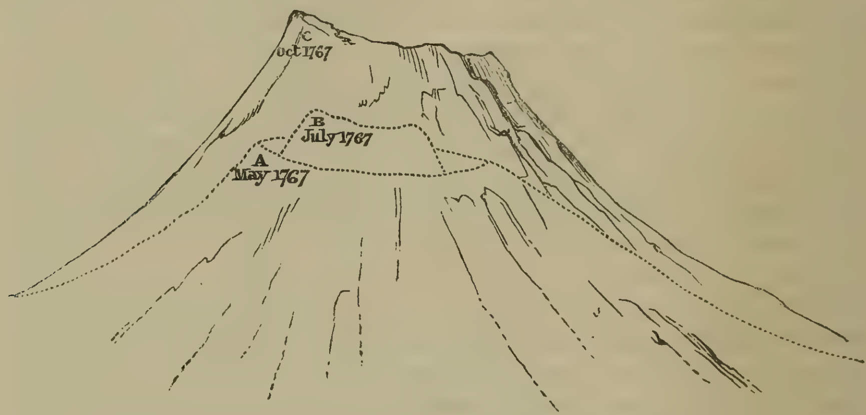
Fig. 1.—*Outline-sketch of Vesuvius as it existed in* 1756. (After Sir W. Hamilton.)



a. Somma.

By the beginning of the year 1767, the continuance of moderate eruptions had obliterated the inmost cone and increased the intermediate one, until it very nearly filled the principal crater (fig. 2, A, B). An eruption in October of that year, 1767, completed the process, and re-formed the single cone into one continuous slope all round from the apex downwards (fig. 2, c). The dotted lines in fig. 2 (after Hamilton) represent the shape of the outer and inner cones before this eruption, and the space between them and the firm outline represents the amount by which the cone was in the intervening

Fig. 2.—*Outline-sketch of Vesuvius as it appeared in October* 1767; *with dotted outlines of its form in July and in May of the same year.*



ten years augmented in bulk and height by the ejectamenta of that eruption. An interval of comparative tranquillity followed, until, in 1794, the paroxysmal eruption occurred, described by Breislak, which completely gutted this cone, then solid, lowered its height, and left a crater of great size bored through its axis. Later eruptions, especially that of 1813, not merely filled up this vast cavity with their products, but once more raised the height of the cone by some hundred feet. When I first saw it in 1819 the top formed a rudely convex platform, rising towards the south, where was its highest point. Several small cones and craters of eruption were in quiet activity upon this plain, and streams of lava trickled from them down the outer slopes of the cone. So things went on until October 1822, when the entire heart of the cone was again thrown out by the formidable explosions I have so often referred to, and a vast crater was opened through it; while the cone itself was found to have lost several hundred feet from its top. In fact, nothing but an outer shell of it was left (fig. 3). Eruptions, however, soon recommenced. In 1826–7 a small cone was formed at the bottom of the crater, and, continuing in activity, had reached a height which rendered it visible from Naples in 1829, when of course it must have nearly filled up the crater. In 1830 it was 200 feet higher than the crater's rim; and in 1831 this cavity was completely filled, and the lava-streams began to flow over it down the outer cone. In the winter of that year a violent eruption once more emptied the bowels of the mountain, and left a new crater, which soon began to fill again from ejections upon its floor; and by the month of August 1834 this crater had been in its turn obliterated, and lava overflowed its edge towards Ottaiano. In 1839 the cone was again cleared out, and a new crater appeared in the shape of a vast funnel, accessible to its bottom, which for a few years then remained in a tranquil state. In 1841, however, a small cone began to form within it, and increased so rapidly, that in 1845 it was visible from Naples above the brim of

Fig. 3.—*Crater of Vesuvius after the Eruption of October* 1822.

the crater, which soon after was completely filled. And the cone from that time went on increasing in bulk and height from the effect of minor eruptions, until in 1850 one of a violently explosive character opened the two deep craters on its summit, of which I have already spoken. The more recent eruption of May last, being confined chiefly to a prodigious efflux of lava from the outer side of the cone, unaccompanied by any extraordinary explosive bursts from the summit, has not altered materially the form impressed upon it in 1850.

It is thus seen that within the last 100 years the cone of Vesuvius has been five several times gutted by explosive eruptions of a paroxysmal character, viz. in 1794, 1822, 1831, 1839, and 1850; and its central craters formed in this manner as often gradually refilled with matter, to be again in due time blown into the air. Meanwhile the old external crater of Somma is itself becoming choked up by the accumulation of all the lava-streams and fragmentary matter that are expelled towards the northern and outer side of the cone. It would be, therefore, in exact accordance with the habit of this volcano (as of volcanic mountains in general), if, after some further period either of quiescence or of moderate activity, the entire cone of Vesuvius should be blown up by a more than ordinarily violent paroxysm, and the crater of Somma itself reformed.

With this well-authenticated history of the mountain within our knowledge, would it not be wholly unphilosophical to deny (except upon such grounds of impossibility as have never been adduced) that the larger containing crater in the case of Vesuvius (and the argument applies to other similar volcanic mountains) had the same origin as the smaller contained ones; and that the external cones were produced in the same manner as the internal, and similarly constituted ones? And therefore those who refuse to believe the former to be of eruptive origin must be prepared to extend their incredulity to the latter. Indeed the elevation-crater theorists usually do not shrink from this consequence. With them the cone of Vesuvius, and that of Monte Nuovo itself, were not the products of eruption, but of elevatory expansion by a single shock. Obviously, it ought to follow, that no volcanic mountain was ever in eruption at all, that the whole is an ocular illusion; at least, that the lava-streams we see pouring for weeks and months from the summit of a cone and hardening there, and the enormous showers of fragmentary matter which, during equally long periods, we see thrown up from the crater and falling on the surface of the cone, do not, even in the lapse of ages, add to its bulk or tend by their frequent repetition to compose the substance of a volcanic mountain, but, by some unaccountable process, disappear without leaving a trace behind. I own that, to my mind, such an hypothesis is wholly unintelligible. I see in the ordinary phænomena of a volcanic mountain, such as I have described them in the brief record of the principal eruptions of Vesuvius during the last century, a simple and natural process by which such a mountain is gradually built up; and, having observed this mode of formation going on in some instances before my eyes, I think it reasonable to apply it to explain the mode of formation of other mountains of the same class, with their cones and craters, old and new, central and lateral, or parasitic; and making allowance, as I said at first, for a certain amount of internal accretion and elevation, by means of intrusive dykes and earthquake shocks, I know nothing in the appearance, figure, or structure of any volcanic mountain yet discovered, which such an ordinary and observed mode of formation will not account for.

II. *The nature of the liquidity of lavas.*—So much for that branch of my subject,—the formation of cones and craters. I wish now to ask attention to some circumstances respecting the mode of emission and nature of the lavas that proceed from them. I have already spoken of the comparatively tranquil manner in which some lava-streams are seen to well out from the flank of a volcano, or its summit, and the probability that differences in the liquidity or viscosity of the heated matter at the time of its efflux may occasion corresponding differences in the character of the phænomena. Observation confirms this expectation; and it has been remarked, that the very liquid and vitrified lavas, such as those of Kilauea and Bourbon, are poured out more or less tranquilly without any very violent explosions, their imprisoned vapours evidently escaping with comparative ease, while the more viscous and ultimately stony lavas, possessing a minor degree of liquidity, and consequently not allowing so easy a passage to the vapours that rise through, and struggle to escape from them, are protruded with fiercer explosive bursts, and the ejection of far greater quantities of scoriæ and other fragmentary matters.

This observation, coupled with other reasons to which I shall presently advert, led me to an opinion expressed in the works above referred to, that the ordinary crystalline or granular lavas (making exception of the vitreous varieties), although at a white heat at the moment of their emission from a volcanic vent, are not in a state of complete fusion; that a large proportion, at least, if not all, of the crystalline or granular particles of which, when cooled and consolidated, they appear composed, are already formed and solid, their mobility being aided by the intimate dissemination through the mass of a minute but appreciable quantity of some fluid,—in all probability water,—which is prevented from expanding wholly into vapour by the pressure to which it is subjected while within the volcanic vent, or in the interior of the current, until that pressure is sufficiently reduced to allow of its expansion in bubbles, or its escape through pores or cracks, by which it passes into the open air from the surface of the intumescent lava.

I was strengthened in this opinion by several concurrent considerations:—

1. If all lavas are (as they are usually supposed to be) in a state of complete fusion when they issue from a volcano, how is it that they do not all present the same glassy texture which is seen in some, the obsidians, pitchstones, and pumiceous lavas especially, and in the ropy, cavernous, filamentous basalts of Kilauea, Iceland, and Bourbon, and which these very crystalline and stony lavas themselves put on when melted under the blowpipe or in a furnace? The usual answer is, that the granular and crystalline texture is acquired subsequently to emission by slow cooling; and the experiments of Gregory Watt and Sir James Hall are cited in support of this assertion. In the present day, probably the process by which Messrs. Chance and Co., of Birmingham, devitrify a mass of fused basalt (from the Rowley rag, near Dudley) by causing it to cool slowly in an "annealing furnace," would be considered as a strong confirmatory fact.

But there is no fact more certain than this, that the superficial portions, at least, of a lava-current flowing in the open air, do not cool slowly. On the contrary, they are rapidly, I might say instantaneously, upon their exposure, consolidated and cooled down to a temperature which permits them to be handled and even walked upon without damage. How is it that this scoriform crust, or the solid cakes and slabs which so instantly form upon every exposed surface of lava, nay, even the scoriæ which are tossed up in a liquid state by the eruptive jets, and harden while yet in the air before they fall, exhibit on fracture no glassy texture, but much the same earthy or stony grain, and occasionally crystals of considerable size in the solid matter separating their cellular cavities, as is found in the interior of the current which is known to have cooled very slowly? How is it that some lava currents are stony throughout, others vitreous throughout, as, for example, some of the large pumice-streams of Lipari, Iceland, and the Andes?

I have recently visited the manufactory of the Messrs. Chance, at Oldbury, near Birmingham, for the purpose of examining the mode in which the basalt used there (and which is the same upon which Mr. Gregory Watt experimented) conducts itself in their furnaces, and I found, that when the liquid and fused contents of a furnace at a white heat is poured out upon a brick or other floor into the open air, so as to represent a stream of lava flowing out of a volcanic vent, it consolidates throughout, whatever its bulk, into a homogeneous and purely vitreous black obsidian, in fact, an absolute glass, with a conchoidal fracture and sharp cutting edges. It is only when made to consolidate very slowly in an oven kept at a high temperature for some days, that it assumes the deadened and semi-crystalline texture of the manufactured article.

If this process be interrupted, it is found to have commenced by the formation, at numerous points within the vitreous mass, of globular concretions about the size of a small pea, of a lighter colour than the base, and having a pearly lustre and radiated structure. The multiplication and confusion of these crystallites or sphærulites ultimately destroy the glassy character of the substance altogether, and give to it a pearly semi-crystalline texture, without, however, restoring the far more crystalline aspect of the basaltic rock. A similar change may be often observed to have taken place in nature among the vitreous lavas, which pass into pearlstone and pitchstone by the formation of the same kind of sphærulitic concretions, and of course there is no question as to the complete state of fusion in which such lavas have been produced. But there is no trace of such a process in any of the ordinary earthy, and stony or crystalline and porphyritic lavas. I am not aware of a single current from either Etna or Vesuvius having ever exhibited, even on its most rapidly cooled surfaces, any passage into true obsidian, or sphærulitic pearlstone, or any portion of such vitrifactions. A pellicle, or glaze, of a semi-vitreous appearance coats the surface in some parts, or lines the cellular cavities; but it seems evident that the bulk of the matter could not have been at the time of its emission in that thoroughly fused condition which it assumes when melted in a furnace or under the blowpipe.

2. It struck me that temperature does not alone determine the fusion or liquefaction of substances; and that compression may prevent the liquefaction of a solid at a high temperature, just as it prevents the vaporization of a liquid, in the common experiment of boiling water at a lower temperature in a rarefied atmosphere. If so, the intense pressure to which heated lava must be subjected before it rises from the bowels of the earth to discharge itself on the surface, intensified by the reaction of its own expansive force from the confining surfaces, might perhaps prevent its complete fusion, however high the temperature.

3. I had long been impressed by the vast volumes of aqueous and other elastic vapours evidently discharged from every volcano in eruption, and to all appearance the chief agents in the expulsion of lavas from the bowels of the earth. That this vapour is liable to be developed in every part of the mass of lava is shown by the formation of vesicles throughout its substance wherever the pressure is so

reduced as to permit their expansion; for instance, in the superficial portions of a current; and in some lava-currents throughout the entire mass.

The experiments of Mr. Knox, related in a paper read before the Royal Society in 1824 *, had taught me that water in an appreciable quantity is mechanically combined with the elementary particles of all the crystalline rocks of igneous origin. The question, therefore, arose,—Might not the water thus intimately disseminated through a mass of crystalline lava, although at an intense temperature, remain unvaporized, owing to the still greater intensity of the pressure by which it is confined while yet within the bowels of the earth? and would it not under these circumstances exert an intense expansive force upon all the confining molecular or crystalline surfaces between which it lies, and thus occasion a tendency to separation among these solid particles whenever the compressing forces were relaxed, or the temperature increased sufficiently, so as to give a certain degree of mobility to these particles *inter se*, and an imperfect liquidity to the mass composed of them? And, supposing the intumescence thus occasioned to raise any portion of this semi-liquid matter into the open air, would not the instantaneous absorption of caloric from the contiguous particles, that must accompany the vaporization of this water, and its escape in bubbles or pores and through cracks, owing to the nearly absolute cessation of pressure, account for the sudden cooling down and *setting*, or consolidation, of the exposed surfaces, without having undergone complete fusion (except in the case of mere superficial films), notwithstanding their previous intense temperature, amounting even to a white heat?

This supposition seemed to me to account satisfactorily, not only for the absence of a vitreous texture even in superficial portions of many lava-streams, and their instantaneous consolidation on exposure, in cellular or porous slabs and cakes, but also for several other characteristics of igneous rocks, not easily to be reconciled with the idea of their having always issued from the earth in a state of absolute fusion; such, for example, as the cracked and vitrified aspect of the felspar-crystals of many trachytes, the broken and dislocated appearance of the leucites, felspars, and other crystals in many basalts; the frequent arrangement of their longest axes in the direction of the bed of the rock, that is, of the movement of the lava when liquefied; the finer grain often exhibited towards the tail or extremity of a current than at its source, the brecciated lavas which appear to have enveloped fragments in great number of the same material without any fusion even of their finest angles. So also might be explained the more or less spongy, porous, and loosely crystalline texture of many trachytes, and their disposition in thick beds or dome-shaped bosses, attesting their protrusion in a very imperfect state of liquidity, more resembling the intumescence of some kinds of dough in an oven than the fusion of metal in a furnace.

And here let me remark, that Dr. Daubeny, and some other writers on volcanic phænomena, have spoken of the vesicles or air-

* Phil. Trans. 1825.

bladders in lavas, as being proofs of their having been in a state of complete fusion. But have the loaves baked in our ovens been in fusion? The comparison of a cellular scoria with a loaf or a French roll will show that vesicles of precisely similar appearance to those of lavas are producible in substances of a pasty consistence, which owe their liquidity to an aqueous vehicle, the heat applied being only sufficient to develope the contained gases. Other kinds of baked cakes are porous rather than cellular, and aptly represent the texture of the earthy and porous trachytic lavas.

Plutonic rocks.—This theory as to the nature of the liquidity of many lavas appeared to me so reasonable, that I proceeded to examine its applicability to the still more generally crystalline plutonic rocks, from the alteration of which by heat lavas are usually supposed to derive. I asked myself, what would probably be the effect on a mass of granite, for example, containing water intimately combined with its molecular particles, and confined beneath overlying rocks and seas, under circumstances of intense compression, and at the same time high and increasing temperature? Surely a tendency to intumescence, which, wherever, and in proportion to the extent to which, it takes place, must elevate and fracture the overlying rocks, and likewise disintegrate more or less the crystalline particles of the swelling mass, through the irregularities of their internal movements and mutual friction. Many of the crevices broken through the neighbouring rocks would be injected by the intumescent matter. Some may be sufficiently enlarged to allow of its forcing its way into the open air as a lava, perhaps accompanied by eructations of the gases and vapours developed in the lower parts of the mass, or, should the liquefaction not be sufficient to admit of the rise of aëriform bubbles, as matter of a porous, pasty, or glutinous consistency, perhaps even semisolid in texture and bulky in form.

It might happen that, circumstances occasioning in turn the preponderance of the compressing over the expansive forces (by reason, for example, of a diminution of temperature), portions of the subterranean crystalline mass will, after a partial intumescence of the kind supposed, return to a state of solidity. The result may be a more fine-grained rock, owing to the partial disintegration of the crystals; or, if the disintegration had proceeded sufficiently far, new mineral combinations might take place. Indeed, Watt long since proved that the particles of even apparently solid rocks are capable, through changes in temperature, of internal motion sufficient to admit their rearrangement according to polarity, that is, of crystallization. Still more likely is this result to occur on the condensation or escape of any fluid which had previously kept them from contact with each other, since the crystalline polarity can only exert itself within minute distances. And thus might be accounted for the frequently observed passages of granite and gneiss into syenite, greenstone, trap, or trachyte, and the varieties of mineral composition which these rocks at times exemplify. So also the transitions from the larger crystalline grain to the finer, and the dykes and veins which these rocks so often contain themselves, or intrude into their neighbours. So too the finer grain of the sides, or selvages, of such dykes might be owing to the greater disintegration of the crystals by friction along these sides as the matter was driven through them.

Another problematical fact which this theory of an aqueous vehicle in heated granite would account for, is the usual appearance of the quartz in this rock, not in crystals, but as a paste or base, seeming to be moulded upon the crystals of felspar. Had the rock crystallized from a state of fusion, the felspar, being far more fusible than quartz, might have been expected to be the last, not the first, to crystallize. But if the water disseminated through the rock were supposed to have taken the quartz into solution by aid of the alkalies present in the felspar, the fluid vehicle would in fact become a liquid or gelatinous silicate; and upon consolidation would naturally mould itself on the felspar crystals, or appear as a paste to them. I adduced the hot siliceous springs of Iceland and other volcanic districts as proofs that heated water under such circumstances could dissolve silex.

Those who will take the trouble to refer to the 2nd, 4th, 5th, and 6th chapters of my 'Considerations on Volcanos,' will see that the above is a brief summary of the arguments there put forth, perhaps at too great length, and in a form which may have hindered their obtaining at the time of their publication the attention which I believe they merited.

Certain it is, that they were at that time, now thirty years back, neglected, or generally discredited. I was told that my views were "unchemical." I was represented as asserting incandescent lava to be "cold or thereabouts" *. The igneous and the aqueous origin of certain rocks had been so hotly contested, and fire and water were usually considered so antagonistic, that it seemed at first view an absurdity to imagine that both could be combined in a substance seemingly in fusion. Probably also the idea was scouted at first through the notion that water could not be present within an incandescent mass of lava without causing it to explode like a mine; which might of course be the result of any considerable body of water being localized at one point. But the view I entertained, as has been explained, was that the water (and to some extent, perhaps, liquefied gases), to which I attributed much of the liquidity of some lavas, was disseminated throughout its mass, occupying minute interstices, and in intimate, though probably mechanical, combination with every molecule,—indeed intercalated between the plates even of its solid crystals; and moreover that the pressure to which the rock was subjected while beneath the earth was so enormous as to prevent the vaporization of these minute portions of liquid anywhere except at points where the intensity of temperature and consequently of expansive force overcame the resisting forces, and thereby caused either the formation and rise of great bubbles of vapour from the lower depths of the subterranean lava-mass, or the inflation of minor bubbles and pores throughout it, or at least in the superficial portions which by intumescence were forced into the open air.

Of late, however, views precisely in accordance with the theory

* Westminster Review.

printed by me in 1824 have been put forward, and have attained extensive adhesion among continental geologists.

M. Delesse has proved by experiment the solubility of the silex of rocks in heated water containing either of the mineral alkalies. And, indeed, the manufacture of artificial stone is now carried on in this country (Messrs. Ransom's process) by saturating loose sand with an artificial hydrate of silica. Huge blocks of flint, I understand, are thrown into the hot alkaline water, and melt down like so much sugar.

Again, the experiments of Boutigny have shown that water at a white heat remains unvaporized, in the form of spheroidal globules, in which form it is obvious how readily it would communicate mobility to the solid particles among which it was entangled; and how (according to these experiments) it might flash into bubbles of vapour on the reduction of its temperature by exposure to the air.

M. Deville, in his recent observations on the vapours disengaged from Vesuvius since the eruption of May in last year (for the perusal of which I am indebted to the kindness of my friend Dr. Daubeny), arrived at the conclusion, to use his own words, that "water in the proportion occasionally of 999 per mille must have formed an integral part of the Vesuvian lava at the moment of its emission; and consequently, that in the interior of the incandescent lava there is such an arrangement of molecules, as to permit the gaseous and volatile matters to remain there imprisoned, until in the progress of cooling and consolidation, they evolve themselves."

Above all, M. Scheerer, of Christiania, the eminent Norwegian geologist, who is better acquainted perhaps than any other with the granites of that country, published in 1847 a theory, which, he says, his observations had suggested to him in 1833, on the production of granite, entirely identical with that which I had ventured to suggest in 1824–25. I take the following account of it from the paper read before the Geological Society of France in 1847, and published in the fourth volume of the Bulletin de la Soc. Géol., p. 468.

M. Scheerer attributes what he calls the "plasticity" of granite when protruded on or towards the surface of the earth (a condition evidenced by the veins it throws into the fissures of neighbouring rocks) to the combined action of *water* and heat. He describes the water as "intercalated between the solid atoms of the crystalline and other constituent minerals, endeavouring to escape by its tendency to vaporization, and consequent elasticity, but unable to do so owing to the pressure to which the enclosing mass is subject." He considers the water so contained in granite to be "primitive," that is, one of the original bases of the rock, and not the result of infiltration. He attributes to it the solution of the quartz, aided by the alkali, and the consequent moulding of this mineral on the felspar-crystals. He even goes the length of styling the condition of granite before its protrusion by the term "une bouillie aqueuse," *a granitic broth.*

These theoretical opinions of M. Scheerer appear to have received the assent of M. Elie de Beaumont and other French geologists*.

* See Bulletin de la Soc. Géol. France, new series, vol. iv. p. 1312.

Their exact comformity with those which were first developed in my treatise on Volcanos, published 1824–25, and repeated in the Preface to my volume on Central France in 1826–27, will be evident to any one who will take the trouble to refer to those works.

It is not, however, for the vain purpose of claiming a priority in these views, that I now ask the attention of the Society to them, but because the subject has not, I think, yet attained the consideration it deserves from the geologists of this country; and especially because of its leading, if followed out, to further inferences of considerable importance, which were likewise suggested by me in 1825, but have been hitherto only partially pursued to their legitimate consequences.

Laminated or schistose rocks, slaty cleavage, and folded rocks.—I refer to the mechanical changes in the texture and structure of the plutonic rocks which could not fail to have resulted from the mutual friction of the component crystalline particles attendant on their internal movements, whether caused by mere dilatation and re-compression in place, or by a shifting of the entire mass in any direction, under intense and opposite, but irregular pressures.

I was led to reflect on this by observation of the ribboned pitchstones of Ponza and Ischia, in which, while in a state of vitreous fusion, crystallites had formed (just like those of the Oldbury obsidian), and subsequently been broken up by the movement of the semi-liquid mass, and drawn out into long stripes, giving a ribboned appearance to the rock.

Further examination proved to me that the ribboned trachytes of Ponza and Ischia, and some ribboned clinkstones, owed that character to a similar elongation of the felspar crystals and felspathic particles which they previously contained, in the direction in which the semi-liquid mass flowed, or rather was forced to move, and in which the pores or cells, when there are any, are equally elongated. These observations suggested to my mind the reflection that the solid particles of any crystalline rock which is put in motion while in a state of imperfect solidity, and under the influence, of opposing pressures, must be subject to a great amount of mutual friction or disturbance, by which their final arrangement when wholly consolidated will be determined.

Thus suppose a mass of granite, of which A B (fig. 4) represents

Fig. 4.

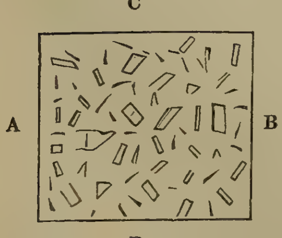
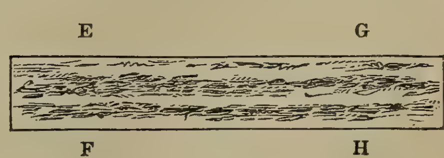


Fig. 5.



the section, consisting of crystals of felspar and mica irregularly disposed in a basis of more or less liquefied or gelatinous silex, exposed to movement in the direction A B, while under vast pressure both from above and below, that is in the opposite directions C and D. Whether the surface, C, or D, or both, remained fixed, or merely moved, owing to resistances, at a slower rate than the other parts, the crystals in the latter would be turned round by internal friction, and rearranged and drawn out in stripes or planes in the direction of the motion, while the proportionate dimensions of the mass would be equally varied so as to produce a section something like E, F, G, H (fig. 5), in fact, a rock which, if no further change occurred in it except consolidation in place, would have all the characteristics of *gneiss*. The same movement, if still further continued, might, it appeared to me, be expected to disintegrate the angular crystals of felspar altogether, so as to cause them to disappear, perhaps to force their elementary molecules to melt into the intensely heated silicate, to which they would impart their alkalies. And the resulting rock, supposing the laminæ of the mica-crystals to slide readily past each other, when lubricated by the silicate, and not therefore to be so far disintegrated as those of felspar (as from their peculiar form might be expected), would put on a lamellar structure, and very much resemble *mica-schist*,—especially since the great flexibility of the mica would render its laminæ extremely liable to yield to the irregularities of pressure pervading the mass, in a variety of directions, and consequently to take such wavings and contortions as are often exemplified in that rock. Whoever will examine the tortuous way in which the plates of mica envelope and bend round nodules of half-melted quartz or crystals of garnet in mica-schist, will be convinced, I think, that the whole mass has been subjected to great internal movement and consequent friction in the direction of the layers of mica, while under intense pressure, and in a comparatively softened state, the mica being lubricated, as it were, by a vehicle of liquid or gelatinous quartz. Whatever fissures or cracks were formed during this movement in the semi-solid rock, or subsequently, so long as the silicate remained unconsolidated, would be necessarily filled by it, and ultimately appear in the shape of the quartz-veins so frequent in this class of rocks.

Under this supposition gneiss and mica-schist would bear the same relation to granite as the ribboned trachytes and schistose lavas (clinkstone) to ordinary crystallized or granular trachyte; and the quartz-rocks associated with granite, represent the quartzose trachytes of Hungary, Ponza, and the Andes.

These views, developed by me in 1825, I cannot but think, deserve the attention of geologists engaged in investigating the origin of the so-called "plutonic" and "metamorphic" rocks. It seems to me more probable that some process of this kind may have metamorphosed granite into the laminated rocks of plutonic origin, gneiss, and mica-schist, than that these rocks should have been formed by the mere fusion and reconsolidation or crystallization in place of sedimentary strata *already laminated*, according to the usual "metamorphic" doctrine. I can understand the clay-slates and other fine-grained schists to have been formed through the mechanical disintegration of mica-schist, but not mica-schist by the baking or melting and cooling of the clay-slates in place, in the manner suggested by Sir C. Lyell.

In the formation of the clay-slates, perhaps, the action of heat was not concerned (except as engendering the pressure to which they have evidently been subjected), but that of water or an aqueous silicate only. Still in their case also internal movements and mutual friction of the component particles under extreme and irregular opposing pressures have, I am convinced, had a primary influence in occasioning that parallel arrangement of the scaly and flaky micaceous particles to which their slaty cleavage is due. This, at least, was the conviction forced upon my mind by a close examination of the fissile clinkstone of the Mont Dor and Mezen, which is used for roofing-slate, and is in its lamination and cleavage undistinguishable from many clay-slates. And that opinion I recorded at the time in my 'Considerations on Volcanos *.'

I have since found this view of the origin of slaty cleavage supported by Mr. Darwin in his work on 'Volcanic Islands,' and by Mr. Sorby in his paper on slaty cleavage in the Edinburgh Philosophical Journal for 1853. I need not say that such support affords strong confirmation of its correctness.

Of course we are led to connect the movements under extreme pressure, to which this peculiar texture of the laminated rocks is here attributed, with the action of those same forces by which their beds have been so generally bent and contorted into a series of folds or wrinkles, more or less at right angles to the general strike.

If we seek to discover under what circumstances these flexures were brought about, we can hardly be wrong in ascribing them to the same violent process by which they have been elevated, usually on the flanks of some protruded ridge or enormous dyke of crystalline rock, which is seen to form the axis of the mountain-range to which they belong.

Now what may we suppose to have been the character of this elevatory process?

The phænomena of active volcanos, and the protrusion of intumescent crystalline matter on so many points of the earth's surface, and at all periods of its history, may be admitted to prove the continued existence beneath a very large area of that surface—if not the whole—of a mass of intensely heated crystalline matter, having disseminated throughout its substance (in the manner already dwelt upon) some fluid or fluids, such as water, affording an imperfect liquidity to the mass, and, by its intense elastic force, communicating to it a powerful tendency to expansion. Now suppose any considerable diminution to occur locally in the amount of pressure confining this expansible mass beneath the crust of the globe,—such as might be brought about by any extraordinary concurrence of the ordinary barometric, tidal, oceanic, or excavating causes (not to suggest others),—or, on the other hand, any considerable increase of its expansive tendency, owing to a local increase of temperature, from some

* See pp. 103, 144, and 202.

unknown, but easily imagined, cause,—we should anticipate, as the necessary result, the violent fracture and elevation of the overlying crust of rocks, and the extrusion through some principal fissure, or line of fracture, of a ridge of the subterranean intumescent crystalline matter.

It seems very probable that under such circumstances the central axis of the protruded ridge may retain its irregularly crystalline grain and structure, but that the portions of crystalline matter that from either side would rush or be thrust up by pressure from behind (consisting partly of the weight of the overlying rocks on the semi-liquid matter below them) towards the opening should be subjected to so much internal friction of their crystalline particles, and so much pressure at right angles, or nearly so, to the direction of the movement, as must stretch and draw them out into parallel planes,—just as happened evidently to the striped and ribboned trachytes in the protruded dykes of Ponza and Palmarola. This friction and pressure would be extreme, of course, along the lateral parts of the protruded mass, that is, the selvages of the great dyke; which, if the original mass were granite, would thus appear composed of an axis of granite, passing on either side into gneiss (or squeezed granite) and further on into mica-schist.

But every irregularity, whether on the large or the small scale, obstructing more or less the even motion of the layers, must create a waving or contortion in them, especially in the planes of slippery mica-plates, such as is exemplified even in hand-specimens of the Ponza trachytes, and also on the largest scale in the same locality. And the extreme irregularities of motion, occasioned on the upper layers of the intumescent mass by the pressure and resistance of the overlying beds, may be expected to carry their wavings still further, and at the throat of the fissure where the squeeze and jam of the protruded matters must be at its maximum, to occasion those enormous and repeated zigzag foldings of the laminated beds, so frequently observed in mica- and chlorite-schists in such positions.

Meantime another influence would be similarly affecting the overlying stratified rocks above, or on the outer flanks of the elevated axis, namely their own specific gravity, urging them to slide or slip laterally when tilted up at (perhaps) a considerable angle on either side. The more compact and indurated strata would be partly fractured into cliffy masses, partly broken up into breccias and conglomerates by this movement; but the softer beds, especially those which were saturated with water (perhaps even yet under the sea), or which contained interstratified beds of silt, shale, or clay, permeated with water, would glide laterally away from the axis in extensive land-slips, and be wrinkled up into vast foldings under the intense pressure compounded of their own weight, and that perhaps of portions of the protruded matter thrust against them,—in a manner very similar to the contortions produced in the more crystalline laminated rocks by the violent squeeze which accompanied *their* protrusion. It may even be difficult to draw a line between the effects of these two replicating and fracturing forces. But, together, they seem to me sufficient to account for most of the phænomena of the kind observable in mountain-chains.

These were the ideas on this subject which I endeavoured to develope, though very imperfectly I am aware, in the more theoretic portion of my work on volcanos, so often referred to, and they were illustrated by a rude ideal section of an elevated mountain-chain in the frontispiece to the volume. I still think they will be found a not improbable solution of this the greatest problem in the dynamics of geology. It appears to me, that the results would be much the same, whether we suppose this elevatory action to have been *paroxysmal* and simultaneous, or gradual, taking place by minor and successive expansive throes or shocks, or even still more slowly in the manner of a *creep*, as Sir Charles Lyell would probably conceive it to have operated, and to be still continuing. On these last assumptions, the earthquake-shocks which certainly accompany at present every effort of elevation, and appear to be propagated in waves through the substance of the earth's crust, in directions usually at right angles to the principal axes of elevation, or fissures of crystalline protrusion, may indicate the force by which the extreme replications and slaty cleavage of the laminated beds are occasioned.

I would ask of geologists to consider whether such a mode of protrusion of the laminated crystalline rocks and of the lateral replication of the more earthy schists and marine strata, as is here suggested, does not accord with the general facts known respecting their position? Let me take two descriptions of the general position of the crystalline rocks from two writers of experience, judgement, and wholly impartial character, as respects the theory here indicated. Mr. Evan Hopkins* gives as the results of his extensive mining experience in the Andes and elsewhere, "that the great base [of all mountain-chains] is below more or less granitic, strongly saturated with mineral waters, and that this passes upwards by insensible gradations from a crystalline homogeneous compound into a laminated rock, such as gneiss, and still higher up into schists in vertical planes; the peculiar varieties of the higher rocks depending on the mineral character of the 'parent rock' below; the schistose rocks forming, in short, the external terminations of the great universal crystalline base,"—that is to say (as I would phrase it), the squeezed out, and therefore laminated, upper and lateral portions of the inferior crystalline mass.

Mr. Ruskin, in his recently published volume, having closely examined the structure of the Alps with the eye of a geologist no less than of a painter, but certainly without any theory to support, declares that the central axes of "irregular crystallines" (as he calls the granitic rocks) uniformly graduate on either side into the foliated or "slaty crystallines," *i. e.* into gneiss and ultimately mica- and chlorite-schists.

One point observed in the structure of the Alps and many other

* Quart. Journ. Geol. Soc. vol. xi. p. 144.

mountain-chains I may notice before I conclude, namely the occasional dip of the elevated strata towards the central axis of extruded crystalline rock, producing a synclinal, instead of an anticlinal, ridge. Another section copied loosely in the frontispiece to my work on volcanos, from Von Buch's paper on the Tyrol, may show the mode in which I conceive this to have occurred through the injection of a mass of crystalline matter into a wedge-shaped fissure, opening downwards; such as must have frequently occurred among the fractures of the overlying strata—giving occasion in some cases to the further rise of the heated and intumescent matter into the hollow between the outer slopes of the synclinal valley. It would indeed accord with the theory suggested above, if such dykes or extravasations at synclinal axes were found to alternate frequently with the elevated anticlinal axes, for the cracks formed in indurated beds of overlying rock would very frequently open alternately upwards and downwards*.

Time will not allow of my dwelling now upon other points explanatory of geological problems, which are afforded by the theory of an expansive subterranean crystalline mass preserved by external pressure in a more or less solid condition beneath the crust of the globe, but always ready to expand and perhaps to intumesce upwards on any relaxation occurring in the overlying pressure. But I suggest it now, as I did thirty years since, as the solution most reconcileable with the known facts of the structure and relative position of the great elevated rock-formations of the globe, and as a theory founded, not upon mere guess-work, but on careful and extended observation of the phænomena of both active and extinct volcanos, and the disposition of volcanic products of all ages.

May 7, 1856.

The following communications were read:—

1. *On some* Footmarks *in the* Millstone Grit *of* Tintwistle, Cheshire. By E. W. Binney, Esq., F.G.S.

Some years since a series of strange impressions was found in one of the lower beds of Millstone Grit in a quarry belonging to James Rhodes, Esq., at Rhodes Wood, near Tintwistle, in Mottram-en-Longdendale, Cheshire. Mr. Rhodes was much struck with the impressions, from the fact of two of them bearing some resemblance to the mark of a human foot; and the workmen employed in the quarry, when they first showed him the impressions, remarked, "Master, somebody has been here before us." During several weeks the quarry was visited by many hundreds of people from Glossop and the surrounding neighbourhood. The common opinion was that the impressions were the footprints of some of Noah's

* See the diagram at p. 205 of 'Volcanos.'

SINCE the above paper was in print my attention has been called to a translation, in our Journal for February 1848, of the essay of Prof. C. F. Naumann, "On the probable eruptive origin of several kinds of gneiss, &c.," in which views very similar to those here entertained are given, in relation to the laminated and fissile structure of the crystalline plutonic rocks,—reference being there made to my observations on the *Trachytes* of Ponza and Palmarola, and the *Phonolites* generally, as illustrating the mode of formation of gneiss and mica-schist, and leading to the inference that these rocks owe their structural parallelism rather to pressure and friction accompanying their eruptive protrusion, than to the effect of metamorphic action upon sedimentary strata. I rejoice to find my early views on the subject supported by such high authority, and trust that other geologists of weight and influence may thereby be induced to give them their unbiassed consideration.

family. This was founded on the supposition that the ark had rested on the high hills above Woodhead. Other parties, who would not so readily admit of this change of all previously received ideas as to the resting-place of the Ark, contended that they were the footprints of people who had lived before the flood. These opinions are introduced for the purpose of showing how great was the resemblance of some of the specimens to the impressions of a human foot, in the eyes of ordinary people.

The writer of this notice went over to Tintwistle, and examined the impressions as they lay in the rock, and before they had been at all disturbed. At that time there were five marks visible, and the commencement and termination of the track could not be perceived, owing to the circumstance of its commencing near some old workings, and proceeding up into the hill-side where the rock had not been excavated; so there were in all probability many more impressions, if the track could have been followed in either direction. However, only one series was met with; and, from the effect their discovery produced on the workmen, it appears pretty certain that none had been met with there for some time.

As previously stated, the quarry is in the lowest part of the Millstone Grit; certainly 1000 feet down in that deposit, and very near to the Limestone Shale. The strata dipped towards 80° west of south at an angle of 12°. At a depth of about 25 feet in the quarry which is situate on the hill-side opposite to that on which runs the Manchester and Sheffield Railway, a series of five casts taken from as many moulds was met with. They all lay in a straight line, and nearly on the rise and dip of the strata.

The mould or impression on the western side (No. 1 in the drawing*) was nearly oval in shape, turned a little towards the north; the two next (Nos. 2 and 3) somewhat resembled in form marks made on very wet sand by a human foot with a shoe on; and the two on the eastern side (Nos. 4 and 5) resembled No. 1, with the exception of being rather more circular than that one.

The long impressions did not part with their casts in the stone so well as the oval and circular ones; consequently they are not so clean and sharp; indeed part of the cast still remains in them, the stone having broken. In all, the wet sand of the matrix appears to have partly run into the mould before the cast was taken, and they have more the appearance of having been made under water than on an exposed sandy beach.

No two of the impressions were exactly alike in shape; but the bulk of the wet sand which had been displaced out of the holes was the same in each instance, whether the impressions were deep and short, or shallow and long; and the sand removed was forced up on the western side, *and on that side only*, of every impression; it being in the former thrown a little more to the south than in the latter; just as if the force acting on the soft matrix had in each instance

* This drawing, made to scale, is deposited in the Society's library. It represents three of the impressions, now in the Museum of the Manchester Society, and one (No. 1) not preserved.

been pressed down at certainly two, if not more, distinct times; at the first projecting the sand further towards the west than the subsequent force, which did not send the sand more than one half the way over that first discharged; so that the surface of the stone now shows two terraces,—just what we might expect to see, if one portion of a semi-fluid mass had been displaced, and then another portion poured partly over it.

The distances between the impressions, from the middle of one to the middle of the next, measured 2 feet $10\frac{1}{2}$ inches in every instance. Nos. 2 and 3, those most resembling human footmarks, were each 13 inches in length at the bottom, and 17 inches at the top; their breadth being respectively 4 and $3\frac{1}{2}$ inches at the bottom, and 8 and 9 inches at the top; their depth being about 3 inches*. In these two impressions, as before observed, the cast has not come clean out of the mould, but left a little of it in; so the depth is not easy to obtain. The bottom of the impressions was concave, so far as they can be seen; and in two of them there were marks of something resembling claws or nails visible.

Nos. 1, 4, and 5 (the last of which is not figured, but resembled exactly its neighbour, No. 4) were about the same size, and measured 6 by 8 inches at the bottom, and 10 by 12 inches at the top; their depths being about 5 inches each. The bottom parts of these impressions are concave, and their casts have come cleaner out of the moulds than the longer ones have done.

No portion of the sandstone-rock (which is a coarse grit containing white quartz-pebbles, sometimes nearly an inch in diameter) nor the beds of shale, either above or below it, afford any evidence whatever of sun-cracks. This is the case, so far as the writer has examined, with the whole of the great Lancashire Coal-field, comprising arenaceous and argillaceous beds to the thickness of 6600 feet, although he has met with numerous instances of such markings in the sandstone beds of the Trias at Lymm, and at Weston Point near Runcorn, where the tracks of the *Labyrinthodon* and *Rhynchosaurus* are found. The English Coal-measures up to the present time have not afforded evidence of sun-cracks; but Sir Charles Lyell has noticed them in the Carboniferous strata of the United States at Greensburg†; so it is probable they will be ultimately met with in this country as well.

How have the impressions above described been produced? At the time of their discovery it was safely concluded that they had been made by some force acting upon the sandstone before it was consolidated, and when it had existed in a soft or semi-fluid state; and that such force had in each case acted twice, so as to displace two portions of wet sand at two different, but not long distant, periods. The straight line of the track, and the regular distances between the impressions led many persons to believe that they had been made by

* The measurements are difficult to make correctly; for the surface of the matrix has evidently shrunk near the sides of the impressions, and some of the wet sand gone into them.

† Manual of Elementary Geology, 3rd edition, p. 337.

an animal, but whether a biped or a quadruped no one ventured to decide. This opinion was maintained, notwithstanding the varying characters of the markings. One gentleman suggested that a tree with a projecting stump, carried by short waves towards a sandy beach, might cause such appearances by allowing the stump to touch the wet sand each time it came into the trough of the wave. This hypothesis would no doubt account for the regular distances of the impressions, and the sand having all been pushed out on one side; but it would not account for the two distinct projections of sand: besides, there is this objection,—waves so short as the distances between the impressions are not now very commonly met with.

By the liberality of Mr. Rhodes, the impressions Nos. 1, 2, and 3 are now in the museum of the Manchester Geological Society. On seeing these last year, Sir Charles Lyell expressed himself much interested in them, and it was at his instance and request that this sketch was written, the writer having some years since given an account of the specimens for a local print. Lately, Mr. Waterhouse Hawkins has examined the specimens, and he is strongly inclined to believe that the impressions are the track of an immense Chelonian Reptile, resembling the *Chelichnus gigas*, figured by Sir William Jardine in Plate I. of his 'Ichnology of Annandale,' or the *C. Titan* which the same author alludes to, but does not figure. This opinion is further borne out by the varying character of the impressions, and it accounts for the pushing out of the wet sand at two successive times, namely first on the planting of the fore-foot of the animal, and then of the hind foot in the same or nearly the same place, and for the similar quantity of wet sand displaced and thrown back in each instance. In tracks of Batrachian Reptiles, like those of the *Labyrinthodon* of the Trias, the impressions are nearly in a straight line, and the mark of the small fore-foot is not always seen, even when the impressions have been taken in a fine stiff red clay, resting on a fine sand, and partly hardened by the sun. In the impressions described in this paper there is a probability that they were made on soft sand under water, for the sides of the matrix have given way and partially run into the moulds in a manner such as we scarcely ever see now in footprints made by animals on a sandy beach. Under these conditions, we could hardly expect to find a distinct fore-foot mark, even if the track were that of a *Labyrinthodon*, which it resembles in its straight direction more than that of a *Chelichnus*. But no animal of the genus *Labyrinthodon* appears to have pushed out the wet sand behind, in the same way that the Tintwistle fossils show. The *Chelichnus* shows this protrusion; therefore it is more probable that the impressions under consideration were made by an animal of the last-named genus, or one allied to it. The distance (in breadth) between the hind and fore foot-marks, which is certainly greater than that seen in the tracks of the *Labyrinthodon*, may have disappeared by the two impressions being nearly opposite to each other, having run together and formed one wide hole, as in specimens Nos. 1, 4, and 5; whilst in specimens Nos. 2 and 3, the hind foot came nearly in the same place as, or only just behind, the impression of the fore foot, and thus caused the long and shallow mark. A heavy slow-walking animal, like a Tortoise, with an irregular gait, on wet sand, it is probable may have caused the track. This creature must have been of immense size, even larger than the *Chelichnus Titan* of Sir William Jardine, and for a provisional name I would propose to call it *Chelichnus ingens*.

Before concluding, I may add that Mr. Rhodes, the proprietor of the quarry where the specimens were found, not only presented the original slab to the museum of the Manchester Geological Society, but he took a plaster-cast of them, which he is desirous of presenting to some public institution.

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2. *On the* LIGNITE DEPOSITS *of* BOVEY TRACEY, DEVONSHIRE. By Dr. J. G. CROKER.

[Communicated by the President.]

(Abstract.)

THE author first described the physical features of the basin, surrounding the junction of the Teign and Bovey Rivers, in which these beds of lignite and their associated clays (used in pottery) are found. The lignite-beds come to the surface at Bovey Heath towards the north-western margin of the basin; they underlie towards the south-east about 11 inches in the fathom, and are covered by clays and gravels; their vertical thickness is about 100 feet. In the upper portion of the lignitic series are several (five and more) beds of loose lignite, covered and mixed with variously-coloured clays and granitic detritus; a ferruginous sandy clay, 9 feet thick, succeeds, which is followed downwards by ten beds of "good coal" or lignite, separated by bluish clay-beds, and worked for fuel.

Fir-cones, referable to the Scotch fir (*Pinus sylvestris*), have been found in one of the uppermost layers of loose lignite. Large flabelliform leaves also are represented by fragments 2 feet long and 20 inches wide in some of the higher beds, together with tangled masses of vegetable remains. In the second and fourth beds of good coal (the latter about 80 feet from the surface) the lignite abounds with the little seeds lately described as *Folliculites minutulus* by Dr. Hooker in the Society's Quarterly Journal*. The lignite generally is composed of compressed coniferous wood, and retin-asphalte is locally abundant.

The Bovey Basin is about 60 feet above the sea-level, and was almost a swamp until it was drained within the last ninety years. A peat-deposit, in which fir-timber is found, covers the lignites towards the south.

The author also referred to the extensive denudation that the district has undergone, and pointed to the Dartmoor granitic tract as the source of the clays of the lignitic deposits. He also noticed the

* vol. xi. p. 566.

several writers * who have treated of the lignites and the geology of the neighbourhood. Lastly, Dr. Croker supplied some notes on the local occurrence of the numerous varieties of rocks and minerals in the vicinity of the Teign, such as ores of lead, manganese, and iron, also labradorite, schorle, &c., all of which, as well as the lignite and its vegetable remains, were illustrated by a large series of specimens.

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3. *Notice of some appearances observed on* DRAINING *a* MERE *near* WRETHAM HALL, NORFOLK. By CHARLES J. F. BUNBURY, Esq., F.R.S., F.G.S.

WRETHAM HALL, the seat of Wyrley Birch, Esq., is situated about six miles north of Thetford, in that extensive tract of open sandy plains which occupies much of the south-western part of Norfolk and of the north-western part of Suffolk; a tract which may be called upland in comparison with the fens, but of very moderate elevation above the sea-level, as is shown by the slow course of the streams flowing from it. About Wretham there are several *meres*, or small natural sheets of water, without any outlet. The one to which my attention was particularly called by Mr. Birch occupied about forty-eight acres, and was situated in a slight natural depression, the ground sloping gently to it from all sides. The water has been drawn off by machinery, for the purpose of making use, as manure, of the black peaty mud which formed the bottom. This black mud, which is in parts above 20 feet deep, is nothing else than a soft, rotten, unconsolidated peat; or perhaps it should be described as vegetable matter in a more complete state of decomposition than ordinary peat, showing no distinct trace of vegetable structure. At the depth of about 15 feet, in this peat, occurs a distinct horizontal layer, from 2 to 6 inches thick in various parts, of compressed but undecayed *moss*, unmixed with any other substance. The stems and leaves of the moss, though closely matted together, are easily separable, and are in so good a state of preservation as to show their distinctive characters very clearly under the microscope. All that I have examined belong to one species,—*Hypnum fluitans*; a moss by no means uncommon in watery bogs and fenny pools throughout the British Islands, and often growing in dense masses in shallow water. The layer that I speak of is of considerable extent, although apparently not extending over the whole area of the mere, as there are parts in which the whole thickness of the black mud has been penetrated without finding it. While wet and fresh, it is of a bright rusty red colour, turning to a yellow brown when dry. What is remarkable, I think, in this case, is the occurrence of a distinct bed of moss, perfect and undecayed, beneath 15 feet of mud, in which no trace of moss is to be seen.

* See Phil. Trans. vol. li. p. 534; Parkinson's 'Organic Remains,' vol. i. pp. 112, 126; Trans. Geol. Soc. 2 ser. vol. vi. p. 439; and De la Beche's 'Report on the Geology of Devon,' &c., p. 143.

Numerous horns of Red Deer have been found in the peaty mud, generally (as I was informed) at 5 or 6 feet below the surface, seldom deeper; many attached to the skull, others separate, and with the appearance of having been shed naturally. What is most remarkable, several of those which were found with the skulls attached had been *sawn off* just above the brow antlers,—not broken, but cut off clean and smoothly, evidently by human agency. Some of these horns are of large size, measuring 9 inches round immediately below the brow antler.

The black peaty mud (which is of the same quality beneath as above the layer of moss) rests on a bed of light grey sandy marl, which effervesces briskly with acids. This is the lowest stratum that has been reached, owing to the difficulty of keeping out the water. I could find no trace of shells, nor learn that any had been found, either in the peat or the marl. Wood is found in the peat, though not in great quantity: we found some pieces, apparently of birch, and saw a trunk of considerable size, I believe of an oak, which had lately been dug out. The wood of this is of a dark brown colour, and was in a very soft and almost *pasty* condition when fresh and wet, but when dry becomes tolerably hard. Its tissues, at least the woody fibre and medullary rays, appear to be in good preservation; but, as is usually the case with wood under similar circumstances, it has become too opake to be easily examined under the microscope.

The peat shows appearances of bedding, and thin horizontal layers or seams of white sand may be observed in it here and there, but are seldom continuous for more than a very few feet, often only for a few inches. Stones are also found singly imbedded in it in various places, without any sort of order; partly irregular flints, partly rolled and rounded pebbles of quartz, exactly as in the gravel of the country.

Numerous posts of oak-wood, shaped and pointed by human art, were found standing erect, entirely buried in the peat.

It would appear, from the facts I have stated, that a great part of the thickness of peaty mud overlying the bed of moss must have been accumulated *before* the time when the Red Deer became extinct in this part of England; and consequently, that the age of the bed of moss must be some centuries at least. Dr. Lindley, in his celebrated experiment* on the destructibility of different plants by immersion in water, found that the very few kinds of Mosses which were subjected to his experiment decomposed rapidly; and he inferred, that the extreme rarity of this family of plants in a fossil state was owing to their perishable nature. The fact observed at Wretham, however, seems to show that (as might have been suspected) the aquatic Mosses are *not* rapidly destroyed by exposure to moisture; and I think we must seek some other explanation for the almost universal absence of the *Musci* from the strata deposited in former geological periods.

* See Fossil Flora of Great Britain, vol. iii. p. 4.

4. *Analysis of the* Cleveland Iron-Ore * *from* Eston.

By A. Dick, Esq., Metallurgical Laboratory, School of Mines.

[Communicated by Dr. Percy, F.G.S.]

The ore was weighed after drying at 100° C.

Protoxide of iron	39·92
Peroxide of iron	3·60
Protoxide of manganese	0·95
Alumina	7·86
Lime	7·44
Magnesia	3·82
Potash	0·27
Carbonic acid	22·85
Phosphoric acid	1·86
Silica, soluble in hydrochloric acid	7·12
Sulphuric acid	trace
Bisulphide of iron (iron-pyrites)	0·11
Water in combination	2·97
Organic matter	trace
Residue, insoluble in hydrochloric acid	1·64
	100·41

Composition of the residue insoluble in hydrochloric acid:

Silica, soluble in dilute caustic potash, consisting chiefly of oolitic concretions	0·98
Silica, insoluble in dilute caustic potash	0·52
Alumina with a trace of peroxide of iron	0·10
Titanic acid, about	0·03
Lime	trace
	1·63

The ore contains no metal precipitable by sulphuretted hydrogen from the hydrochloric acid solution.

In the residue insoluble in hydrochloric acid, minute, bright, black crystals were detected, which were proved to contain titanium, and were supposed to be anatase. Prof. Miller of Cambridge has been able to measure certain of the angles, and found them to be identical with similar angles of anatase. The discovery of this mineral in the Cleveland ore is at least a point of considerable mineralogical interest, and may possibly furnish some additional indication of the nature of the rock from which it was derived.

The silica in the insoluble residue exists, it will have been observed, in two states, about two-thirds being soluble in dilute caustic potash, and one-third insoluble in that solvent. The rounded white

* See also the 'Memoirs of the Geological Survey,' 1856, p. 95. This iron-ore is derived from the Marlstone or Middle Lias series of the Cleveland district in the north-eastern portion of Yorkshire. See also a notice of this ironstone by Mr. Crowder; Edinb. New Phil. Journ. new ser. vol. iii. no. 2. April 1856, p. 286.

particles, which, according to Bowerbank, have a truly oolitic or concentric concretionary structure, are entirely formed of the soluble silica.

The silica which existed in the hydrochloric acid solution was that which was present in a state of combination in the ore, probably with both protoxide and peroxide of iron; and the peculiar greenish-grey colour of the ore was doubtless due to the presence of this silicate of the mixed oxides of iron, just as the colour of the green particles in the so-called greensand is believed to be due to the like cause.

The proportion of phosphoric acid in the ore is comparatively large, and may be easily accounted for by the fossiliferous character of the ore. The quality of the iron smelted from this ore would certainly be very sensibly affected by the proportion of phosphorus, and probably also by the silica existing in a state of combination.

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5. *On the Occurrence of* Coal *near the City of* E-u *in* China. By the Rev. R. H. Cobbold.

[Forwarded from the Foreign Office by order of the Earl of Clarendon.]

On Monday, December 17, we left the city of E-u, and, after walking a few miles, met every hundred yards with men bearing coals. On inquiring of them where the coals were obtained, they pointed to some hills in front of us, called the "Coal Hills." As the mines were said to be but a short way off our road, we determined to visit them. About a mile off the main road the work of the miners was very evident, and rude straw huts, dotted about on the sides of the hills, showed both where the pits were, and the residences for the workmen. Two of the nearest pits were visited, and I was sorry that I had not seen the working of coal in England, that I might have been able to make, in various particulars, a better comparison, and so give a clearer account. The pits were from 300 to 500 feet deep. The descent was made by about ten storeys (in the first we visited); so that only 40 or 50 feet were descended at once; and then a fresh platform, with a fresh windlass reaching another 50 feet; and so on to the last: from each platform galleries were cut, about 6 feet wide, following of course the vein of coal. The workmen did not descend by the basket, as I believe is usual at home, but climbed down the pit by means of beams let into the sides. The mouth of the pit was about 6 feet by 4, and this seemed to be the dimensions all the way down. The descent was thus very easily and very safely effected, the men swinging themselves from one side to the other, as if they were going down some huge chimney. About forty men were at work in each pit, besides those engaged in sorting and packing the coal on the surface. The coal was very bright, but it was not bituminous.

The price at the pit's mouth varied from 200 to 500 "cash" for a burden of 130 catties, which gives 1·62 to 4 dollars per ton (English).

The best seemed of a very good quality, and considerable care was taken in its packing.

Those who open pits have to pay a certain rate to Government.

The nearest place of any importance to these pits is the city of E-u, a place without walls, though a third-class city, in the prefecture of King-hua, from which it is distant by water 120 leagues, or forty English miles. After even moderate rains, there would be plenty of water for boats of a large size; we were there after a long season of drought, when probably no boat could have borne a freight of more than 1000 catties, or somewhat more than an English ton. From King-hua water-carriage is direct by Lau-ke, Yeu-chow, and Foo-gang to Hangehow, about two days' journey. [King-hua is situated in lat. 29° 15′ N., long. 119° 46′ E.]

Ningpo, 14 Jan. 1856.

May 28, 1856.

The following communications were read:—

1. *On the* Silurian Rocks *of* Wigtownshire. By J. C. Moore, Esq., F.G.S.

The objects of the following communication are—1st, to point out a remarkable arrangement in the rocks which form the Peninsula between the Mull of Galloway and Corswall Point*; and

2ndly, To show the relative positions of the Graptolitic Schists of Wigtownshire to the coarse Conglomerate and Limestones of Ayrshire.

I. In a paper which I had the honour to read before the Society in 1849, the principal object of which was to give an account of the Limestones on the Stinchar and their fossils, I stated that the rocks from the Corswall Lighthouse for a great distance to the south have in the main a southerly dip; but that, after passing to the south of Port Patrick, the dip is found to be reversed, that is, to the north. Visits since made at different periods to these coasts have enabled me to add to my acquaintance with the arrangement of these rocks, and I find them to obey a certain law. From the Corswall Point, which consists of a coarse conglomerate of blocks of granite, &c., to within six or eight miles of the Mull of Galloway the rocks are bent into a series of anticlinal and synclinal folds, which are thrown over to the N., the axes of the curves dipping south. The shorter side is often quite vertical, while the longer is inclined at varying angles, often not more than 30°, and in some cases less. The crown of the arch may sometimes be found still subsisting, but in many more cases it has disappeared from denuding causes; still its former existence can be inferred thus:—for some hundred yards the rock will consist of vertical beds, which as we proceed to the south gradually begin to

* For sketch-map and sections of this district see also Quart. Journ. Geol. Soc. vol. v. p. 12, &c.

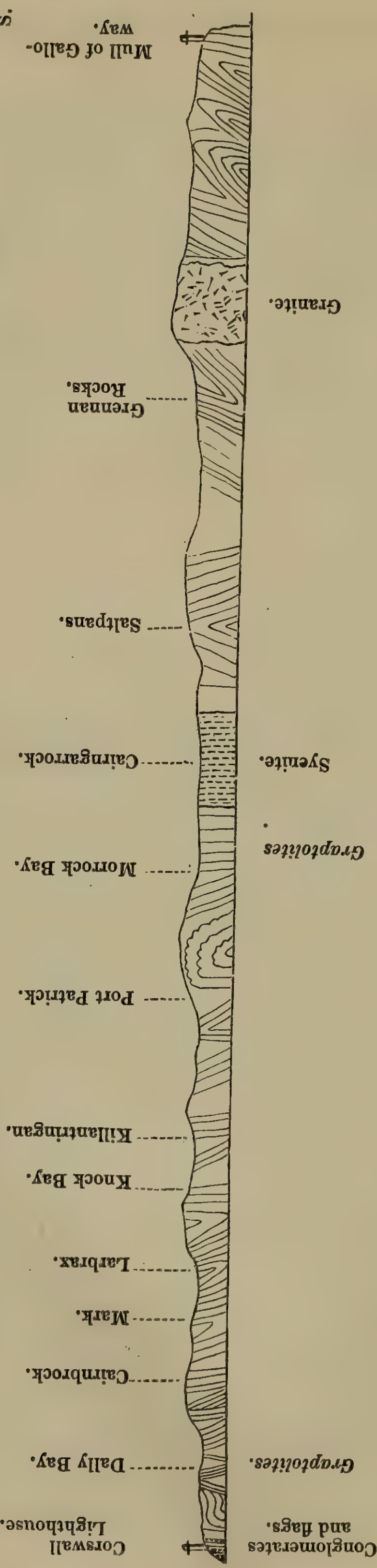

Fig. 1.—*Section from Corswall Point to the Mull of Galloway.* Length about 30 miles.

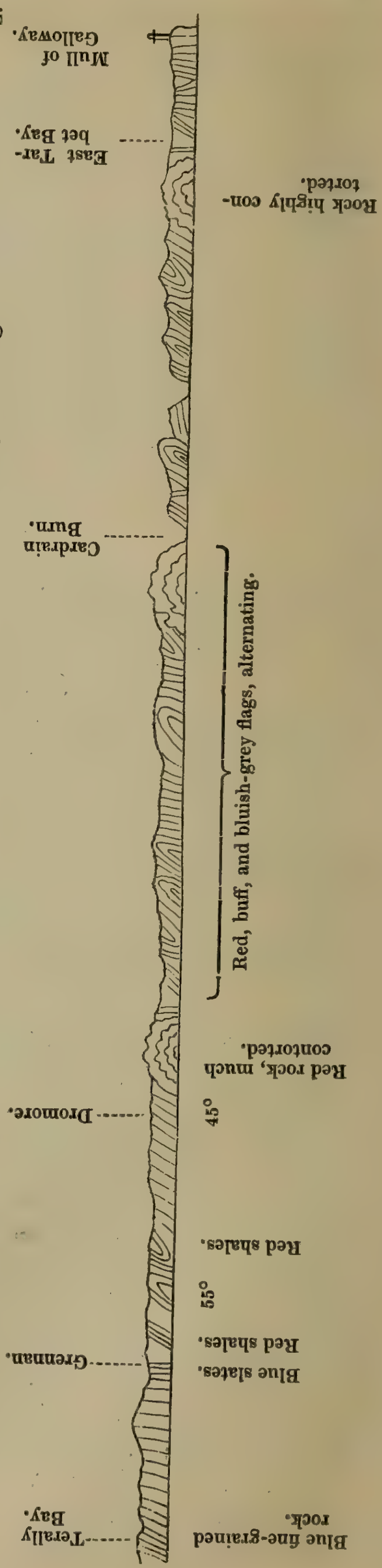

Fig. 2.—*Section from the Mull of Galloway northwards: west side of Luce Bay.* Length about 7 miles.

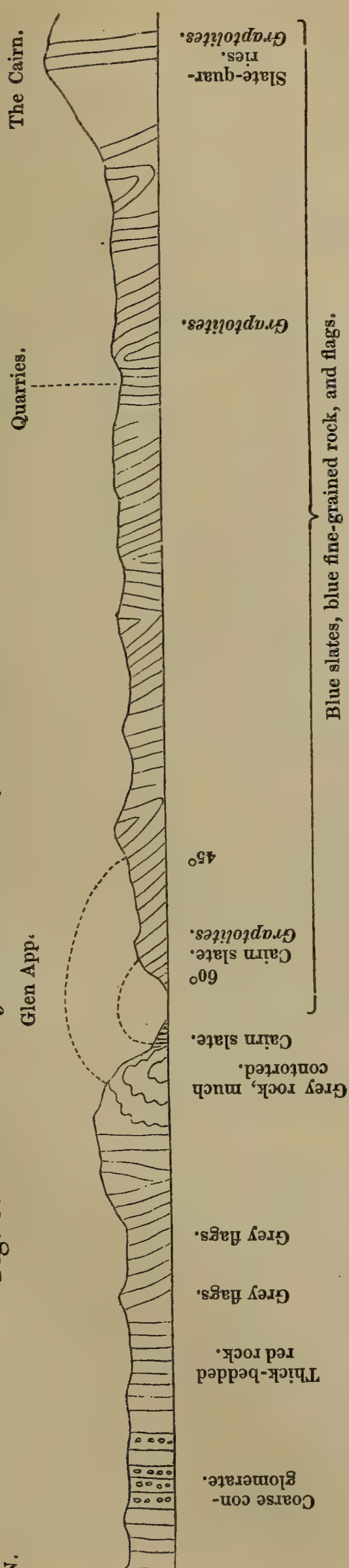

Fig. 3.—*Section along the east shore of Loch Ryan.* Length about 4 miles.

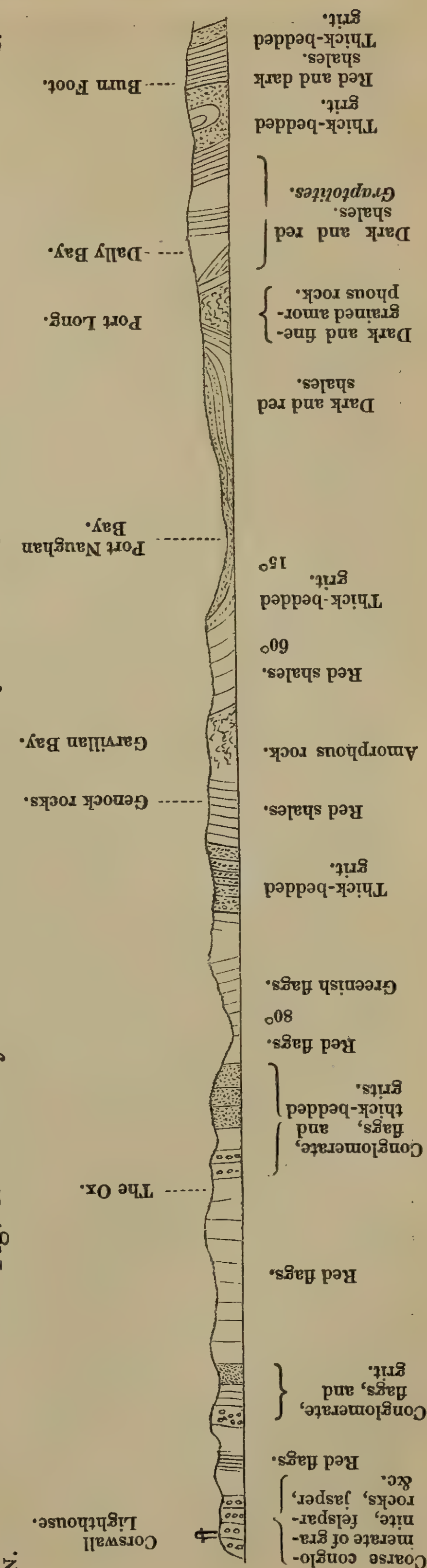

Fig. 4.—*Section from Corswall Point to Burnfoot.* Length about 3 miles.

have a southerly dip; advancing further in the same direction, they fall to a lower and lower angle, until they reach their minimum elevation; the next rock we come to is suddenly vertical, and so continues for a space, when it again gradually subsides to a low angle which again is succeeded by vertical beds. This arrangement prevails for at least twenty-five miles, during all which distance, although northerly dips do occur (and in one instance for near 200 yards), yet they are quite insignificant in comparison with those to the south, and are never at such low angles. See fig. 1.

Without fatiguing the Society with too many details, I will state briefly that good examples of this structure may be seen along the coast from Airies to Cairnbrock, and thence to Galdenoch. Between the two last-mentioned places occur some very fine instances of flags bent so sharply that the two planes are almost parallel, while no fracture is to be perceived at the angle, and both limbs of the synclinal dip southward. From Galdenoch by Larbrax to the Knock, the rocks have always a southerly dip, when not vertical, and the synclinals are sometimes seen with both legs dipping south. North of Killantringan Bay the rocks dip north for about 200 yards, being almost a solitary exception. They then recover their southern dip, and continue so until near the Dunskey Glen, where they are vertical. We then pass another anticlinal, and, approaching Port Patrick, the rocks fall down to a low angle, dipping south. Immediately south of Port Patrick, the rock is again vertical, and the beds from which Port Patrick Harbour was built are then seen to form a magnificent arch, of which the northern limb is vertical, and the southern gradually dips away to the south, and so sometimes past the old castle of Dunskey to the Morroch Bay, where again the rocks are vertical. From thence by Cairngarrock to Port Float, great masses of intrusive plutonic rock interfere, but a prevalence of south dip may still be traced among the stratified rocks. Further south in the parish of Kirkmaiden the same arrangement subsists, but with an opposite direction, the axes of the folds always dipping north. About a mile to the north of the Grennan, where slate is quarried, the rocks begin to dip pretty persistently to the north; and from thence to the Mull of Galloway, the rocks are either inclined to the north or vertical.

I do not pretend to have entered in my note-book all the folds of the rocks for a distance of thirty miles: to get the materials for such a section would require an amount of labour which I have not had opportunities of bestowing upon it. Sometimes the flexures are very numerous, for in parts which I have studied in detail, as for instance from the granite of Dunman to the Mull of Galloway, as many as fifteen occur in five miles. Still there is no part of this coast which I have not visited, and I feel satisfied that this view of the structure is rigidly true. The section (fig. 2) from the Grennan to the Mull of Galloway, a distance of six miles, is pretty accurate, no fold of importance being omitted; it will there be seen that the rock dips constantly north, or is vertical, with two trifling exceptions, where the rock dips south at an angle of about 80°; but these form no exception to the rule that the *axis* of the curves bends to the north.

If, now, we cross over to the east side of the Bay of Luce, we shall find confirmations of the same structure. From Port William to the Burrow Head, the rock is seen to dip north; then it is perpendicular; and after three magnificent undulations, of which the northern sides are the longest, it plunges perpendicularly into the sea.

Returning to Port William, which is about the parallel of the Grennan Rocks, where the change of dip is seen on the western side of the bay, we find that here also as we go north the dip is reversed; and from thence to Glen Luce, the rock is either vertical or dips south. From thence to the Cairn, the section, being inland, is too much concealed to give any results; and I would remark that all these observations are drawn solely from coast-sections; as in those only where the base is washed by the sea can the rocks be followed uninterruptedly for any distance. Whenever we leave the coast, the rock, particularly when inclined at low angles, is so covered by drift that no conclusions can be arrived at. Omitting therefore everything until we reach the Cairn (fig. 3), we there find the slates vertical; about a quarter of a mile to the north they are seen dipping *south* at an angle of about 30°; from thence to Glen App they are bent into three or four sharp folds, always dipping south; on the north side of Glen App they are seen for the last time highly inclined, but still with a south dip; and from thence set in a series of flaggy beds which also dip south, or are vertical, until we reach the coarse conglomerate, with blocks of granite and porphyry, which is the continuation of the beds of conglomerate at Corswall Point, from which we set out. The beds cannot be pursued much farther, since at the Correrie Burn the rock changes its character; and from thence to the Stinchar consists solely of porphyry, greenstone, and amygdaloid.

The structure I have described is similar to those inversions of rock in the north of Germany, in the Ardennes, and the Eifel, and to that of the Appalachian chain in the United States. It has never yet been observed in this country on so considerable a scale; and what is very remarkable, if my view be correct, it does not obtain in the parts of the chain to the eastward. There, according to the published sections of Prof. Harkness, Prof. Nicol, and Sir Roderick Murchison, the lowest rocks form an anticlinal of the normal character, with the newer beds on their flanks dipping away from the older: whereas in Wigtownshire, as I shall presently show, these Graptolitic schists in the centre of the section are older than the conglomerate to the north, on which they appear to repose. It is also observable, that where the change in the dip of the axes of the curves takes place, there is no such change of circumstances as to hint at the cause. In the parallel cases quoted above there is always present some great mass of granite, gneiss, or crystalline schist, which appears by its forcible intrusion to have occasioned the inversion of the masses on its flank. Here nothing of the kind is observable: the hills preserve the same heights with little variation: there is no unusual appearance of violence or dislocation. It is true that a mass of granite (Dunman) is intruded near that quarter, and that the bearing of that granite towards the granite of Cairnsmuir in Kirkcudbrightshire is nearly in the line of strike of the stratified rocks. But the granite of Cairnsmuir is nearly thirty miles distant from that of Dunman; and this last does not occur at the point of change of dip, but about two miles to the south of it. Moreover there are many reasons which show that all the principal movements which these Silurian rocks have undergone had been impressed upon them previously to the intrusion of the granites, which have deranged the E.N.E. strike of the rocks—not occasioned it. Lastly, it seems to me that the intrusion of a small wedge of rock, not two miles thick, is wholly inadequate to account for a displacement which is felt for a distance of more than thirty miles.

II. I now come to the question of the relative ages of the Graptolitic schists of Wigtownshire and of the coarse conglomerates of the south of Ayrshire.

There can be no doubt that the slate and anthracitic schists of Selkirkshire and Peebleshire* are the equivalents of similar rocks seen along the western coast of Wigtownshire; and also that the Wrae limestone with its associated conglomerates is the counterpart of the limestones and conglomerates of the south of Ayrshire. And as Prof. Nicol, in a section laid before the British Association in 1852, distinctly places the Wrae limestone above the Graptolitic slates of Grieston, the question may appear to be determined. Still, as the two sections appear to be contradictory, the whole country for many miles to the south of the Stinchar appearing, as above described, to lean on that to the north, it may be worth while to attempt to reconcile them.

Beginning about three miles south of the Corswall Lighthouse (fig. 4), at the point marked 'Burn-foot' in the Ordnance Map, near Dally Bay, we find thick-bedded grit overlying red shales and black shales, which are in all respects similar to the shales of the Cairn on Loch Ryan, and contain the same *Graptolites*: all these rocks dip south at a high angle. As we proceed north, the thick-bedded grit is again met with, traversed by a band of porphyry, and apparently forming a sharp synclinal, with both legs dipping south. Next to them, to the north, the red and black shales fill up all the space to the middle of Dally Bay: they are vertical, or have a slight dip to the south. The rock then becomes almost amorphous, with scarcely a trace of bedding; but is of the same fine-grained material as the black shales. This amorphous rock forms the north side of Dally Bay; still further north the black shales, covered by red flags, and these last by a thick-bedded grit, again appear, dipping *north*. It is clear that we have passed an anticlinal, and the amorphous rock is doubtless the dark shale, which, being in the centre, has suffered enormous

* See Papers by Prof. Nicol, Prof. Harkness, and Sir R. Murchison: Quart. Journ. Geol. Soc., vol. iv. p. 204; vol. vii. p. 46 & p. 139; vol. viii. p. 393; vol. xi. p. 468; and vol. xii. p. 238.

pressure by the folding, and so has preserved no vestiges of stratification.

The beds then decline to a low angle, becoming almost horizontal, still showing red shales covered by thick-bedded grit, until at the north side of Port Naughan Bay they resume their south dip at an angle of about 15°. At the south side of Garvillan Bay the red flags dip S.E. at an angle of 60°, and a little farther north, the rock underlying these red flags loses all traces of bedding;—again suggesting that we have arrived at an anticlinal folding. Accordingly a little farther north, near the Genock Rocks, vertical red flags are seen, with thick-bedded grit to the north of them. These continue to a point a little south of the Ox, where the first bed of coarse conglomerate occurs, and from thence to the Corswall Lighthouse the rocks consist of repetitions of red flags, grit, and conglomerate, all vertical or nearly so. Where the conglomerate first occurs, it is almost indistinguishable from the grit: it is, in fact, a grit of the same kind of sand, but containing here and there a block of granite or felspar-porphyry from 1 to 2 feet in diameter.

Farther north, near the Lighthouse, the rock is mainly composed of these blocks, some of them of very large dimensions. I have measured one of 6½ feet in its greatest diameter.

If we take the section along the eastern shore of Loch Ryan, and examine it carefully, we shall come to the same results. The coarse conglomerate is found on the Ayrshire shore near the Finnart Point, and from thence to the Cairn the Graptolitic schists appear to lean against it: but I believe the following to be the true interpretation. At the Cairn the schists are vertical; a quarter of a mile to the north they are seen dipping at an angle of about 30° to the south; from thence to Glen App they are bent into three or four folds which all dip south: at the south side of Glen App they are still seen, containing the *Graptolites* and dipping south at an angle of about 45°. From thence to the north side of the bay all rock has been washed away: but at the north side the slates are seen again vertical, and some highly contorted flaggy beds immediately to the north of them. I infer therefore that Glen App is the site of an anticlinal arch, and that the valley has been scooped out along a line where the fracturing of the rocks has facilitated their removal by denudation. From thence to the conglomerate at Finnart Point the Graptolitic schists never re-appear; but the rocks consist of flaggy beds similar to those which intervene between the conglomerate and schists first described along the Irish Sea. From both of these sections, therefore, I conclude that the coarse conglomerate is superior to the schists with *Graptolites*.

With respect to the rocks from thence to the Mull of Galloway, I would only state briefly that the red and buff shales near the Mull of Galloway are lithologically very like those next to the coarse conglomerate at the Corswall Point; that the bluish slates of the Grennan, and perhaps also the dark anthracitic shales of Morroch Bay, containing *Graptolites*, are probably repetitions of the blue flags of the Cairn; and lastly, that certain dark gritty beds, consisting of grains of dark sand, white quartz, and fragments of slate which prevail in the neighbourhood of Port Patrick, are probably the lowest exhibited.

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2. *On the* Action *of* Ocean-currents *in the* Formation *of the* Strata *of the* Earth. By C. Babbage, Esq., F.R.S.

[Communicated by W. H. Fitton, M.D., F.R.S., F.G.S.]

(Abstract.)

In the year 1834 the author communicated to the Society a paper on the Temple of Serapis, at Puzzuoli, near Naples, in the concluding portion of which paper* he suggested an explanation of the fact that certain portions of the earth's surface are subject to periodical alternations of elevation and depression, extending through vast periods of time: and the extreme slowness with which certain very fine powders of a heavy substance (emery) subside in water, suggested to the author the vast extent to which very finely divided matter suspended by the Gulf Stream might be spread over the bottom of the Atlantic, —a subject alluded to by him in 1832 in the 'Economy of Manufactures†.'

Some years afterwards, looking for better explanations of the phænomena of outliers and the folding and inversion of strata than he had hitherto met with, Mr. Babbage reverted to the consideration of sedimentary deposition. Hence the origin of the present communication.

In the first part of this paper the author traced out the laws which regulate the distribution of very finely divided earthy matter, borne outwards from river-mouths and sea-cliffs into the ocean-currents, over extensive areas. The time that a particle of matter requires to fall through a given distance in a resisting medium depends—

1st. On the specific gravity of the particle itself.
2nd. On its greater or less magnitude.
3rd. On its form.
4th. On the law of the resistance of the medium through which it falls.

These several points were treated of by the author, who then proceeded to show under what conditions certain finely triturated substances, of given size and composition, suspended in a current of a given velocity, would be deposited in a sea of a given depth.

Supposing a river to send out, suspended in its water, particles of triturated limestone, of different degrees of fineness, and the river at its junction with the sea to be 100 feet deep, and the sea to have a uniform depth of 1000 feet over a great extent, the different results in the deposition of the several varieties of the suspended particles

* Proc. Geol. Soc. vol. ii. p. 75; and Quart. Journ. Geol. Soc. vol. iii. p. 206, &c.
† Art. 63, 4th edit.

are shown in the following table, in which four varieties of sediment, falling respectively through 10, 8, 5, and 4 feet of water per hour, are laid down:—

No.	Velocity of fall per hour.	Nearest distance of deposit to river.	Length of deposit.	Greatest distance of deposit from river.
	Feet.	Miles.	Miles.	Miles.
1.	10	180	20	200
2.	8	225	25	250
3.	5	360	40	400
4.	4	450	50	500

Thus four separate deposits will be found at various distances from their common origin.

The author noticed also how the uniformity of a stratum might be interfered with by the varying conditions both of the sediment and of the sea-bottom. Altered relations between the specific gravity, the shape, and the size of the particles, when duly adjusted, render ocean-currents capable of either separating mixed substances, or of combining together different substances. Hence endless combinations arising from the variation of these conditions.

Local elevations and depressions of the sea-bed, on which sediment brought from a distance is deposited, were pointed out as probable causes of irregularities in stratified deposits,—giving origin, indeed, to outliers or disconnected masses, which might be sometimes supposed to have been due to subsequent denudation.

Sedimentary matter carried by ocean-currents to the profound depths of the ocean subside into these depths beyond the reach both of currents and of wave-action. The downward motion becomes continually diminished, and the particles ultimately come to absolute rest, or move through water of increasing density with excessive slowness, so as to cover the ocean-bottom with an incoherent pulpy mass of fluid mud, of great thickness, and less dense for the most part in the upper than in the lower part,—or to form a similar mass of sediment suspended in mid-water.

It was also pointed out that in the immense period of time during which this sediment is subsiding into the profound ocean-depths and massing itself into a mud-bed, various hydrographical changes might take place and cause new currents to bring different sediments over the same area, which newer deposits might descend into and be mingled with the older precipitates.

The author proceeded to treat of the effects of an alteration of isothermal surfaces, caused by the interference of this more or less suspended mud-cloud with the conduction of heat from the earth's surface. Consolidation of the lower strata would be caused by the isothermal surfaces below the ocean rising upwards. Currents of heated water, similarly caused, might variously disturb the sediment and give it flexuous stratification. Heated water might be retained in portions of the sedimentary masses, and alter by its solvent power the constituent materials; or the heated water might be converted into steam, or generate permanent gases, which might derange or alter the suspended material in various ways. If the sediment had not reached the bottom, but formed a freely suspended mud-cloud in mid-ocean, the effect of the interposed bed of fluid mud impeding the upward progress of heat from the lower region would be necessarily to increase the heat of the water below the mud, and thus place the sediment between the upward pressure of the heated water and the downward pressure of the overlying water. The ocean above would cease to derive its usual supply of heat from below, and become climatally altered. The now consolidated mud-bed would of its own weight either sink bodily down, and take different positions according to its consistency and the form of the ocean-bottom, or it would be contorted and broken through from the effect of the accumulated heat below. In tracing the results of this upward pressure and bursting, the author observed that on the enormously thick and partially consolidated stratified mass one or more weak points would admit of the formation of elevated domes, and that from the bursting of one of these domes, in a sea of much greater length than breadth, a vast wave would be propagated through the plastic matter, which would advance and be followed by others less perhaps in degree. As the original wave advanced, the diminishing depth of the ocean would cause the head of the wave to advance with greater speed than its base, impeded by friction on the ocean-floor, and give it its advancing form and a steeper declivity in front than on its hind side; this might be carried so far that the foremost wave might even double itself over, and yet, owing to the plasticity of the mass, there might be no breach of continuity. To the transmission of such impulses through semi-consolidated strata, the author refers for an explanation of the overlapping and inversion of strata seen in the Appalachian and other mountain-ranges.

The paper concluded with remarks on the indications of the age, and causes influencing the structure of deposits, such as cleavage, &c., in connexion with the foregoing observations on sedimentary formations, and as illustrating, with them, some of the consequences of several physical causes which act through vast intervals of time upon the strata forming the crust of the earth.

JUNE 4, 1856.

Ernest P. Wilkins, Esq., was elected a Fellow.

The following communications were read:—

1. *On the* UPPER* KEUPER SANDSTONE (*included in the* NEW RED MARLS) *and its* FOSSILS *at* LEICESTER. By JAMES PLANT, Esq.

[Communicated by J. W. Salter, Esq., F.G.S.]

BEDS of Keuper sandstone were first ascertained to exist in this locality by my brother, Mr. John Plant, in 1849; they were then found in the cuttings of a short branch line made to connect the Leicester and Swanington Railway with the Midland Railway.

At the time that several short hills on the line were excavated, an opportunity occurred for selecting specimens of the superficial casts and markings, together with the cololitic remains of *Annelida*, from the thin shaly beds of grey marls and sandstones which were abundantly exposed to view; thus a large collection was got together, and specimens were distributed to the museums of the metropolis and to others in the country. A notice of their occurrence was also read at the Meeting of the British Association in that year at Birmingham.

The finishing of the railway debarred a satisfactory examination in that direction; but as the strike and dip of the beds had been exposed in the cuttings, it was not difficult to follow them along a low and narrow ridge for about two miles in a north-east direction, and one and a half mile to the west, until lost under a part of the town.

It is from the excavations in the immediate vicinity, and under the town itself, that additional knowledge of the beds forming the Keuper has been gained; while many interesting discoveries of their organic contents, such as Crustaceans, Teeth, Bones, Plants, and a Foot-mark, have been made in the strata traversed by well-shafts, which have been recently sunk to a depth of 75 feet.

The development of the Keuper sandstone on the north and west sides of the town varies from one mile to a mile and a quarter in width at the surface; the strata cropping out at intervals,—at the Castle Mount, Danett's Hall, Dane Hill, and at several knolls on both sides of the Braunstone Turnpike Road; generally they are hidden under clays and marls of the alluvium and drift. The dip of the beds is to the east, at an average angle of 3°, and they soon dis-

* I have reasons for concluding, from lithological characters and from the position of the strata, that there are two distinct beds of Sandstone, an Upper and Lower, included in the New Red Marls, and separated from each other by a considerable thickness of red clay; the lower bed lying at about the same distance horizontally and vertically from the "water-stones," as the upper does from the base of the Lias. I may probably have a further notice upon this point when my examination is more matured. It is the *upper sandstone* alone that the present notice describes.—July, 1856. J. P.

appear under the deep beds of gypsiferous clays and marls of the Spinney and Knighton Hills.

The sandstone agrees very closely with the same formation in Gloucestershire and Warwickshire, as described by Murchison and Strickland in their memoir*,—even to the "pink tinge and small fragments of decomposed felspar," as mentioned at pages 334, 335 of that memoir. The Keuper sandstone is described by them as consisting, in detail, of the following members:—

a. Finely laminated, flag-like, marly sandstone, of delicate greenish and light-drab colours, alternating with marls, 20 to 30 feet.

b. Thick-bedded, finely laminated, soft, siliceous sandstone, of various colours, the prevailing one being a white or pinkish-white, with occasional tints of green, purple, &c., 15 to 30 feet.

c. Finely laminated, flag-like sandstone, similar to *a*.

At the boring in the vicinity of the Old Roman Wall these flag-like marly sandstones were penetrated, and it was difficult to decide whether it was the *upper* or *lower* member, until during the progress of the boring the Red Clay was reached, which at once decided it to belong to the latter; the boring was carefully measured and gave the following results:—

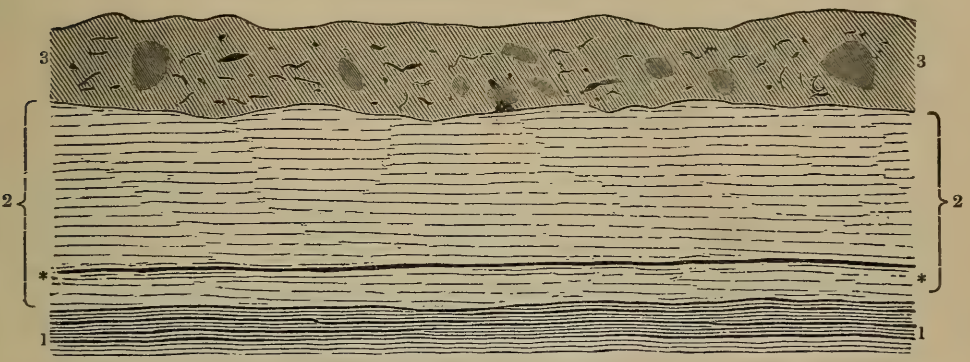
	Feet.
Drift and gravels	40
Thin, flag-like, marly sandstone........	35
Total depth............	75

These marly sandstones rarely exceed 4 inches in thickness, varying from that to half an inch; generally they are 1 inch laminations, and are separated by way-boards of green marl of unequal thickness (in this respect resembling the same beds at Inkberrow, Shrewley Common, and other localities in Gloucestershire and Worcestershire). Their surfaces are so entirely covered with impressions and markings as to be quite irregular and rough. The commonest markings are broad unequal ripple-marks,—and small nodules and granular casts in relief, which usually are considered as rain-markings; together with most abundant remains of Annelid-markings; there also occurred a single well-formed footstep, 4 inches in diameter, in form similar to the well-known Labyrinthodont footmarks of Storeton in Cheshire. The surfaces of these shales are crossed in all directions by cracks, which had subsequently been filled in with a fine white sand.

At the railway-cutting (at a distance of about two miles in a straight line from the well), in excavating for ballast, for which the thick beds (the middle member) are admirably suited, they have recently penetrated these thin flag-like sandstones to a depth of about 2 feet; the following section (fig. 1) will illustrate this:—

* Transact. Geol. Soc. 2nd series, vol. v. p. 331.

Fig. 1.—*Section of the Keuper Sandstone on the North-east side of the Railway-cutting at Shoulder of Mutton Hill, near Leicester.*

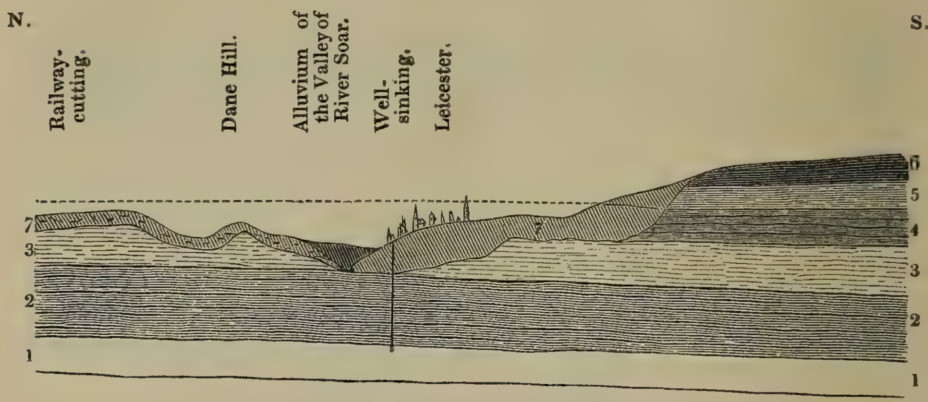


3. Drift, with boulders of Syenite, &c.: 8 to 10 feet thick.
2. Soft white sandstone, "Middle beds:" 14 to 16 feet.
*. Black carbonaceous band, with supposed *Algæ*.
1. Thin marly sandstones, "Bottom beds:" exposed to the depth of about 2 feet.
Average dip about 5° to the South.

This shows the middle member from 14 to 16 feet thick. It contains numerous fragments of pure coal, no doubt from the Ashby field. On the top are alluvial deposits, containing remains of Deer and Ox, with nuts, leaves, and vegetable debris; and Drift-clay with granitic boulders and detached and worn fossils from the Oolitic, Liassic, and Carboniferous formations. Where the upper surface of the thick soft beds is exposed by the removal of the drift, it is found to be very irregular and grooved, and is much harder than the mass of the beds (which can be rubbed into sand with the fingers), and seems to contain lime, which has agglutinated the particles of silex strongly together,—forming, in fact, a kind of hard skin, thus preserving the soft sandstone below. The upper member I consider to have been here entirely denuded; and its debris has assisted in forming the numerous sand-beds found so abundantly along the river-valley. The accompanying section (fig. 2, p. 372) from the Red Clay, on the west, to the Lias, on the east, will serve to illustrate this.

In support of this view, I may mention that I have taken many specimens of the thin sandy shales containing the Annelid-markings in the sand- and gravel-pits, at a depth of 15 feet from the surface. They are slightly rounded and worn, and mingled with rolled Oolitic and Liassic fossils. It is obvious that these worn specimens could not have been derived from the lower member of the Keuper Sandstone; as that would require the whole of the middle member—the thick beds—to have been swept away. They can only be considered as the remnants of the upper thin sandy shales; the whole of which appears to have been denuded in this locality; and, from the scored and worn character of its upper surface where exposed, a great portion of the middle member (possibly to the extent of one-half of its original thickness) was probably at the same time removed: in that case, it would bring up the thickness of the middle portion to the standard of the similar member in the Keuper Sandstone of Gloucestershire and Worcestershire.

Fig. 2.—*Section across the River-valley at Leicester.*
Length about 5 miles.



7. Gravels and clays, with bones, boulders, &c.
6. Lias.
5. Upper marls ⎫
4. Upper sandstone-shales ⎪
3. Middle sandstone ("soft beds") ⎬ Upper Keuper.
2. Lower sandstone-shales ⎪
1. Red clay ⎭

[*Note.* In this section the Marls No. 5 are not represented sufficiently thick, whilst Nos. 4 & 6 are proportionally too thick.]

Combining the data afforded by sections south and north of the river-valley, the following table will show the position and extent of the Upper Keuper beds, from the base of the Lias to the Red Clay in descending order:—

Lias.

Upper Keuper.
- *a.* Upper Keuper marls, containing beds of gypsum and several *thin* bands of green marly sandstone, on which are found numerous pseudomorphic salt-crystals; thickness from 80 to 120 feet.
- *b.* Thin sandy shales, with way-boards of green marl; 25 to 30 feet.
- *c.* Thick soft beds of white sandstone, 20 to 30 feet.
- *d.* Thin sandy shales, similar to *b*; 35 feet.

Total about 200 feet.

Red clay.

It is considered that on the north and north-west side of the river-valley, the whole of the beds *a* & *b* (5 & 4 of the Section, fig. 2), and part of *c*, have been denuded, and a large accumulation of drift-clay, gravel, and alluvium deposited on the thick soft beds (and probably, where that is entirely denuded, on the lower shales, *d*) to the thickness in some places of from 60 to 80 feet.

Most of the fossils contained in the following list were collected from the well-boring in the town, excepting one very fine detached tooth, which was found in the thick beds at the railway-cutting.

Plantæ.

Casts of *Echinostachys oblongus* and *Equisetæ*, and remains of *Voltzia*.

I am inclined to think, from the impressions left on the overlying bed of sandstone, that the jet-black deposit intercalated in the thick beds (middle member) contains the remains of *Algæ*.

Annelida.

Cololitic remains of Annelids, and casts of their tubes.

Crustacea.

*Estheria minuta** ; found both in the green marls and the thin sandy shales.

Pisces.

Teeth of Placoid Fishes †; widely scattered through the strata; the surfaces are marked with three grooves and the anterior edges finely serrated.

Ichthyodorulites ‡, of a curved and slender form; these are but rarely found perfect; their existence is often to be traced in an intaglio impression, stained with a dark red oxide of iron, or by a cavity from which the organic form has perished, leaving only the mould and external markings impressed on the sandstone. The longest spine measures 10 inches, decreasing from a diameter of three-quarters of an inch to one-eighth.

One of the best specimens is deposited in the Museum in Jermyn Street, another in the Town Museum at Leicester (the ribbed surface is very sharp and distinct upon this specimen): these both show the fibrous structure of the interior and the socket-like hollows which run through their entire length.

On the surface of some of the shales nodules are frequently found, which from their appearance are most probably the casts and remains of Fish-coprolites.

Fragments of bone have also been found in one of the beds of marly sandstone, about 2 inches thick; the largest fragment is 5 inches in length, and nearly an inch in diameter; it is coloured by a light red oxide of iron; the centre of this specimen is filled up with a fine sand, but the hollow may prove to be the effect of crushing forces having brought the edges of the bone together, as it seems greatly distorted and broken. Another fragment of bone is firmly cemented to an Ichthyodorulite.

* This is the little Triassic shell that has been termed *Posidonomya* and *Posidonia minuta*. In Morris's 'Catalogue of British Fossils,' 2nd edit. 1854, it is included in the *Crustacea* (as *Estheria minuta*); but (apparently from inadvertence) it has not been expunged from the list of Molluscs in that work. Mr. Rupert Jones having informed me that, from a microscopical examination of this little fossil, he had been enabled to determine its real Crustacean character, I have on his authority entered it here as a Crustacean.—July, 1856. J. P.

† According to Sir P. Egerton, to whom I sent a selection of the teeth, they resemble those of the genus *Strophodus*; but may possibly be of a new genus.

‡ Probably belonging to the same species as the teeth.

2. *On the* Upper Keuper Sandstone (*included in the* New Red Marl) *of* Warwickshire. By the Rev. P. B. Brodie, M.A., F.G.S.

Having lately obtained some slabs with *Posidonia* (*Estheria*) *minuta* * from the Keuper Sandstone near Warwick, and these being finer specimens than are usually procured, I thought a few of them might be acceptable to the Society.

The Keuper formation of Warwickshire has been already so ably described by Sir R. I. Murchison and Mr. H. E. Strickland †, that I have but little to add respecting it. The slabs with *Posidonia* occur plentifully along the banks of the canal near Shrewley, in green marls and sandstone, a few feet above the inferior red marl; but the specimens are best preserved in the sandstone. The old quarries on Shrewley Common, now enclosed, are entirely stopped up; but a partial excavation near the canal last summer afforded numerous Ichthyodorulites of various sizes, and probably belonging to an undescribed species of fish, the small palatal teeth of which are the same as those which had been previously noticed by my friend Mr. Symonds and myself at Pendock, in Worcestershire, and which Sir P. Egerton considered to be referable probably to a new genus ‡. Portions of long, thin, slender bones were also discovered, and one of some size, but too imperfect to be determined. I have also in my cabinet a cranial bone of a *Labyrinthodon* from Shrewley. A few small teeth and scales of fish occur in the soft gritty bed in No. 2 of the Section given below.

Most of the blocks of sandstone are strongly ripple-marked, a prevailing character with this portion of the Keuper in Warwickshire, Worcestershire, and Gloucestershire. On some slabs I found the footsteps of a small Batrachian; and, though I carefully instructed the workmen to preserve *all* markings on the stone, few were brought me which could be traced to any organic origin. The Ichthyodorulites are met with both in the sandstones Nos. 2 and 6, chiefly in the former, and in the gritty sandstone intercalated with it. The palatal teeth of *Acrodus*, with small teeth and scales, appear to be confined to the gritty sandstone.

The following is a section of these strata on the banks of the Canal at Shrewley, in descending order:—

	Ft.	in.
1. Green Marl	0	3 or 4
2. Beds of grey and light-coloured fine-grained sandstone, divided by marl; with *Posidonia minuta*, and ripple-marks. In the middle occurs a coarse gritty sandstone with white specks (less coarse than at Pendock in Worcestershire), which contains bones, teeth, and spines of *Acrodus*	1	9

* See Appendix, p. 376. † Trans. Geol. Soc. 2nd Ser. vol. v. p. 331.

‡ See Quart. Journ. Geol. Soc. vol. xi. p. 451. Sir P. Egerton thinks that it is possibly the same as that figured in Trans. Geol. Soc. 2nd ser. vol. v. pl. 28. fig. 3.

	Ft.	in.
3. Green Marl	0	$2\frac{1}{2}$
4. More finely grained sandstone, more or less ripple-marked; with footsteps of *Labyrinthodon*	2	3
5. Green Marl	0	2
6. Hard workable sandstone ("bottom bed"), the only good building-stone of the locality; with imperfect casts of *Posidonia*	3	6
7. Thin beds of sandstone, divided by green marls; with remains of plants (*Voltzia*, *Calamites*?, and *Fucoides*?). This is best seen at Rowington	10	0
8. Red Marl.		
Beds horizontal.		

The last 10 or 15 feet of sandstone and marl reposing immediately on the red marl are not quarried here; but at Rowington, on the Canal-bank, about a mile and a half to the west, these are better seen; and from them I have procured a small series of imperfect remains of Plants, some of which appear to belong to *Voltzia* and *Calamites*?, and some small Fruits not easily determined. Fucoids (or markings such as are usually referred to Fucoids) occur in more or less abundance throughout, especially in the marls.

The Warwickshire Keuper agrees both lithologically and zoologically with that of Worcestershire. In Mr. Symonds's paper * on that formation at Pendock, it will be seen that the green marls are thicker and more indurated, and the gritty sandstone, which he calls "osseous conglomerate," is a much finer band at Shrewley, and with fewer traces of bones and teeth, and no particles of carbonaceous matter (which often struck me when examining the quarry at Pendock), although identical with it in every other respect. The plant-beds at the bottom also seem to be similar to those at Rowington.

The New Red Sandstone group in England is on the whole, as is well known, by no means rich in organic remains; if the beds formerly classed as "Bunter" are correctly assigned to the Permian, we have only the Keuper to afford us any insight into the palæontological history of that period, and the fossils are neither numerous nor well preserved. It is singular too, that the little *Posidonia* should be the only shell † at present known in strata of such extent and thickness as the Trias,—and the more so, as there seems no reason why the sea should not have been tenanted by other contemporary forms of Mollusks equally suitable to the same conditions of marine life. The prevalence of peroxide of iron in the overlying and underlying red marls may account for the absence or extreme

* Quart. Journ. Geol. Soc. vol. xi. p. 450.

† Since the above was in type, Mr. Symonds has shown me a little shell which he had detected in the Keuper at Pendock, quite distinct from the *Posidonia*; and I have an imperfect cast of what appears to be another genus, from the Shrewley sandstone. [October 1856.—P. B. B.]

rarity of marine animals; but the intervening Keuper is an exception to this rule.

Appendix.

Note on Estheria minuta. By T. Rupert Jones, Esq., Assist. Sec. G.S.

Not long since the Rev. W. Symonds favoured me with some well-preserved specimens of this little Triassic fossil; and, with Prof. J. Quekett's kind assistance, I was enabled to see most distinctly the true Crustacean character of the tissue of its valves. This confirmed an opinion I had long held that this fossil is not a Mollusc, but closely allied to the *Limnadia*, *Limnetis*, and *Estheria* *, bivalved phyllopodous Crustaceans (*Entomostraca*) of the present day; and indeed, as far as the carapace-valves are concerned, it well represents the *Estheria* of Rüppell and Baird † (*Isaura*, Joly).

In the Quart. Journ. Geol. Soc. (1847) vol. iii. p. 274, Sir C. Lyell figured a similar fossil from the coal-shales of Eastern Virginia, and remarked that, with Mr. Morris, he doubted whether the so-called "Posidonomya" may not be a Crustacean rather than a Mollusc ‡. Similar fossils, of different species, occur in the Devonian rocks (Caithness and Orkney), Carboniferous (Northumberland), Liassic (Skye and Gloucestershire), Oolitic (Scarborough), Purbeck (Dorset), and Wealden (Sussex). Others are met with in the Jurassic Coal-fields of North Carolina and Virginia §, and along their north-eastern extension, forming the so-called "New Red Sandstone" of Virginia and Pennsylvania ‖; in the plant-bearing sandstones of Central India ¶ (Nagpur and Mangali); and in the Triassic deposits of Europe.

Although occurring so constantly in the different geological periods, from the Devonian to the Wealden**, and again in the recent marine and fresh waters, yet it is in the Triassic deposits of England and the Continent, in the sandstones and shales of Virginia and Pennsylvania, and in the plant-bearing beds of Virginia and Central India, that this little bivalved Entomostracan appears to be pre-eminently abundant; so as to serve probably as a faithful index of a peculiar geological horizon††.

In like manner, among the still lower forms of life, the Nummulite is represented in the Silurian ‡‡, Carboniferous, Liassic, and

* See also above, p. 373, *note*. † Proc. Zool. Soc. part 17. p. 86.

‡ See also Lyell's 'Manual of Geology,' 5th edit. p. 332.

§ Lyell, *loc. cit.*; and W. B. Rogers, Boston Nat. Hist. Soc. Proc. v. p. 15.

‖ Continuous with the Sandstones of New Jersey, and most probably with those of Connecticut also: Rogers, *loc. cit.*

¶ Quart. Journ. Geol. Soc. vol. xi. p. 370.

** I have no satisfactory evidence of the presence of the genus in question in the Cretaceous and Tertiary deposits.

†† Prof. W. B. Rogers has already pointed out (*loc. cit.*) the probable value of this little fossil in the comparison of the Mesozoic rocks of North Carolina and Virginia, and of these with the so-called Triassic beds of the United States.

‡‡ Annals and Mag. Nat. Hist. ser. 2. vol. xv. p. 58.

Oolitic rocks, and exists also at the present day ; but it particularly distinguished one epoch (the Tertiary) by a surprising fecundity and a temporary profusion of individuals.

The occurrence of a fossil *Estheria* in the Upper Sandstone and Shale of the Scarborough district (*E. concentrica,* Bean*, sp.) is of interest, as being indicative of the association of this Crustacean with the Oolitic flora in England, as it is in India and America.

In India a Triassic Labyrinthodont Reptile (*Brachiops laticeps*†) is found in the same strata as yield the *Estheria* at Mangali and the plants at Nagpur ; and in Pennsylvania reptilian remains ‡ occur with the so-called "Posidonia" : in America indeed the evidence seems to point to a contemporaneity of the Virginian plant-beds, the shales and sandstones of Pennsylvania and New Jersey, the foot-marked sandstones of Connecticut, and the upper red sandstone of Nova Scotia and Prince Edward's Island, which is also reptiliferous § ; and it is evident that in the Virginian and Pennsylvanian shales the minute Crustaceans under notice are important fossils. The plants of Nagpur and Virginia having a Jurassic facies, like those of Scarborough, it will be interesting, as further evidences turn up, to see how far we are to regard the Triassic or the Jurassic element as preponderating, or whether a passage-group of deposits are indicated by the evidence,—or, lastly, whether these Plant-beds with Reptiles and Crustaceans indicate the terrestrial and lacustrine conditions only of the early secondary period.

The Jurassic flora of Australia || and that of Southern Africa have been hitherto collected without affording any clear traces of the *Estheria.* The latter country, however, has its probably Triassic Reptile, the *Dicynodon,* imbedded with this flora ¶ ;—so that the peculiar association above-indicated for India and North America obtains there also.

In pointing out these facts of the geological and geographical distribution of the fossil *Estheria,* I merely touch upon the salient points of an interesting subject of research,—for the elucidation of which careful inquiry at home and abroad is still requisite.

In conclusion, although the recent *Estheria* is a marine Crustacean, yet, since very closely allied forms are of freshwater habits, and since among bivalved Entomostracans different species of a genus and even the individuals of a species occasionally live either in marine or in fresh water, there is no *certain* evidence afforded by the fossil in question whether the so-called Triassic deposits in which it is found were formed in rivers, lakes, or seas.

* Mag. Nat. Hist. ix. p. 376.

† Quart. Journ. Geol. Soc. vol. ix. p. 37 & 371.

‡ Lea on *Clepsysaurus Pennsylvanicus,* Journ. Acad. N. Sc. Philad. n. s. vol. ii. p. 185 ; and on *Centemodon sulcatus,* Proc. Ac. N. Sc. Philad. vol. viii. p. 77.

§ Leidy on *Bathygnathus borealis,* Journ. Acad. N. Sc. Philad. n. s. vol. ii. p. 327.

|| See M'Coy's paper, Annals and Mag. Nat. Hist. vol. xx. p. 145, &c.

¶ Trans. Geol. Soc. 2nd series, vol. vii. part 4. p. 227, *note.*

3. *On an* Orthoceras *from* China.
By S. P. Woodward, Esq., F.G.S.

(Plate VI.)

The specimen in question is one of several that were obtained by Mr. Lockhart of Shanghae, from some place 200 miles distant, and transmitted by him in 1854 to Daniel Hanbury, Jun., Esq., of Plough Court. They are longitudinal sections in thin plates of limestone, and seem to have been used as screens, for they were mounted in carved-wood frames with stands. The same gentleman at an earlier period communicated some Devonian *Brachiopoda*, identical with French and Belgian species, described by Mr. Davidson in the Geological Journal, 1853, p. 353.

The largest specimen measures in length 29 inches, and 4 in its greatest diameter; it wants the last chamber and about 5 inches of the spire. The angle of the spire is only 6°, and the intervals between the septa vary from $\frac{1}{2}$ to less than $\frac{1}{4}$ the diameter of the cells. The siphuncle is central and quite simple.

The most instructive specimen is smaller, measuring 18 inches in length and 4 in diameter; it only wants the last chamber (see Pl. VI. fig. 1). The angle of the spire is 12 degrees, and the depth of the chamber is from $\frac{1}{2}$ to less than $\frac{1}{3}$ their diameter.

The siphuncle is filled with dark reddish-brown limestone; the air-cells are lined with white spar and filled with converging crystals of the same, or with greenish-grey stone. The shell has been entirely replaced by grey stone, recording its outline and thickness, except in some of the thinner *septa* which are only indicated by curved lines.

The siphuncle is simple, central, and incomplete; the shelly part of the tube (*s*) extending only one-third of the way from the convexity of each septum towards the concavity of its predecessor. In the last seven chambers, only two of which (*a*, *a*) are represented in the figure, the siphuncle appears to have been completed by a membranous tube (*t*), which has disappeared from those of the spire.

In the last of these chambers, with an incomplete siphuncle (*b*), the lining membrane appears to have separated a small space from the wall, equally all round; this space being filled with spar, whilst the general cavity of the chamber is occupied by red stone, like the siphuncle.

In the next chamber the separation and contraction of the lining membrane has proceeded to a greater extent; and so on in each successive chamber, until the fifth, after which the siphuncle seems replaced by it, and gives off on each side a process directed towards the anterior angle of the cell. The originally membranous nature of this tube (formed by the contracted lining of the air-cells) is shown by its want of symmetry. Towards the apex of the fossil it is black, as if carbonized. The space (*c*, *c*) between the true shell and its lining membrane is lined with spar, and sometimes filled with it, as before mentioned; but in some instances the limestone has penetrated, after the dissolution of the shell.

The changes which this specimen has undergone appear to be these:—1. When buried in the sea-bed, mud entered the siphuncle and filled the remains of those chambers in which the siphuncle was incomplete. 2. Water containing carbonate of lime in solution penetrated the air-chambers and other closed spaces, and coated all the surfaces with tufa. 3. The shell was dissolved and removed, before the consolidation of the surrounding mud, which thus obtained access to all those cavities whose calcareous lining was incomplete. 4. The cavities which the mud could not enter were filled, or nearly filled, with crystalline carbonate of lime.

The same structure is exhibited, with great regularity, in the small specimen represented by fig. 2 (the locality of which is unknown); in this the more highly curved lines alternating with the septa represent the collapsed lining of the air-cells.

I have before noticed similar appearances in many polished sections of *Actinoceras*, especially those from the black limestones of New York, one of which is represented in Pl. VI. fig. 3. In these "it is evident that the mud has gained access to the air-chambers along the course of the blood-vessels; but the chambers are not entirely filled, because their lining membrane has contracted, leaving a space between itself and certain portions of the walls, which correspond in each chamber *.

The collection of Prof. Tennant contains the apex of a small *Orthoceras* from the Carboniferous Limestone of Ireland, one side of which is fractured, showing what appears to be an enormous siphuncle, slightly moniliform, and nearly filling the shell (fig. 4 *a*). On making a section of this specimen, however, the true siphuncle (fig. 4 *b*, *s*) proved to be small, central, and cylindrical, and contracted at each septum. The lining membrane of the air-cells has separated from the outer shell-wall only (*c*, *c*), producing the appearance noticed on the outside.

A specimen of the same species of *Orthoceras*, in the British Museum, measures a yard in length and 6 inches in diameter at the larger end, although the body-chamber is nearly all wanting. Part of the apex has been slit, and shows the same structure as Mr. Tennant's specimen, but is less regular, and the septa are closer.

Something of this kind was noticed by Mr. Charles Stokes in a Russian *Orthoceras* (Geol. Trans. 2nd series, vol. v. p. 712. pl. 60. f. 4), and was attributed to a separation of the laminæ of the septa. The figure is very obscure, and the specimen probably lost †.

It will probably be found that these appearances are of constant occurrence in the shells of this genus; and that they arise from changes which took place in the lifetime of the animal, commencing at the apex and progressing onwards, and resulting to a greater or less extent in the death of the shell.

* Manual of the Mollusca, 1851, p. 82.

† At the sale of Mr. Stokes' collection all the most important specimens of *Orthocerata* were purchased for the British Museum; but unfortunately many of those figured in the 'Geol. Trans.' by Dr. Bigsby (2nd series, vol. i.), including the type of Bronn's genus *Conoceras*, and others figured by Mr. Stokes himself, could not be found.

I was formerly of opinion that some progressive changes could be observed in the *siphuncle* of the *Orthocerata*; but of this I have not yet obtained entirely satisfactory evidence.

In the work before referred to I stated that the *Orthocerata* did not appear to have become *decollated* in their old age, and that "the preservation of the shell was provided for by the increased size and strength of the siphuncle, and its increased vascularity. In *Endoceras* we find the siphuncle thickened by *internal* deposits, until (in some of the very cylindrical species) it forms an almost solid axis."

This last statement was founded on Prof. Hall's figures *, there being no specimens of *Endoceras* in Europe. The diagram I gave was ideal, and most likely incorrect; for the internal tubes are probably invaginated siphonal joints (if anything) as suggested by Mr. Salter.

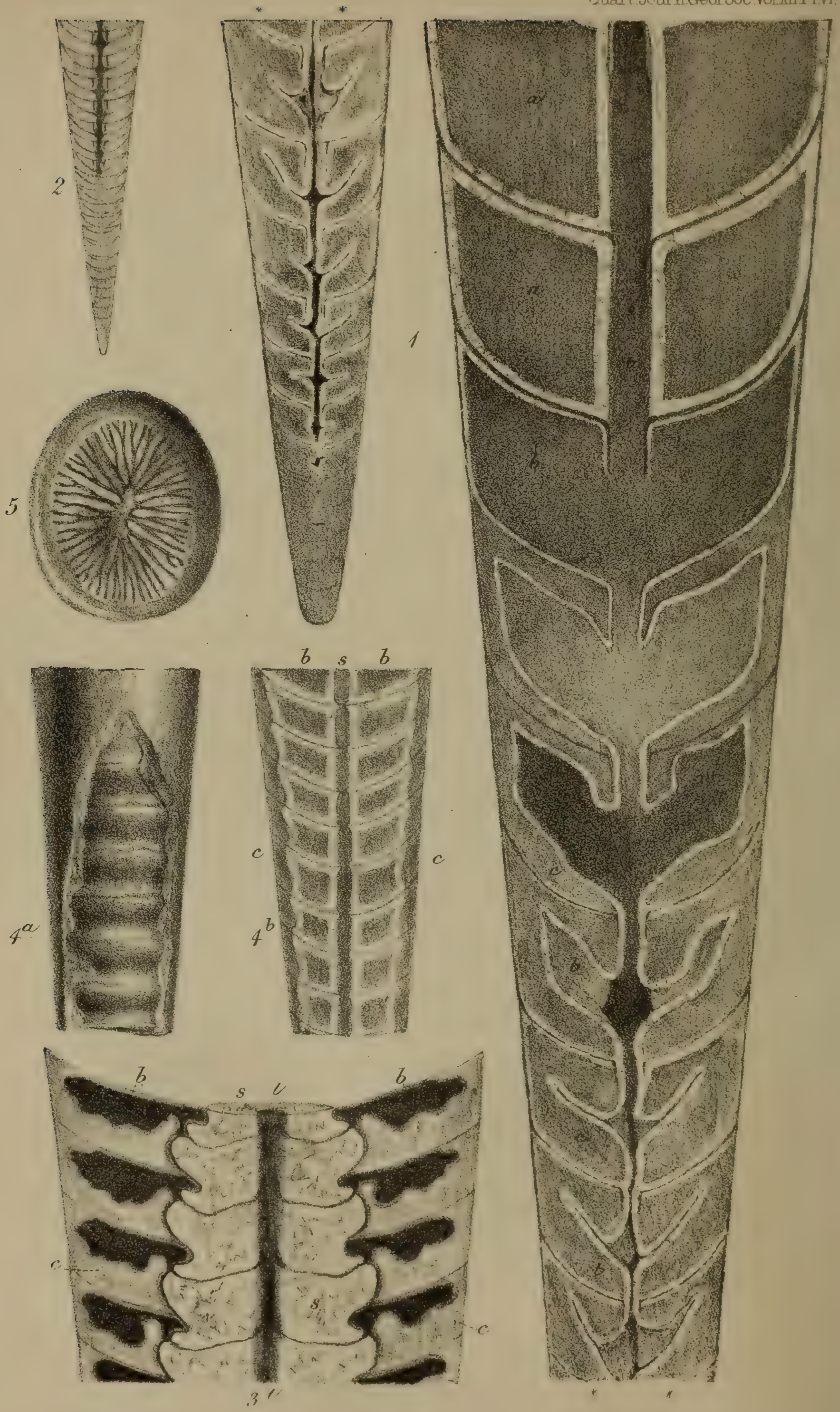
In the Chinese *Orthoceras*, now described, and in all the typical species of the genus, the siphuncle is a simple tube, as in the recent *Nautilus*, where it is nevertheless vascular and connected with a thin membrane lining the air-chambers. But in those species which have been separated under the generic name *Actinoceras* (including *Hormoceras* and *Huronia*), the siphuncle possesses a complicated internal structure, the appearance of which is liable to be modified extremely by fossilization. In all these the structure is essentially like that of the specimen figured and described by Mr. Stokes as *Hormoceras Bayfieldi* (*l. c.* pl. 60. f. 1), the vascular siphuncle being divided into segments, which are radiately plaited and calcified. The vessels which supplied the lining membrane of the air-chambers (Pl. VI. fig. 3, *s*) passed through intervals or foramina between the beads of the siphuncle; in *Actinoceras Bigsbyi*, and other Silurian species, these foramina radiate equally from all sides of the siphuncle, but in *A. giganteum*, and others from the Carboniferous Limestone, the foramina occur in only the ventral side of the beads.

The reduplication of the vascular siphuncle is most remarkable in "*Orthoceras*" *trigonale* (Pl. VI. fig. 5) from the Devonian of Gerolstein.

The figure given by MM. d'Archiac and Verneuil † is taken from a large specimen, and does not represent any peculiarity of structure; and those in the splendid work of the brothers Sandberger on the Devonian fossils of the Rhine ‡ are not so definite as the example now figured, which was obtained by Sir R. Murchison, and given by him to Mr. Stokes. This specimen seems to have escaped more attention from having passed as a fragment of "*Cyrtoceras*" *Eifeliense* (*l. c.* pl. 29. f. 1 *a*), which has a similar siphuncle; and probably belongs to the same genus, although *O. triangulare* has a straight shell.

With regard to the *position* of the siphuncle in the eccentric *Orthocerata*, it seems probable that such species would occupy, normally, an inclined position near the bottom of the sea, with the

* Palæontology of New York, vol. i. pl. 18.
† Geol. Trans. 2nd series, vol. vi. pl. 27. f. 1.
‡ Verst. des Rheinischen Schichtensystems in Nassau, p. 155. pl. xvi.



S. P. Woodward del. Geo. West lith.

W. West Imp.

Orthoceras and Actinoceras

dorsal side upwards, like the recent *Nautilus*. In this case the *siphuncular side* would be *ventral*.

EXPLANATION OF PLATE VI.

Fig. 1. Section of an *Orthoceras* from China; representing the apical portion [divided on the plate], and two out of the seven last air-chambers in which no alteration had taken place.

a, a, air-chambers; *b, b,* the same contracted; *c, c,* intra-mural spaces; *s,* siphuncle; *t,* membranous tube.

In the British Museum.

Fig. 2. Apex of a small *Orthoceras* (*O. conicum*, His. ?) in red limestone; showing the septa alternating with more strongly curved lines of the collapsed lining membrane. Locality unknown.

In the British Museum.

Fig. 3. Section of *Actinoceras Lyonii*, Stokes, from the Black-river Limestone of New York; the membranous siphuncle and the tubes leading from it to the contracted air-cells are filled with black marble; the empty spaces with white spar.

In the British Museum.

Fig. 4 *a*. Fragment from near the apex of an *Orthoceras* (*O. striatum*, Sby. ?), from the Carboniferous Limestone of Ireland; the surface is broken away, showing what appears to be a large internal siphuncle.

Fig. 4 *b*. Section of the same specimen, showing the small central siphuncle and the line of separation of the internal membranes from the shell-wall.

In the Cabinet of Prof. Tennant.

Fig. 5. Siphuncle of *Orthoceras trigonale*, d'Arch. and Vern.; magnified 2½ diameters; from the Devonian of Gerolstein.

In the British Museum.

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4. *On a* NEW GENUS *of* CEPHALOPODA, DIPLOCERAS (Orthoceras bisiphonatum *of Sowerby*); *and on the occurrence of* ASCOCERAS *in* BRITAIN. By J. W. SALTER, Esq., F.G.S.

(Abstract.)

[The publication of this paper is deferred.]

IN this communication the author pointed out the apparent relations of this peculiar form, which has been figured in the 'Silurian System' and in 'Siluria.' It possessed ordinary septa, pierced by an excentric beaded siphuncle, and also had a deep lateral cavity (supposed hitherto to be a second siphuncle) passing down side by side with the siphuncle, and affecting at least seven, if not more of the uppermost septa.

Mr. Salter remarked that the structural peculiarities of *Orthoceras paradoxicum* and of *Gonioceras* might offer some analogy with the shell in question; but he thought that the real affinities were with *Ascoceras* and *Cameroceras*.

Mr. Salter also described a new species of *Ascoceras* (*A. Barrandii*), found not long since in the Upper Ludlow rock, at Ludlow, and at Stansbatch in Herefordshire. The genus is new to Britain.

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5. *On* Trap-dykes *intersecting* Syenite *in the* Malvern Hills, Worcestershire. By the Rev. W. S. Symonds, F.G.S.

Among the varied phænomena described and registered respecting the Malvern Hills in Prof. Phillips's admirable work in the 'Memoirs of the Geological Survey of Great Britain' (vol. ii. part 1), I am not aware of any notice of the effect of injected and intersecting trap upon the syenite of which the great mass of the Malverns is composed.

I had for some time been aware that greenstone and trap-dykes traversed syenite in a quarry worked between the Winds-point and the Obelisk, and to which last autumn I directed the attention of Mr. C. J. Fox Bunbury. Having been requested by Sir W. Jardine to examine the site of the great Malvern bonfire of January last, in order to discover whether any signs of the vitrification of the rocks were visible, I did so, and was immediately struck with the appearance of the roasted syenite which formed the platform, and the similarity presented by the baked mineral to syenite in contact with dykes of trap and greenstone at the quarry at the back of News Wood, half-way between Winds-point and the Obelisk.

I was accompanied during this investigation by a Swiss geologist, Dr. De la Harpe, well accustomed to metamorphic phænomena; he was much struck with this most interesting quarry.

I may here mention that a high wind prevented the flames of the Beacon fire ascending to any height, and I was informed by those present that an intense glow was concentrated upon the syenitic platform.

At the quarry in question several dykes traverse and alter the syenite, and the metamorphism presented by the rock in contact with the greenstone is nearly identical with the effect produced by the Malvern fire.

One of the dykes runs nearly north and south, and is about 10 ft. thick, another from east to west; while a third, of a different kind of trap, traverses from north-east to south-west.

The syenite is altered for several feet from its contact with the dykes, and then gradually assumes its crystalline form.

I have traced the dyke running from north to south to a considerable distance, and at the Gullet Pass it traverses the Holly Bush sandstone, metamorphosing that rock into a steatitic gneiss.

At the valley of the White-leaved Oak, trap is again seen in contact with Holly Bush sandstone, and there also changes it into a gneissose schist. I am inclined to attribute this effect to a prolongation of the same dyke in a southward extension, and I think that the infiltration of the trap took place before the upheaval of the syenite, but after that rock was consolidated.

6. *On the* Movement of Land *in the* South Sea Islands. By James Gay Sawkins, Esq., F.G.S.

Tongataboo, one of the Friendly Islands, was visited a few months previous to my sojourn there in 1854 by an earthquake, when the north-east portion of it was tilted down to an inclination sufficient to produce an encroachment of the sea for nearly two miles inland, gradually diminishing to the south-eastern shore as far as Nuku-alofa, where it now washes the roots of a tree that grew within a garden adjoining a house that has been entirely destroyed. The western coast has visibly risen some feet, and a spring of water has sunk below the surface.

The island is formed of coral; there is no appearance of volcanic intrusion through it; but there have been disturbances that have elevated some parts as high as 116 feet, with a good depth of vegetable soil on them, which in the low land assumes the form of peat, emitting under the rays of the sun strong humic acid.

The overflow of the sea on the northern and eastern sides of the island, and the elevation on the south and west, are interesting in connection with the report of another island having appeared about this time to the westward. This fact was asserted by many, and among them by a whaling captain who had cruised often over the same track, and who landed in an open boat with his crew on the western coast, having stranded his vessel on the said island, which he described as being only a few inches above the ocean (at a distance of thirty miles), and covered with black sand exactly like that on the shores of other volcanic islands in this and the Haabai group; he said that "tons of this sand were being levelled down by the wash of every wave." I made particular inquiry of the natives of Tongataboo if they had ever before seen any appearance of land in that direction, to which they replied, No,—but that it was their belief that it rose on the night of the earthquake (Christmas-eve, 1853), when the sea came over the land at Hihifo (the North Point).

Since this occurrence an eruption took place at Niuafoou, an island to the north, which destroyed nearly one half of its inhabitants; it occurred about midnight, and so sudden was the overflow of lava from several apertures in the vicinity of a village, that the people who ran for the shore were overtaken by it and destroyed. This eruption was not felt at Tongataboo.

From these and other circumstances I am very doubtful if there exists so great an amount of subsidence as of upheaval of land at present in the Pacific; also the fact of my never having been able to find a well-rounded pebble or much-waterworn stone among the alluvial deposits in the interior of any of these islands, convinces me there has been no drift as in Europe, and forcibly leads me to the opinion that a continent is forming and not disappearing, as some have been led to suppose by a similar oscillation, perhaps, as I have endeavoured to describe.

When examining the Island of Tahiti, one of the Society Islands, ascending some of its higher mountains I found several strata of coral and volcanic matter alternately overlying each other; and at the boring of an artesian well near the town of Pepita five alternate strata of coral and volcanic ashes were bored through in the space of 25 feet, showing not only that several eruptions had occurred, but that sufficient time must have intervened for the zoophytes to have formed the coral between each, long before the island was elevated to the height it now is. The same thing occurs at Oahu (near Honolulu), one of the Sandwich Islands, at the foot of an extinct crater called "the Punch bowl *." In conclusion I must say I returned from the Pacific Islands with a conviction there is a greater extension of land going on by volcanic and coral formations, than diminution by abrasion or subsidence.

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7. *On the Possible Origin of* Veins of Gold in Quartz *and other Rocks*. By L. L. B. Ibbetson, Esq., F.R.S., F.G.S.

[Abstract.]

Having mixed a solution of gold in nitromuriatic acid with five times its weight of water, and placed it in a Berlin evaporating-dish on a thick sheet of copper over a gas-lamp, the author observed a crack in the basin, which was increasing. On transferring the solution to another basin, he found that the crack presented a vein of gold; the pure gold forming small nodular masses along the fissure, both inside and out, and resembling veins of gold in auriferous quartz-rocks. Under the circumstances of the low temperature at which the solution was being evaporated, the diluted state of the solution still left unevaporated, and the difference of the appearance of the nodular form of the gold-vein from the usual appearance of the metallic gold obtained by evaporation from such a solution, the author thought it worth while to describe and exhibit the specimen to the Meeting.

June 18, 1856.

SPECIAL GENERAL MEETING.

Sir C. Lyell, V.P.G.S., in the Chair.

1. It was announced from the Chair that, in consequence of the lamented decease of Daniel Sharpe, Esq., the late President, the Society was now called upon to elect a President and a Member of Council.

* This was filled with fresh water until 1837, when it disappeared during an earthquake.

2. Scrutineers were appointed, who, after the Ballot, reported that Col. Portlock, R.E., F.R.S., was unanimously elected President; and that Hugh Falconer, M.D., F.R.S., was unanimously elected a Member of Council.

ORDINARY MEETING.

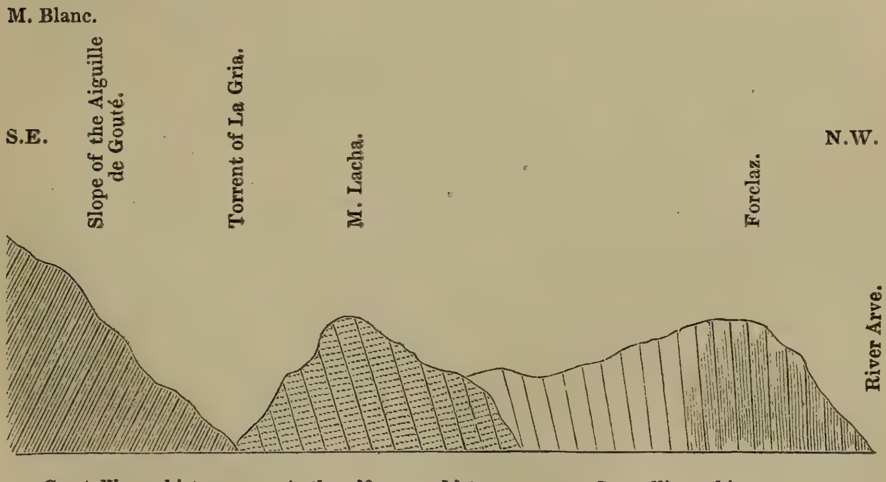
Col. Portlock, President, in the Chair.

The following communications were read:—

1. *On a* Section *near* Mont Blanc. By Major S. Charters, F.G.S.

[In a letter to Dr. Fitton, F.G.S.]

On looking over an old note-book I found a Section which satisfies me that Mr. D. Sharpe is correct in the view he has taken of the cleavage. I send you a copy of it, which, if you have an opportunity, you may show him,—not that the observations of so unscientific a geologist as I am can have any weight, but it may be satisfactory to him, now that his paper has been attacked, to see that the difference between cleavage and stratification, as exhibited at Mont Lacha, attracted the attention of such a mere *dilettante* as myself, now five years ago,—and that I scouted the idea of strata plunging under the igneous rock that had upheaved them; and that, until I had made out the cleavage of Mont Lacha, I had attributed the anomaly to reversal.



The dotted lines represent the lines of cleavage perpendicular to those of stratification, which dip to the north-west at an angle of 75°.

Ascending the torrent of La Gria, which nearly marks the separation of the calcareous rocks of Mont Lacha from the crystalline rocks of the Aiguille de Gouté, we find a dark-coloured compact limestone, the strata of which dip at an angle of 75° to N.W. Proceeding further up the ravine, the calcareous rock becomes more schistose, and frequently talcose. *Belemnites* and *Ammonites*, in bad preservation, are not rare in the calcareous schists, but I found no impressions of plants. At first sight, the cleavage may easily be mistaken for stratification; but by attentive observation, the strata are evident, and their dip is normal, supposing Mont Blanc to be the centre of upheaval. The Forclaz is a continuation of Lacha, but towards the N.W. end, where it is separated by the River Arve from the Aiguilles Rouges, the rocks are crystalline and the strata nearly vertical.

The above section is a true copy of one taken by myself on the spot in 1851.

Mont Lacha throws much light on the apparently abnormal position of the strata in some points named by Prof. Forbes, as Mont Fretty, Côte de Piget, at the foot of Mont Bochard, &c.,—in short the whole "Superposition Monstrueuse" of De Saussure disappears, and I am fully convinced (as far as the Section here described is concerned) of the accuracy of Mr. Sharpe's observations.

Until I studied the stratification and cleavage of Mont Lacha, I was under the delusion that the strata of Mont Fretty, &c. dipped towards the crystalline rocks; but as they were mere fractions, compared to the immense masses of Mont Cramout, Mont Carmot, &c. on the south of Mont Blanc, all in their normal position, I attributed them to reversal.

Bath, April 25, 1856.

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2. *Further Notice* of the* Recent Eruption *from the* Volcano *of* Mauna Loa *in* Hawaii (Owhyhee). By W. Miller, Esq., H.M. Consul-General for the Sandwich Islands.

[Forwarded from the Foreign Office by order of Lord Clarendon.]

(Abstract.)

The stream of lava burst forth in August, 1855, from the side of Mauna Loa, which rises to a height of 14,000 feet above the sea, at a short distance below the summit, and about sixty miles in a direct line from the harbour of the town of Hilo in Byron's Bay. At the date of Mr. Miller's letter it had not ceased to flow, and had then continued for a period of twenty-three weeks, and the stream had a length of about fifty miles in all its windings. For the first three weeks it had flowed uninterruptedly about thirty-eight miles, when it met with a dense forest of trees and jungle which arrested its rapid progress. It had forced its way through ten or twelve miles of the forest, at the rate of about half a mile in a week. There still remained about three miles of the forest to the open ground which extends to the town of Hilo, the lava being about five or six miles distant from the town.

* Dated March 1, 1856. For the first notice, see this volume of the Journal, p. 171. Mr. Miller's communication was accompanied with a sketch-plan of the position of the Lava-stream, and with a box of specimens of lava, &c. collected by Mr. John Ritson.

Mr. Bishop, who examined the stream near the place it had then reached, thus describes * what he saw :—On ascending a low hillock between two nearly dry cascades he saw before him the blazing woods and jungle and the flowing lava in a narrow dull sluggish stream filling a side channel of the brook. It appeared to be about 100 yards in advance of a larger body, about 300 yards wide, which, unobstructed in the smooth channel, rolled on about 100 feet in an hour; its front a glaring red, cooling as it flowed. A bright tongue of the stream dashed forward, and rolled with dull plash over the precipice. It formed a brilliant cascade of 25 feet, first in a broken and at last in a continuous torrent, striking on a ledge, and sliding off into the deep pool below. It gradually heaped up a mound of half-solidified lava. It is stated that the higher regions of the mountain were flooded with vast tracts of smoking lava, while the streams which flowed down the side spread over a surface of several miles in breadth; and that the main stream now runs all the way in a covered duct, so that it can be seen only at its vents which let off the gas. A vessel at sea saw the light caused by the eruption at a distance of fifty miles.

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3. *On the* Geology *of* Varna *and its Vicinity, and of other parts of* Bulgaria. By Capt. Spratt, R.N., F.R.S., F.G.S.

[Abstract.]

(The publication of this paper is postponed.)

Capt. Spratt first noticed a series of whitish calcareous sandstones and marls, seen on the Bulgarian coasts; these are nearly 1000 feet thick, and are overlaid by reddish sands and marls. The former are of marine origin and of Eocene tertiary date; the latter are chiefly of freshwater origin. Near Varna the freshwater beds have been much denuded, and are not anywhere more than 200 feet thick. At Cape Aspro, fifteen miles south of Varna, both of the series—the grey and the red deposits—are seen disturbed and dipping to the south, but unconformably, one series (the lower) having an angle of 30°, whilst the upper dips at 20°. At Cape Emineh, south of Cape Aspro, and forming the termination of the Balkan, these beds are still more disturbed and dip to the north. Capt. Spratt then described the geological appearances along the coast southward. At the Gulf of Bourgas and in the vicinity are igneous rocks, and deposits formed from their waste. Granite occurs on the southern point of the bay.

Returning to Varna, Capt. Spratt pointed out the localities of the fossils collected in the neighbourhood. The calcareous sandstones abound in casts of shells and in Oysters and Pectens immediately around Varna; and contain *Nummulites* in profusion at the upper part of the Lake near Allahdyn. In this last-named neighbourhood

* In 'The Friend,' Honolulu, March 1, 1856.

the uppermost strata, left by the denuding agencies that have affected the district, are more durable than the underlying marls, &c., and have a thickness of about 20 or 30 feet. They consist of a stony mass of *Nummulites*, *Operculinæ*, and *Orbitoides*, with *Pectines*, *Terebratulæ*, and *Ostrææ*. This harder portion of the superficial rock has become apparently weather-worn into vertical pillars, either isolated or still connected above by an horizontal layer of hard rock which has resisted the destructive action of the weather. Capt. Spratt observed that in some places in the vicinity the surface-rock was split by vertical cracks, so as to resemble an open pavement. These fissures, operated upon by atmospheric agencies, illustrate, in the author's opinion, the method in which the columnar fragments above alluded to, and other masses more or less spherical, remaining on the land, must have originated. The *Nummulites* contained in the disintegrating rock have not been destroyed, but remain intact, lying about in heaps around the remaining nodules of limestone.

Capt. Spratt referred to the possibility of this columnar state of the hard rock of the upper marine series having been brought about, during the period which intervened between the deposition of the marine strata and that of the freshwater beds overlying the marine series in the neighbourhood, by means of water-action: as it is possible that the columnar surface of the degraded eocene beds may have been covered up by the later deposits, and subsequently re-excavated. This opinion seems to be supported by the fact of columns occurring in a part of the Bay of Varna, at about 5 fathoms depth. But Capt. Spratt leans to the opinion that the columnar degradation is atmospheric, modern, and in actual progress.

Capt. Spratt then described the geology of the coast north of Varna. The Eocene deposits (yellowish limestone and sandy marls) occur as far nearly as Mangalia. The reddish freshwater sands and marls then come in, overlying, and form generally the steppes of the Dobrudcha. Land-shells occur in some of the upper beds of this district. The author then dwelt on the points of correspondence between the rocks composing the termination of the Balkan with those of the Crimea, and of the steppes of the Dobrudcha with the northern part of the Crimea.

Capt. Spratt proceeded next to consider the age of the overlying red marls and sands; and pointed out their resemblance to the freshwater deposits on the northern shore of the Sea of Marmora, on the Macedonian coast, the northern end of Eubœa, and the Locrian shore. In fact, almost all the Thracian peninsula is composed of freshwater deposits of brown and grey marls and sandstones, nearly horizontal and attaining about 500 feet of thickness, which appear to be contemporaneous with the upper pliocene freshwater deposits on the western side of the Archipelago, in Eubœa and Macedonia, and in Rhodes, &c. on the south.

The author concluded with a notice of a post-tertiary or recent marine deposit on the coast of the Dardanelles at a height of about 15 or 20 feet above the present sea-level.

4. *On the Geology of* Trinidad. By H. G. Bowen, Esq., F.G.S.

[Abstract.]

The northern district of the Island of Trinidad, with the islands between it and the mainland, is composed of flagstones, slates, and schists, with quartz-veins and some dark-coloured intercalated limestone. These rocks are all apparently unfossiliferous; the slates often abound with iron-pyrites and magnetic iron-ore, and some of the ochreous quartz-veins (gossans) are slightly auriferous. Stalactitic caves occur in the limestone of the Island of Gaspar Grande, and at Las Cuevas and Arouca. Alluvial beds of clay and gravel are extensive in this district, and are sometimes 60 feet thick. At Lateen Bay, in Chicachicare Island, a patch of aluminous clay-slate occurs, with seams of crystalline limestone. The soil of this northern district is fertile on the limestone, and barren on the slates. The slate-rocks appear to be the same as those of Venezuela, which overlie the quartz-rock that crops out at Upata; and rounded boulders of quartz-rock occur in the flagstones.

In the south of the Island of Trinidad, red sandstone abounds, often ferruginous, and associated with clays which are often either bituminous or pyritous, and contain lignite and impressions of dicotyledonous leaves. In the Erin district the clay-beds have been sometimes indurated and jasperized by heat. They afford also small aluminous, chalybeate, and sulphuretted hydrogen springs, and in the blue-clay formation are found hillocks throwing up mud and water, and ponds covered by a film of mineral tar. The mud-volcanos throw up saline water and greyish mud, in a cold state, with iron-pyrites and water-worn pebbles of blue limestone like that of the northern part of the island, and sometimes of sandstone. They do not appear to be connected with the sea; and are most active at the close of the rainy season. At Moruga small hills of granular limestone occur. The succession of deposits in this southern part of Trinidad appears to be—beginning from below—1. Sandstones, variegated sands, lignitiferous clays (sometimes jasperized), and the Moruga limestone; 2. Blue and brown clays, with bitumen; comprising the pitch-lakes, salt and alum springs, &c.; 3. Modern marine sand formation, from 50 to 100 feet thick; and alluvial deposits, seldom more than 30 feet thick.

The eastern coast of Trinidad appears to consist of the red sandstones and bituminous clays as far north as Matura, beyond which the clay-slates set in.

The western coast of the island, south of Port of Spain, which is built of the slate-rocks and limestone, exhibits only modern alluvial deposits, sometimes calcareous, frequently ferruginous, and apparently resting towards the south on the red sandstone of the southern district.

5. *On the Fossils found in the* Chalk-flints *and* Greensand *of* Aberdeenshire. By J. W. Salter, Esq., F.G.S.

[Abstract.]

(The publication of this paper is postponed.)

A notice of the occurrence of chalk-flints and greensand in Aberdeenshire* has been published by W. Ferguson, Esq., F.G.S., in the Proceed. Glasgow Phil. Soc. vol. iii. p. 33, and the Phil. Mag. 1850, p. 430, and some of the facts had been previously noticed; but no lists of the fossils had been given.

This communication showed the presence of characteristic Upper Greensand fossils in the low ground at Moreseat: *Thetis minor, Arca carinata, Pinna tetragona,* and *Galerites castanea*; with other species, some of them new.

Among the Chalk fossils, *Lima elegans* of Nilsson is a new fossil to Britain, and is found with the ordinary *Inocerami* and *Echinites* of the Chalk in the rolled flints which form terraces round the hills in Aberdeenshire. The probable continuity, therefore, of these beds with those of the south of Sweden, where the same order of succession prevails, is inferred; the extension of the Upper Greensand so far north is a point of much interest.

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6. *On the* Correlation *of the* Middle Eocene Tertiaries *of* England, France, *and* Belgium. By J. Prestwich, Esq., F.R.S., Treas. G.S.

[Abstract.]

(The publication of this paper is postponed.)

In a former paper the author had shown the correlation of the strata beneath the Bracklesham series in England, the *Calcaire grossier* and *Lits Coquilliers* in France, and the Upper Ypresian system in Belgium, and had proposed to designate that lower series the "London Tertiary Group," from the circumstance of these strata attaining the largest and most distinct development in the English area. In the present paper Mr. Prestwich entered into an account of the structures of the deposits next above. In France this is the *Calcaire grossier,* which the French geologists have divided into four stages:—1. a series of white and light-green marls, apparently of freshwater origin; 2. an upper divison, of calcareous rock, harder and more flaggy than the next below, and rich in *Miliolites* and *Cerithium,* mixed with a few freshwater shells and the remains of plants and land-animals; 3. a middle one, of a calcareous freestone abounding in marine organic remains (Grignon, Courtagnon, and other celebrated localities being in beds of this zone); and 4. a lower one of green sands, with few fossils. Each division attains at places a thickness of 30 to 40 feet, but the lower ones are thickest in the centre and west

* It appears not very satisfactorily proved that the chalk and greensand exist *in situ* in this locality; Proc. Glasgow Phil. Soc. vol. iii. p. 44 *et seq.*—Ed.

of the Paris basin; whilst the upper, on the contrary, are thickest to the eastward. The total thickness of the deposit, therefore, rarely at any one place exceeds 100 feet, whilst the Upper Bracklesham series, with which it corresponds, is more than 500 feet thick. This difference the author attributed to a more rapid subsidence of the English area than of the French at that geological period. This, he showed, was accompanied by more marine conditions prevailing all through the English deposit, and by the continuance throughout of the same green sands which in France were confined to the lower division. That the whole series was, however, synchronous with the *Calcaire grossier* he considered proved by the circumstance, that, although the freshwater beds which existed in France did not extend to this country, yet the organic remains of some of the beds of the Bracklesham series gave evidence of an upper division higher than the beds with the *Venericardia planicosta* and *Cerithium giganteum* of Bracklesham, for at the latter place the proportion of shells ranging up into the overlying Barton series was 30 *per cent.*, whereas in some beds recently discovered by Mr. F. Edwards at Bramshaw, and apparently at the top of the Bracklesham series, the proportion is 46 *per cent.* The middle beds of the upper Bracklesham series show the closest affinity with the Middle *Calcaire grossier*, although there are only 140 species in common. The lowest division of this series is more fossiliferous in England than in France, showing a closer relation (43 *per cent.*) with the underlying beds than does the mass of the *Calcaire grossier*, in which the proportion is as 28 *per cent.* The total number of Molluscs in the *Calcaire grossier* of the Oise is 651, and in the Bracklesham series of Hampshire 368.

Above this zone is the series of the *Sables moyens* in France and Barton clays in England. Owing to the number of *Calcaire grossier* fossils which had been found at Barton, these beds had been considered synchronous with the *Calcaire grossier*, a view which the author himself had formerly adopted with reserve. Seeing, however, that the Bracklesham series probably represents all the divisions of the *Calcaire grossier*, and that the distinction between the Bracklesham and Barton series was of equal value to that between the *Calcaire grossier* and the *Sables moyens*, the author now correlated the Barton clays with the *Sables moyens*, as suggested by M. Graves, M. Dumont, Sir Charles Lyell, and M. Hébert. He, however, alluded to the difficulty of doing this upon the evidence of any small number of organic remains, or even of a few species considered characteristic in one area; and he showed that in the Barton clay itself, although there were many *Sables moyens* species (63), still there were a greater number of *Calcaire grossier* species (69). In the same way in the Laeckenian system of Belgium, which overlies the Bruxellian system (the equivalent of the *Calcaire grossier*), there are forty-five *Calcaire grossier* and Bracklesham sand species, and only forty-four Barton and *Sables moyens* species. But Mr. Prestwich showed that, taking the per-centage of species which range from the lower to the higher series, each area offered nearly an equal amount of distinction; as out of 100 species of the lower series there are in England 30, in France 35, and in Belgium 32, which range upwards.

Mr. Prestwich mentioned that M. Graves had recognized several well-known Barton species, such as the *Voluta depauperata*, *V. athleta*, *Oliva Branderi*, *Conus scabriusculus*, &c., in the *Sables moyens* of the Oise. The total known number of the *Sables moyens* species is 377, and of the Barton clay species 252.

These series the author proposed to term the "Paris Tertiary Group" (its lower part), as the several members of it were more complete in France than in England, and contained a richer and better-preserved fauna. This Paris group forms the great Nummulitic zone. Hitherto none of these *Foraminifera* (*Nummulina*) have been found in the London group.

The author concluded with some general observations on the extent of the ancient seas and the position of the dry land, and took occasion to observe on the fact, that, although the several deposits in each country were so rich in organic remains, yet so small a proportion of them should have hitherto been identified as common to the several areas. Nevertheless the same genera prevailed, and the relative number of species of each genus was generally tolerably well maintained. He hoped, therefore, that Palæontologists would, in cases where there was now good reason to believe the strata to be synchronous, inquire further into the extent of variation which the same species might undergo in areas where the sea had presented such different conditions of depth, mineral composition of sea-bottom, &c. A certain number of peculiar species must necessarily result from such different conditions, but the author considered it probable that the same causes would lead to the existence of such marked varieties as might, viewing each area separately and independently, cause some varieties to assume the permanence and importance of specific differences. Until the exact synchronism of any deposit is established, the Palæontologist cannot always fully take these causes into consideration, and many admirable monographs on Tertiary fossils have necessarily been founded, in great measure, upon the differences actually apparent and persistent in the several areas.

Mr. Prestwich stated that it was his intention to continue this inquiry at a future period, and to examine into the correlation of the interesting freshwater and fluviatile series overlying the Barton clay on the Hampshire coast and in the Isle of Wight.

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PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the GEOLOGY *of the* NORTH-EASTERN PART *of* CARINTHIA. By M. V. LIPOLD.

[Proceed. Imp. Geol. Instit. Vienna, March 6, 1855.]

M. BOUÉ'S supposition that eocene strata exist near Guttaring, N.E. of St. Veit, was confirmed by Von Hauer's examination of the organic remains found in that locality. Still more recently M. Hoernes has determined among the Guttaring fossils fifteen species peculiar to the lowest portion of the eocene formation, and strikingly agreeing with those of the Val di Ronca.

This formation appears in the basin of Guttaring, and forms the ridge separating this basin from the Goerschitz valley, and another ridge separating it from the vicinity of Althofen, without advancing as far as Althofen or into the Goerschitz valley itself. It also appears in some isolated patches at the Dachberg, S.E. of Althofen, near Kappel, and at the Piemberg, W. of Klein St. Paul.

The strata succeed each other, in ascending order, as follows:—

Clay, unfossiliferous.
Marls and limestones, with fossils and beds of coal.
Sands, white and yellow.
Nummulitic limestone and sandy strata.

The nummulitic limestone of the Piemberg contains numerous Echinoderms.

The eocene strata on the northern slope of the Guttaring basin rest immediately on argillaceous mica-slate; those on the south slope, together with those at the Piemberg and Dachberg, rest on cretaceous deposits.

Lignites are found in them near Kappel and on the Somberg, where they are worked. The four coal-beds on the Somberg (the largest of them being scarcely 5 feet thick) are separated from each other by beds of marl-slate and limestones, abounding in Bivalves. The irregularities of the course and shape of the coal-beds denote considerable disturbances in the including strata.

The eocene beds on the north slope of the Guttaring basin dip conformably to the south; those on the south slope have a northward dip. Generally the eocene deposits of North-eastern Carinthia are of no considerable extent, and their thickness does not exceed 800 feet.

The cretaceous deposits occupy a far more considerable range in this region. M. F. von Rosthorn was the first who referred the Rudista-beds between Althofen and the Mannsberg to the Cretaceous formation. M. M. Lipold found confirmation of this both in the *Rudista* discovered at Mount Calvary near Althofen, on the Zennsberg, and on the Reinberg, near St. Paul; and in the petrographical agreement of the Althofen strata with the known cretaceous rocks of Upper Austria, Salzburg and Styria,—especially with the cretaceous marble of the Untersberg near Salzburg.

Limestones, in beds 3 feet thick, predominate among the cretaceous deposits of N. E. Carinthia, marls and sandstones also occurring. Near the base of the formation, breccias of calcareous or schistose rocks are met with.

Besides the *Rudista*, some species of Corals and undetermined specimens of Bivalves were found in the limestone by M. Lipold.

The range of hills separating the valleys of Goerschitz and the Silberbach, and running from Althofen and Guttaring (on the north) to Eberstein and Mannsberg (on the south), is wholly composed of cretaceous rocks. Isolated portions occur at the Zennsberg, N.E. of St. Georgen on the Längsee, S. of Silberegg, near M. Wolschert on the right bank of the river Gurk, and on the left bank of this river at Wieting and Unter St. Paul in the Goerschitz valley. Besides at these localities, cretaceous rocks appear in the lower Lavant Valley at the Reinberg, E. of St. Paul, near St. Martin, S.W. of St. Paul (where they reach as high as the pass leading to Eis), and between Lavamünd and Unter-Drauburg, near Rabenstein, in the shape of rocky cliffs rising amidst the surrounding gravels.

Cretaceous strata have been found resting both on Werfen and Guttenstein strata (Unter St. Paul, Mannsberg, Zennsberg, St. Paul in the Lavant valley), and immediately on grauwacke-slate and argillaceous mica-schist (Wieting and Althofen). M. Lipold estimates the thickness of the cretaceous deposits as not exceeding that of the eocene (800 feet). [Count M.]

On the Ferriferous Deposits *of* Hüttenberg *in* Carinthia. By MM. Fred. Münichdorfer and M. F. Lipold.

[Proceed. Imp. Geol. Instit. Vienna, March 13, 1855.]

The rocks of the district are gneiss, mica-schist, argillaceous mica-schist, clay-slate, crystalline limestone, amphibolic gneiss and slate, and eclogite. Mica-schist predominates near the mountain; and calcareous and amphibolic rocks appear only as subordinate layers in it. The calcareous beds are of particular importance, the iron-ores being exclusively confined to them. The gneiss includes one of these beds, and there are four in the mica-schist. They are parallel to each other; striking S.E. and N.W., and dipping conformably with the stratification of the surrounding crystalline slates. The thickness of these calcareous strata is from 360 to 2400 feet; and they are separated from each other by masses of slates 600 to 2400 feet in thickness.

The iron-ores are chiefly met with as lenticular masses, forming regular beds in the lowest calcareous stratum (nearly 2400 feet thick), belonging to the mica-schist. The ferriferous beds of the principal ore mountain are distinct from those of the other mountain; the former are again subdivided, on account of their occurring either in the Hüttenberg or in the Lölling district. There are altogether twenty-four of the ore-bearing deposits at present opened at twelve distinct levels, the maximum vertical distance of which is 600 feet. These deposits have generally a lenticular shape, and are dispersed through the whole of the respective limestone beds, without any visible mutual connexion. They disappear gradually, or lose their integrity, or even pass insensibly into sterile carbonate of lime (pure or magnesian [Rohwand]), both in their length and their depth. They are sometimes also cut off by strata of the including crystalline slates.

The average longitudinal extent of these ferruginous deposits is from 600 to 1200 feet; their thickness is from 24 to 30 feet. In one instance the length is as much as 2040 feet; while in other places it diminishes to from 120 to 180 feet, the thickness then amounting only to 3 or 4 feet.

The continuity of the deposits of ore is occasionally interrupted by sterile masses of crystalline limestone or of mica-schist; and derangements and irregularities of direction and thickness are not uncommon. They generally extend S.E. and N.W., and dip to the S.W. at an angle of 45° to 50°; in each respect conformably with the including limestone.

Sulphate of barytes is a constant attendant to these iron-ores, either in the shape of masses or layers, or intimately mixed with the ore. Sometimes also it occurs in beds 2 or 3 feet thick. The purest ores occur associated with this mineral, which is worked for the use of the white-lead manufactories.

The iron-ores are smelted in the blast-furnaces of Lölling, Heft, Mosinz, Eberstein, and Treibach, and are either carbonate of iron ("white ores"), or fibrous and compact hydroxides of iron ("brown ores"), or oxide of iron ("blue ores"), or decomposed ochrey hydroxide of iron ("Motte"), or, lastly, very poor carbonate of iron ("Rohwand"). Generally the blue ores predominate in the highest levels; brown ores in the middle; and the white ores in the deepest. Spheroidal masses of fibrous or compact hydroxide of iron, either having a central cavity, or enclosing a nucleus of carbonate of iron, frequently occur on the level of the Lölling chief-gallery, and seem to owe their origin to a process of decomposition from without inwards.

Other minerals occurring in these iron-deposits are skorodite (arseniated iron), calcareous spar, stalactitic arragonite (*flos ferri*), manganese-graphite, quartz, chalcedony, several ores of manganese, the variety of arsenical pyrites known under the name of "Lœllingite," and grey sulpho-antimoniate of copper.

In M. Münichdorfer's opinion, the ferriferous deposits of Hüttenberg are of contemporaneous origin with the associated crystalline limestone, and have not resulted from injections or sublimations.

M. Lipold, who surveyed this district in the summer of 1854, remarks that it is a mistake to suppose that all the deposits of iron-ore occurring on the southern slope of the Carinthian Central Alps belong to one and the same formation or ferriferous zone. Geological investigations have shown the necessity of a separation between the western deposits (Kremsgraben near Gmünd and Turrach) from the eastern ones (Hüttenberg, Walch, &c.). MM. Stur and Peters have proved that the western group belongs to the lowest portion of the Carboniferous formation; while the eastern group is always enclosed in crystalline slates, such as mica-schist, gneiss, &c. Moreover, the former is due essentially to pyrites and hydroxides of iron, and their decomposition; while the latter has for its constituent mineral the carbonate of iron, partly reduced to the state of brown hydroxide.

The geodes (Kernerze), described by M. Münichdorfer, are of great service in the illustration of the origin of the ferruginous deposits and of the changes they have undergone. MM. von Haidinger and A. von Morlot have proved that the carbonate of iron is produced by a catagenic (reductive) process going on at great depths; in opposition to the anagenic (oxidating) origin of the hydroxide of the same metal, caused by the influence of air and water, where they have access to the ferriferous deposit. Observation on a larger scale has confirmed this explanation; the carbonate of iron occupying the deeper parts of the ore-mountain of Hüttenberg, which are inaccessible to air and water; while the hydroxide is found nearer to the surface. The presence of red oxide of iron at the highest level may depend upon particular circumstances, deserving further investigation.

[Count M.]

Mineral Vein *near* Guadalajara *in* Spain. By A. Breithaupt.

[Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1855, p. 705; and Hartmann's Berg- u. Hütten-männ. Zeitung, 1854, 2, p. 9.]

The formation of the main lode in the mining district of Hiendelaenzina near Guadalajara, in Spain, agrees very much in its characters with that in the Neue Hoffnung Gottes mine at Braunsdorf near Freiberg. Quartz is the oldest member, and partially massive. With the silver minerals,—sulphuret of silver and antimony (schilfglaserz, freieslebenite), crystallized, and even in compact masses, red silver (rothgültigerz, pyrargyrite), compact and crystallized, and miargyrite, as yet found only in a compact form,—occur bournonite and galena. In the shallow levels, which especially carry galena, carbonate of lead and sulphate of lead also occur. [T. R. J.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Gneiss *and* Granite *of* Central Bohemia. By M. Jokély.

[Proceed. Imp. Geol. Instit. Vienna, March 13, 1855.]

During the summer of 1854, M. Jokély examined the gneiss and granite mountains around Millotitz in Central Bohemia. The gneiss occurs only at the southern extremity of the district in question, and forms the extreme northern termination of the gneissic group of Southern Bohemia. It constitutes an elevated plateau of slightly undulating country, only in a few localities attaining more than the average altitude of 1500 feet. The strike of the gneiss corresponds with the boundary-line of this formation ; the dip is between N. and W., so that it plunges everywhere beneath the granite.

The most conspicuous rock subordinate to this gneiss is granite in the form of beds or veins. The granite beds, lying conformably with the gneiss, are connected with veins and masses of auriferous and argentiferous quartzites, formerly the object of mining enterprise.

Granulite and amphibolic slates appear locally. Patches of tertiary sand, clay, and gravel, overlying the gneiss, at altitudes of as much as 1400 feet, occupy a larger extent of surface. These deposits were once connected with the tertiary freshwater basin of Wittingau, at the N.W. extremity of which they form a bay.

Alluvial deposits and kaolin, resulting from the decomposition of granitic rocks, are the most recent formations within the district under notice.

The granite prevails within the district; its surface is highly undulating ; the average elevation is 1800 feet; some isolated cones attain a height of 2500 feet. The chief varieties of the granite are granitic gneiss, more or less fine-grained true granite, micaceous granite, and porphyritic granite, which as they nearly everywhere contain particles of amphibole, may also be called amphibolic granites.

Subordinate to the granite are granites in beds or in veins with quartzites, and amphibolites with diorites and porphyries. The stratiform granites, lithologically identical with the fine-grained light-coloured granites of the gneiss, are especially frequent in the eastern portion of the district ; their strike is between N.E. and E., and they are of some importance from their association with metalliferous quartzites.

The amphibolites, of variable granular texture, and always containing some oligoklase, occur in mass, especially around Ob- and Unter-Huip, Milin, and Brezuitz. The diorites accompany them as beds or veins; and, from the conditions of their association and their transition one into the other, the diorites and the including amphibolites appear to have been contemporaneous in their origin.

The porphyries are all quartziferous and euritic; the granitic and biotitic varieties are the most extensive; true euritic porphyries being only subordinate. The last, only locally interspersed with quartz, and frequently composed of unmixed eurite, may be regarded as a compact, finely crystallized variety of stratiform granite.

Granitic porphyries differ from porphyroid granite only by their fundamental mass being compact and more or less fine-grained. This variety of porphyry, which is met with only in a few localities, is generally associated with micaceous (biotitic) porphyry, characterized by containing exclusively the variety of mica named "biotite." According to M. Grailich, the apparent optical angle of the biotite is very small, varying between 0 and 3°. The biotitic porphyries are bedded, with a strike between N.E. and E., and form distinct zones, exclusively confined to the granitic mass, enclosed between two areas of clay-slate, and quite wanting in the rest of the granitic district.

The metalliferous minerals of the granitic district are not of importance, the working of gold- and silver-ores in the light-coloured bedded granite and the biotitic porphyries having been long since abandoned. At present workings are carried on in the silver-ores and red oxide of iron in the amphibolites of Ober-Lichnitz and Sliwitz, and the antimony-ores of the biotitic porphyry of Mitteschau.

[Count M.]

On the Extraction of Silver, Cobalt, *and* Nickel *from the* Joachimsthal Silver-Ores. By M. Patera.

[Proceedings Imp. Geol. Institute, Vienna, November 6, 1855.]

In simultaneously extracting silver, cobalt, and nickel from the rich ores not long since discovered in the Joachimsthal Mines *, in Bohemia, M. Patera first roasts the ore in an atmosphere of aqueous vapour, to prevent loss by the escape of gases and volatilization; the roasted ore is then placed in wooden tubs and treated with moderately diluted sulphuric acid, mixed with some nitric acid, at a high temperature. Nearly the whole of the silver, cobalt, and nickel is dissolved; and the solution contains also some iron, copper, and arsenic. The silver is then precipitated by means of a solution of sea-salt; the chloride obtained, reduced by iron and smelted, gives a silver of great purity. The arsenic is separated by the addition of chloride of

* See also Quart. Journ. Geol. Soc. vol. xi. part 2, Miscell. p. 37.

iron, and by neutralizing the solution with carbonate of lime; basic arseniate of iron is precipitated, together with an excess of oxide of iron, the solution remaining free of arsenic and iron. The cobalt is precipitated from the neutral solution by a solution of subchlorate of lime; and afterwards the nickel, in the state of hydrated oxide, by the addition of caustic lime. This oxyhydrate undergoes drying and heating to redness; it is then ground to a fine powder, brought to a tenacious consistence by means of black meal and syrup, cut into cubical pieces, and again submitted to a red heat. The nickel, so reduced to a metallic state, preserves the cubical form, if the oxide had the proper degree of purity. Some of these nickel cubes were analysed by M. Wisoky, who found only 1½ *per cent.* of other metals, with a trifling proportion of cobalt.

From Karl von Hauer's analysis * of the nickel extracted by M. Patera from the rich silver-ores of Joachimsthal, it appears that 100 parts of this nickel contain

Nickel............	86·4
Cobalt............	12·0
Iron..............	0·22
Sulphur	0·1
Silica	1·4
Copper............	very slight trace.

Hence it may be regarded as equal, if not superior, in purity to the best sorts produced in England and Saxony.

[Count M.]

On the Lignite *of* Kainach, Styria. By Dr. Rolle.

[Proceed. Imp. Geol. Instit. Vienna, November 6, 1855.]

The tertiary basin of the Kainach Valley in Styria, West of Gratz, follows the course of the rivulets Gaessnitz, Lankowitz, Graden, and Kainach, forming a deep sinuosity in the crystalline rock district of Central Styria. It is enclosed on the south and west by mica-schist, gneiss, and transition-limestone, on the north by Gosau-sandstone, and it communicates on the eastward with the basins of Southern Styria and Hungary. Its average length is 4900 fathoms (10,163 yards), and breadth 1200 fathoms (2489 yards); so that its total area embraces about ¾ of an Austrian square-mile. The whole of this surface consists of one lignite-bed, having a depth varying from 3 or 4 fathoms (6·222—8·3 yards) to 10 or 14 fathoms (20·74—29·04 yards). The bed is generally horizontal, or slightly undulates; sometimes it has a dip of considerable steepness in the vicinity of the surrounding rocks of older date. Its thickness, generally varying from 3 to 15 fathoms (6·222 to 31·11 yards), increases sometimes even to 20 fathoms (41·48 yards), and averages not more than 8 or 10 fathoms (16·59 to 20·74 yards). The lignite-bed is

* Communicated to the Imp. Geol. Institute, Nov. 15, 1855.

here and there intercalated with sandy clay and shale; four such layers, ½ to 1 foot thick, are known near Piberstein. Near Voitsdorf and Oberdorf the lignite is interrupted by a clay-bed 8 feet thick; the former having a thickness of about 6 fathoms (12·444 yards) above, and about 7 fathoms (14·52 yards) beneath, the intercalated clay.

The bed of lignite immediately overlies either the older rocks or a thin stratum of grey or blue plastic clay, loose sandy conglomerate, or arenaceous clay. It is overlaid by greyish-blue clay, or occasionally by some gravel or loam.

Generally the uppermost and lowest portions of the lignite-bed are not worth working, and remain untouched.

The lignite preserves the texture of wood, rarely exhibiting bands of compact and shining coal. Thirty specimens, from different localities, examined by Chev. Ch. de Hauer in the laboratory of the Imp. Geolog. Institute, gave Ash 3·43 *per cent.*, Water 13·68 *per cent.*

In its heat-producing power, 13·48 cwt. of the lignite (123·4 pounds avoirdup.) are equivalent to one klafter (100·401 cubic feet) of fir-wood in logs of 30 inches length. The lignite, leaving very little ash, and containing no sulphur, is fit for general technical use; and is in this respect equal to tertiary coal in general.

Supposing the average thickness of the bed to be not less than 6 fathoms (12·444 yards), it may be estimated, from the extent of its area, to contain above 3400 millions cwt. of fuel. It has long been worked; the official lists of 1852 enumerate nearly fifty persons working it. The produce in 1853 amounted to 350,990 cwt., worth 33,717 florins (about £3507 sterling); it was nearly all sold at Gratz at the price of from 24 to 28 kreutzers * for 123·4 pounds avoird.; the carriage of 123·4 pounds costing from 18 to 20 kreutzers.

Recently a mining company has been formed to work an area of 884,595 square fathoms, estimated to contain above 760 millions cwt. of fuel. A privilege for the construction of a railroad within two years from Gratz to Koeflach, a distance of 20,313 fathoms (above 23·57 English miles), has been lately granted to this newly established company. [Count M.]

On a Quicksilver-deposit *near* Cividale.
By Chev. von Hauer.

[Proceed. Imp. Geolog. Instit. Vienna, November 13, 1855.]

In the spring of 1855 some marl containing globules of native quicksilver was found near Gagliano, near Cividale, in the province of Eldine [Venetian Lombardy]. It was discovered in the cellar of a house which was built on a hill, a few feet high, S.S.E. of Gagliano. The rock is at present dug to the depth of about 2 klafters (4·148 yards), and does not differ from the common variety of ma-

* The Austrian florin = 60 kreutzers = £0·104 sterling.

cigno; its strata dip S.W., at an angle of 24° to 30°. The mercury appears to be disseminated irregularly over a space of probably very narrow horizontal extent; no trace of the metal being found in a trench dug outside the house. It does not seem, however, to be confined exclusively to one spot, as several instances of its occurrence around Cividale, both in ancient and modern times, have been recorded.

The macigno of Cividale and the beds of solid calcareous sandstone (quite analogous to the "granitic marble" of the lower Bavarian Alps) are thought by Chev. de Hauer to belong to the eocene nummulitic formation, notwithstanding that some few rolled fragments of *Hippurites* have been here and there imbedded in the sandstone.

The recently discovered mercuriferous drift-deposits, such as those of Sulbeck near Luneburg, &c., found by Prof. Hausmann,—those of Illye, west of Deva in Transylvania, mentioned by M. Grimm,—the deposits of Lisabon and Montpellier, known some time since, &c., bear some resemblance to the deposit of Gagliano, but nevertheless differ from it in several essential particulars.

The deposit at Sulbeck seems to have belonged originally to a block of sandstone washed into the drift with other fragments, and subsequently totally disintegrated. This explanation is not applicable to the mercuriferous marl of Gagliano, the constituent particles of which were evidently carried to their present site as minute grains and not in blocks. Two other quicksilver-deposits in Transylvania, mentioned by M. Grimm (Baron Hingenau's 'Austrian Mining Journal,' 1854, No. 35), although not yet fully understood, seem to bear a closer analogy with that of Gagliano. Springs issuing from the Carpathian sandstone near Esztelek, north of Keydy Vasarhely, in Transylvania, and near Neumarckt, in Galicia, are said to carry sometimes with them globules of mercury, especially after violent thunder-storms. This fact, together with the existence of the cinnabar-mines of Dumbrawa and Baboja, near Zalathna, is a proof that mercury and its salts are to be met with in the Carpathian sandstone of other regions; although, according to M. Grimm's statements, the mercury and cinnabar deposits of Idria, together with the cinnabar-ores of the Pototschnigg ravine, in Upper Carniola, according to M. Lipold, are subordinate to the carboniferous group. At all events the mercury of Gagliano may prove to be worth working on scientific and economical principles. [COUNT M.]

On the late EARTHQUAKE *in* SWITZERLAND. By Prof. NOEGGERATH.

[Proceed. Imp. Geol. Instit. Vienna, November 13, 1855.]

IN September 1855, Prof. Noeggerath visited the Visp Valley (Vallée de Viège), Canton de Valais, in order to study the effects of the recent earthquake. The Visp Valley is one of many descending from the crest of the Valais Alps (the Monte Rosa group) to the Valley of the Upper Rhone. It consists entirely of crystalline, without any trace of volcanic rocks.

The subterranean commotions, so frequent in these parts during the summer of 1855, extended their destructive effects as far as Sion (Sitten) in the Rhone Valley; their greatest activity, however, was concentrated about Vispbech (Viège), at the entrance of the valley, Stalden, and St. Nicholas; so that the centre of the earthquake-action may be supposed to have existed between these three localities.

Nearly all stone-buildings were more or less damaged or destroyed, and most of the churches were so much injured by fissures as to necessitate their being pulled down. The rocks also exhibit recent crevices from 3 to 6 inches wide. Everywhere numerous new springs of water have made their way to the surface, whilst formerly existing springs have disappeared.

Nearly all the devastation suffered by buildings is the effect of a single strong commotion, which took place on July 25, 1855, before one o'clock P.M. The subsequent movements had but subordinate effects, although they had not ceased in September, and occurred at intervals as late as October. The line of greatest energy extends from N.N.W. to S.S.E., for a distance of six hours (about 14 English miles). The earthquake of July 25 was felt through the whole of Switzerland, the Savoy Alps, Lombardy, part of France, Baden, Wirtemberg, Bavaria, and the Hessian territories.

[COUNT M.]

JOHNSTONITE *from* TRANSYLVANIA.

[Proceed. Imp. Geol. Instit. Vienna, November 13, 1855.]

BARON CZOERNING lately presented to the Museum of the Imperial Geological Institute of Vienna some specimens of a mineral, discovered in M. G. Hoffmann's lead-mines of Neu-Sinka, near Fogaras, in Transylvania, to which the discoverer had given the name of "Sinkanite." This mineral is a mechanical mixture of galena, anglesite, and sulphur. In one of these specimens, white compact anglesite (sulphate of lead) traverses, in the shape of veins, a dark-grey compound of sulphur and galena, being itself intersected with delicate fissures filled with sulphur. This specimen shows evidently the mode in which decomposition is gradually proceeding; the sulphuret of lead disappearing, and sulphate of lead with sulphur remaining as a residuum.

The mineral substance in question was first found at Dufton and described by Mr. Johnston. Subsequently M. Haidinger named it "Johnstonite." The Transylvanian variety has been described by M. Haidinger, von Hauer, and R. Hoffmann (Jahrb. Imp. Geol. Reichsanst. 1855). Another variety was found several years ago in the Rhine Provinces by Professor Noeggerath, whose views concerning this substance are identical with M. Haidinger's. It occurs, associated with unaltered galena, some sulphate of lead, and a small quantity of sulphur in a vein near Musen, in the Siegen mining-district, and is known among the miners by the name of "burning-galena." [Count M.]

On the Preparation *of* Lithia. By Chev. K. von Hauer.

[Proceed. Imp. Geol. Instit. Vienna, November 13, 1855.]

The author in this communication explained his new method of obtaining lithia in large quantities and at a comparatively low price. The metallic base of the lithion-alkali was discovered in 1817 by M. Arfvedson, in the laboratory of the celebrated Berzelius. As far as we at present know it occurs only in mineral substances, especially in petalite, lithion-spodumen, amblygonite, triphyline, apyrite, tourmaline of Utoen, and lepidolite. All of these contain rather considerable quantities of lithia, but occur rarely, except lepidolite, which, although proportionally poorest in lithia, is met with in great quantities at some localities. The Austrian Empire, possessing in some places great stores of minerals scarce elsewhere,—such as tellurium, in Transylvania, uranium, in Joachimsthal, &c.—has also a considerable mass of lepidolite in Mount Hradisko near Rozna in Moravia, where lithia-mica, in association with granite-veins, is imbedded in gneiss.

M. Foetterle, having brought with him last summer a quantity of this mica, afforded the laboratory of the Geol. Institute an opportunity for experimenting on the production of lithia. The methods hitherto known for extracting this substance requiring great expense of money and time, it ranks amongst the rarest and most costly of chemical preparations.

M. K. von Hauer tried the use of sulphate of lime, a substance obtainable at a very low price. Lepidolite, finely pulverized, is mixed with an equal weight of powdered gypsum, packed into hessian crucibles, and submitted to a red heat for some hours. The firmly agglutinated mass is comminuted after cooling, and thrown into hot water, for the purpose of dissolving the sulphates of potash, lithia, and manganese produced by the mutual action of the lepidolite and gypsum. The solution, concentrated as much as possible by evaporation, deposits partly its sulphate of potash. Manganese and a small residue of gypsum are precipitated by sulphuretted ammonia and oxalate of ammonia. The remaining solution, having been filtered, contains only sulphates of potash and lithia, and is treated with soda, for the purpose of precipitating the lithia in the form of an insoluble carbonate. The precipitate so obtained, when filtered and washed, contains only an insignificant portion of carbonate of soda. It may be reduced to a state of chemical purity by solution with hydrochloric acid, and precipitation by carbonate of ammonia.

One hundred parts of Rozna lepidolite, thus treated, give three parts of carbonate of lithia, answering to 1·1 part of the pure alkali;

and, as Prof. Rammelsberg found in lepidolite 1·3 *per cent.* of lithia, the loss in operating on a large scale may be considered as trifling. The expenses of this new method exceed scarcely the cost of the fuel consumed.

Hitherto lithia has had no technical use except in fire-works, being mixed with combustible matter to communicate to the flame a beautiful carmine tint. But even for this purpose it could be but of rare use, as half an ounce cost from 8 to 10 florins (=16 shill. to £1 sterling). [Count M.]

On the Fossil Fish *of* Austria. By M. Heckel.

[Proceedings Imp. Acad. Sciences, November 16, 1855.]

In continuation of his 'Contributions to the knowledge of the Fossil Ichthyology of Austria,' M. Heckel communicated a memoir containing:—1. A new arrangement of the Pycnodont family, together with descriptions of twelve new or imperfectly known species: viz., two from the bituminous strata of the Karst, five from Dalmatia, two from Monte Bolca, one from Cracovia, one from Mount Lebanon, and one from Mont-Aimé, near Chalons-sur-Marne; 2. Two new species belonging to the family of *Cheirocentri* (still represented by an existing species); one from the Karst and the other from Monte Bolca; 3. Three new species of the family *Elopi*, from the Karst; 4. Two new species from Monte Bolca, *Acanthurus Lanossæ* and *Carangodes cephalus*; one from Bude, *Smerdis Budensis*, and three from the "Calcaire grossier" of the Leitha Mountains, near Vienna, *Lates Partschii* (a Percoid), *Labrus Agassizii*, and *L. parvulus*; 5. An extinct genus, with pectinated anterior branchial operculum,—*Ctenopoma*; represented by one species, *C. Temelka*.

[Count M.]

On the Geology *of the* Environs *of* Carlsbad. By Dr. Hochstetter.

[Proceed. Imp. Geolog. Instit. Vienna, December 18, 1855.]

Since Becher made the first analysis of the Sprudel Spring (1770), the chemical, mineralogical, and geological constitution of this watering-place has attracted the attention of a great number of naturalists, among whom Klaproth, L. von Buch, Struve, Goethe, Berzelius, von Hoff, von Warnsdoff*, and Haidinger may be especially mentioned.

Klaproth (1790) attempted to explain the origin of the springs by supposing coal-beds to have been in combustion, the heat having been developed by the decomposition of pyrites. Berzelius (1823), struck with the analogy between the environs of Carlsbad and the extinct volcanoes of Auvergne and Vivarais, saw in these hot springs the last and vanishing effect of primæval volcanic action. The question is

* See Quart. Journ. Geol. Soc. vol. xi. part 2, Miscell. p. 45.

now decided by Prof. Bischoff's theory, and its experimental demonstration by Struve.

The controversy concerning the Carlsbad granites has not yet been brought to a satisfactory conclusion. M. von Hoff (1825) considered the coarse-grained and the fine-grained varieties of Carlsbad granite to have been contemporary in their origin; and this able observer was the first who referred to the existence of a deep and broad fissure, the result of volcanic action, and filled up with granitic breccia. All the Carlsbad springs rise to day along this fissure, which is known by the name of "von Hoff's line."

M. von Warnsdorff (1846) considered the two varieties of granite to have been produced at different periods, intimately connected with the origin of the springs themselves, as these latter issue out exactly on the limiting plane between the coarse-grained, or older, and the fine-grained, or younger granite. The Schlossberg of Carlsbad is not a granitic breccia, but a solid granite-mass, traversed with numerous veins of silex deposited by the springs in the form of hornstone. This opinion of M. von Warnsdorff's is now pretty generally accepted, as being confirmed by previous and later observers; but his views relating to the different ages of the Carlsbad granites are still not quite assented to.

Dr. Hochstetter, after a careful examination, came to the following conclusion. The granitic rocks of the Tepl Valley, near Carlsbad, form a portion of an extensive granitic mass, evidently of an eruptive character, stretching from Marienbad through the whole of the Carlsbad mountains, and far into the interior of Saxony beyond the Erzgebirg. This granite is undoubtedly younger than the crystalline slates surrounding it, and is characterized by abundance of tin-ore. It varies in its grain frequently throughout its range; near Carlsbad the fine-grained variety *a* prevails on the right bank of the River Tepl, whilst the left bank is chiefly occupied by the porphyritic fine-grained variety *b*, which contains the well-known twin-crystals of felspar of Elbogen. The bottom of the Tepl Valley, as well as the declivities immediately bordering it, are composed of a third variety of granite, *c*, hitherto thought to be identical with *a* or *b*; but which ought to be carefully kept distinct in thoroughly investigating the geology of the Carlsbad district. The last-named variety has a porphyroid aspect, its chief mass being fine-grained like the variety *a*, but having interspersed isolated crystals of felspar and quartz, or larger aggregations of scaly mica. In other localities, for instance, at Schellerhau near Altenberg, in the Erzgebirg, this variety passes into genuine porphyry. Its component minerals are potash- and soda-felspars, black and white micas (the last probably containing lithia), and quartz, both crystallized and uncrystallized; while the variety *b* is a compound of potash-felspar, black mica, and quartz.

The differences in the mode and result of decomposition are still more striking. The varieties *a* and *b* easily decompose into gravel, the large felspar-crystals of *b* remaining unaltered. In the variety *c*, the decomposition commences with these crystals, which are gradually reduced into a yellowish-green steatitic or a reddish-brown earthy substance; the principal mass of the rock offering considerable resistance to the altering agents, as may be seen in the steep declivities and in the columnar sharp-edged peaks around Carlsbad. The surface of these rocks is full of cavities marking the places of the isolated felspar-crystals now decomposed.

The varieties *a* and *b* are less liable to be divided by fissures, caused by atmospheric agency, into masses with plane surfaces and sharp edges than is the variety *c*. The River Tepl, as far as it runs through the variety *c*, follows exactly the direction of these clefts or fissures. When basaltic eruptions, very probably immediately connected with the origin of the thermal springs, disturbed the rock-masses of the Carlsbad territory, the deepest fissures, it is considered, must necessarily have been formed in the variety *c*, on account of its lithological constitution and the mode of its fissuring. This supposition may serve to explain why all the springs issue from the fissure in the variety *c*. There is nothing to confirm the idea of a difference of age among the granites; which is indeed rather contradicted by the insensible transitions from one variety into another, and by the presence of tin-ore in all the granites, even in and around Carlsbad.

Dr. Hochstetter distinguishes his three varieties of Carlsbad granite by special names; variety *a* is his "Kreutzberg granite;" var. *b* is his "Elbogen granite;" and var. *c* his "Carlsbad granite." A map of the territory of Carlsbad, by the author, on the scale of $\frac{1}{11520}$, is preparing for publication. [COUNT M.]

On PIANZITE *from* STYRIA. By DR. KENNGOTT.

[Proceed. Imp. Geolog. Institute of Vienna, January 8, 1856.]

THIS mineral was first described by M. Haidinger in 1844*, as a new species of fossil bitumen, to which he assigned the name of Pianzite, indicative of the locality where it was first discovered. It occurs at Mount Chum, near Tuffer, in Styria, under the same circumstances as at Pianze in Carniola. This new locality has been made known by Chev. Pittoni de Dannenfeldt, of Gratz.

According to the communications of M. Wodiczka, Imp. Mining Inspector at Cilli, the pianzite occurs, though only in small lumps and very thin layers, in nearly all the mines by which the carboniferous strata running westward from Tuffer, over Goufe and Hrastnigg, to Trifail and Sagor, are at present worked. Near Tuffer, 3000 Vienna pounds (3702 pounds avoirdup.) of this substance have been brought to day.

The pianzite is a black resin, much resembling slaty and lamellar black coal; its texture, never crystalline, varies from compact to lamellar or scapiform; its colour when scratched is light-brown. It melts into a black mass, similar to pitch, at a temperature exceeding

* Poggendorff's Annalen der Physik und Chemie, vol. lxii. p. 275.

300° C.; and it burns with a bright and yellow flame, with a large proportion of soot. [COUNT M.]

On SILURIAN FOSSILS *from* WOSSEK, BOHEMIA. By M. J. BARRANDE.

[Proceedings of the Imp. Geol. Institute of Vienna, January 8, 1856.]

AN interesting collection of fossils was made, chiefly during the summer of 1855, by the Austrian Geological Surveyors in the environs of Rokitzan in the Silurian basin of Bohemia. These are of the more interest as M. Barrande's search for fossils in this locality had been hitherto unsuccessful. The fossils were found at Wossek, N.E. of Rokitzan, in M. Barrande's "Quartzite stage D," and may be regarded as belonging to the commencement of the Second Bohemian Fauna. They are in a rather imperfect state of preservation and occur in very hard quartzose nodules, remaining on the surface of the ground after the decomposition of the schists in which they were originally imbedded.

M. Barrande recognized altogether 37 species among these organic remains from Wossek, trilobites (13 species) being prevalent; and only 5 of these 13 species have previously been found with stage D. Cephalopods are very scarce; there are only 4 species, and the specimens are generally badly preserved. The Gasteropods are represented by 5 species, including the *Ribeiria phodadiformis*, Sharpe, which occurs also in the Silurian rocks of Portugal. There are 3 species of *Acephala*; one of them, *Redonia*, being also represented in the Second Silurian Fauna of France.

The fossil fauna of Wossek also includes 4 species of Brachiopods and 2 of Echinoderms. [COUNT M.]

On a method of procuring ALUMINA. By Chev. VON HAUER.

[Proceedings of the Imp. Geol. Institute of Vienna, January 15, 1856.]

PURE alumina is best obtained from ammoniacal-alum, or from sulphate of alumina, wherever, as in England, those salts are produced on a large scale. At Vienna, however, where they are still scarce objects of commercial transaction, chemists are obliged to operate on potash-alum or on kaolin. The alumina extracted from the first of these materials, even in quantities of a few pounds, requires long-continued washing with hot water, sometimes during several weeks, to get rid of the potash adhering to it. The kaolin requires hot concentrated sulphuric acid for its decomposition, so that operations on a large scale are very troublesome and difficult. The Imperial Geological Institute received some time ago specimens of a very pure kaolin, which forms a bed of about 6 joch (345·342 acres) between Znaim and Brenditz, in Moravia. The quantity yearly raised is between 6000 and 8000 zentners (740,400 to 987,200 pounds avoirdup.), but may be easily augmented, if required, to 20,000 zentners (2,468,000 pounds avoirdup.). A hundred pounds weight (123·4 pounds avoirdup.) of this kaolin, carefully washed and refined, costs at Vienna 2 florins, 24 kreutzners (4 shill. $9\frac{3}{5}$ pence).

The analysis of the kaolin gave—Silica	48·1	per cent.
,, ,, ,, Alumina	38·6	,,
,, ,, ,, Water	13·3	,,
Lime and Oxide of Iron	traces.	

Chev. von Hauer attempted to decompose this kaolin by treating it with gypsum under the influence of high temperature, this method having proved successful with other mineral substances. The kaolin, mixed with gypsum in a proportion adequate to the quantity of alumina contained in it, was heated in a roasting-furnace to a moderate red heat, so as to prevent the decomposition of the sulphate of alumina. After this preliminary operation, the whole of the alumina could be extracted by cold sulphuric acid very considerably diluted. The water for elixiviation is to be mixed with no more acid than what is strictly necessary (together with what is contained in the gypsum) to form a trisulphate of alumina. The filtrated solution is adapted for the production of chemical preparations containing alumina. As yet this method has only been used in the laboratory; but it may be expected to be profitably employed for technical purposes.

[Count M.]

On the Lignites *of the* Hausruck, Upper Austria.
By Baron Hingerau.

[Proceedings of the Imp. Geol. Institute of Vienna, January 15, 1856.]

The Hausruck-Wald is the eastern portion of the mountain-range running between Mattighofen, Friedberg, Frankenburg, Voeklabruck, Wolfregg, Haag, and Ried, along the frontier between the Hausruck and Inn Circles. The western part of the range bears the name of Kobernauser Wald.

The succession of strata in the lignitic deposits of the Hausruck-Wald (in descending order) is—

1. Gravel and conglomerates, 30 klafters (62·22 yards), and more in places.
2. Sandy clay, 6 inches.
3. Lignite, 1 to 3 feet.
4. Argillaceous marl, known by the provincial name of "Schlier," variable in thickness, at Thomasroith 15 klafters (31·11 yards).
5. Lignite-bed, 2 klafters (4·158 yards).
6. Clay, with fragments of coal, variable in thickness.
7. Lignite-bed, 1 to $1\frac{1}{2}$ klafter (2·074–3·111 yards).
8. Bluish argillaceous marl, or "Schlier," frequently occurring in this part of Upper Austria, at a level of 1000 to 1800 feet above the sea. Its fauna, judging from the fossils collected between Ottnang and Wolfsegg, and determined by Dr. Hoernes, is analogous to that of the Vienna "Tegel," having a "Neogene" character.

The lignites above referred to are known at Vienna under the name of "Traunthal coal," and are at present worked over a surface of 6977 joch (17,240 acres). They yield from 19 to 22 *per cent.* of water at a temperature of 100° C.: heated in closed ovens, they give 40 to 45 *per cent.* of coke; and, when burnt in the open air, they leave 5 *per cent.* of ash. In a well-constructed heating-apparatus, 15–16 zentners (1851–1974·4 pounds avoirdup.) are equivalent to 100·401 English cubic feet of fir-wood. The ashes of the lignite have been successfully used for manuring moist meadow-land.

The total mass of this fossil fuel, as at present known from mining-operations, may be estimated, at a moderate rate, as about 6 millions of cubic feet, or 4 millions 800,000 zentners. [COUNT M.]

On the EXTRACTION *of the* SILVER *and* LEAD *from the* ARGENTIFEROUS GALENA *of* PRIBRAM, BOHEMIA. By M. KLESZCZYNSKY.

[Proceedings of the Imp. Geol. Institute of Vienna, January 22, 1856.]

THE ores of Pribram * are argentiferous galena, copiously mixed with zinc-blende, carbonate of lime, and sulphate of barytes, together with quartz, carbonate of iron, iron-pyrites, and grey copper in less proportions. The separation of the blende from the galena is the chief difficulty, as it cannot be brought about by a merely mechanical means. The ores and "Schlichs" produced, during 1852, contained an average of $\frac{1}{400}$ of silver and $\frac{4}{100}$ of lead.

The operation for the extraction of the silver and lead begins with submitting the ores to three consecutive roastings in the open air. Recently the experiment was made of effecting the roasting in furnaces by means of coal, and it succeeded in diminishing the expense. The roasted ores are mixed with 5–8 *per cent.* of cast iron, 10–12 *per cent.* of plumbiferous residuum from former smeltings, and 36–48 *per cent.* of soft-iron-slags, for the purpose of facilitating the fusion and to remove the superfluous sulphur, and are melted down in furnaces. Each smelting requires about eighteen days, and is followed by a cleansing and repairing of the furnace. The substances obtained by the operation are argentiferous lead, cast into iron moulds (with about $\frac{5}{8}$ *per cent.* of silver, slags, furnace-dust, and concretions [Gekraetz]). The lead-cakes are melted down on a flat circular bellows-furnace, with an artificial marl-sole, on which, as a final result of the operation, is left a cake of pure silver, the oxidated lead running out of the furnace or being imbibed into the marl-sole. The silver, after having been completely purified from all trace of heterogeneous substances by undergoing fusion in crucibles, with a mixture of wood-ashes and burnt bones, together with some borax and saltpetre, is finally cast into the form of bars.

* See Quart. Journ. Geol. Soc. vol. xi. part 2, Miscell. p. 40.

The impure or black oxide of lead (litharge) is again melted down to obtain argentiferous lead and slags. These slags are again melted down for lead, and this is repeated until the slags are worthless. The purer sort of litharge is either sent away to be sold, or is added to the ores to be smelted with them, or submitted to a peculiar fusion, with results analogous to those of the smelting of the black sort.

The total of the substances submitted to metallurgic operations in the course of the year 1852 amounted to 74,637 cwt. of ores and 19,880 cwt. of argentiferous substances, together holding 35,111 marks of silver and 33,985 cwt. of lead. The loss was 6½ *per cent.* of silver, and 36 *per cent.* of lead. [Count M.]

On a Remarkable derangement *of a* Metalliferous vein *in the* Erzgebirg. By M. Vallach.

[Proceedings of the Imp. Geol. Institute of Vienna, January 22, 1856.]

The Gellnau tin-vein, in the Schlaggenwald tin-mines, about 3 inches thick, and dipping S.E. at an angle of 40°, and another secondary vein, dipping S.E. at an angle of 95°, traversing the chief vein and deranged by it, are cut through by three argilliferous fissures, ¼ to ½ inch wide, dipping N.W. at an angle of 50°, and 5 inches distant from each other. The two exterior of these fissures have included, and, as it were, lifted up, a portion of the chief vein, about 10 inches long; while the middle fissure went through the same vein without causing or suffering any derangement. Above the point of disturbance, the three fissures unite into one, cutting through the secondary vein and bending it upwards. Similar derangements are not rare in the numerous stanniferous veins running in all directions through the crystalline rocks of the Erzgebirg. [Count M.]

On the Thermal Springs *of* Carlsbad. By Dr. Hochstetter.

[Proceedings of the Imp. Geol. Institute of Vienna, February 14, 1856.]

In this communication Dr. Hochstetter stated the results of his investigations on the situation of the fissures from which the thermal springs of Carlsbad* take their rise. Hitherto all these springs have been regarded as coming from the same fissure, namely that known as "Von Hoff's line," running in an average N. and S. direction. M. von Hoff (1825) considered the Schlossberg of Carlsbad to be a granitic breccia filling up this fissure. M. von Warnsdorff (1846) proved the Schlossberg to be of solid granite, traversed by a great number of veins of hornstone, and declared the fissure known as "Von Hoff's line," to be identical with the plane of contact between two granites of different age.

* See Quart. Journ. Geol. Soc. vol. xi. part 2, Miscell. p. 45; and above, p. 12.

The author had previously proved (Meeting of the Imp. Geol. Institute, Dec. 18, 1855) the presence of three varieties of granite, coequal in age, and not separated by any contact-fissure, in the Carlsbad territory. He had further found evidence that all the thermal springs in question belong to one of these granites; and that "Von Hoff's line" is merely a local phenomenon. Dr. Hochstetter now proves that the Carlsbad springs occur along two parallel lines,—the one the Sprudel, the other the Muhlbrunn,—both running N.W. & S.E., and each having a secondary fissure, parallel to the principal line. The superficial valleys correspond to the direction and extent of these two fissures, which are essentially connected with the clefts produced by gradual decomposition in the "Carlsbad granite." The principal set of fissures have a N.W. & S.E. direction, and the secondary set from N.E. to S.W., corresponding to the run of numerous quartziferous and siliceous veins. As to the situation of the thermal springs, their central point is the Sprudel, corresponding to the point of intersection of the principal Sprudel fissure with the secondary fissure of the Tepl Valley. The Marktbrunn and the Schlossbrunn are beyond the Tepl, along the continuation of the first of these fissures. The next springs occur along lateral and secondary fissures, and have their supply of water more or less directly from the principal Sprudel fissure. As these communications partly take place through the Schlossberg, which is interposed between the principal Sprudel fissure and the secondary fissure of the Muhlbrunn, the origin of the warm waters everywhere pouring out of this hill may be easily explained, together with the other phenomena observable in the Carlsbad springs in general. An accurate knowledge of the fissures giving rise to the springs, and a correct map illustrative of these features, would be of great practical importance, both for regulating the springs, and for preventing any operations that might injure them either in quality or quantity. [Count M.]

Experiment *on* Basalt. By A. Bensch.

[Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1855, p. 597; and Ann. Chem. Pharm. 91. p. 234.]

Some years since the author reduced to a very fine powder, in water, by means of a porphyry slab and grindstone, some of the basalt of the Hirschberg near Grosse-Almerode, intending to apply it to the glazing of bricks. The wet powder remained many months in a glass cup covered with paper, and became so hard a mass that a very severe blow of a hammer could scarcely separate a fragment from the mass. The fracture of this mass was similar to that of the natural basalt. The mass presented a black nucleus, of waxy lustre, surrounded by a somewhat less dense substance, but still very hard and grey. Exposed for some time to the air, the surface of the altered basalt exhibited an efflorescence of carbonate of potash, and of this 1·8 per cent. could be removed by water.

The specific gravity of the natural basalt used in the experiment was 2·887. After lixiviation of the soluble alkaline salt with water, and after drying in the air, until there was no further loss of weight, the specific gravity of the altered basalt was taken; that of the nucleus was 2·1588; that of the less hard external portion was 2·0423.

It is evident that in this case the formation of a hydrate had taken place: and this behaviour of the basalt under the influence of water and of the atmosphere must prove to be of some interest to geologists. [T. R. J.]

On JUNKERITE. By A. KENNGOTT.

[Min. Notizen, xiv. p. 13; and Leonhard u. Bronn's N. Jahrb. f. Min. &c. 1856, p. 49.]

THE examination of a specimen of junkerite from Poullaouen, in Brittany, confirmed Breithaupt's statement that junkerite is rhombohedral and belongs to siderite. It occurs as crystals on quartz, which form a crystalline coating, and are also met with as single crystals. The isolated crystals, although very small, can be recognized as exhibiting a combination of an acute rhombohedron, in the opposition $m\mathrm{R}'$ (taken on the primary form R of siderite), with the basal planes. The rhombohedral planes are somewhat lustrous and convex; the basal planes, rough and dim. The convexity arises from the presence of a scalenohedron, which sharpens the lateral angles of the rhombohedron, the planes of which however by the convexity of the rhombohedral planes can form no distinct angles of combination. The crystals, completely cleavable parallel to the planes of the primary form R (which is the case also in siderite), are yellowish-brown and transparent. [T. R. J.]

On remarkable Crystals of QUARTZ *and* FLUOR-SPAR. By A. KENNGOTT.

[Min. Notizen, xiv. p. 20, 22; and Leohn. u. Bronn's N. Jahrb. f. Min. &c. 1856, p. 39.]

IN the eclogite of the Sau-alps in Carinthia remarkably peculiar crystals occur, which are there known by the name of "white topaz." Close examination, however, shows that these are either imperfect or misformed crystals of quartz.

At Schlackenwald in Bohemia the joint-surfaces of a fine-grained granite are covered over with small quartz-crystals, and on this coating are crystals of fluor-spar of two different kinds, occurring side by side, viz. green octahedrons and violet-blue rhombic dodecahedrons. The latter, fully formed, appear at first sight as triakis-octahedrons, on account of white stripes in the position of the longer diagonals. On close examination, it is seen that the layers corresponding to the three chief sections are colourless, whilst the rest of the mass of the crystals is violet-blue. [T. R. J.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Lower Greensand *and the* Blackdown Fossils *of* England. By M. E. Renevier.

[Bulletin Soc. Vaudoise Sc. Nat. vol. v. p. 51–52, 1856.]

In communicating the general results of his comparison of the lower cretaceous fossils of England (large suites of which his late visit to England had enabled him to study) with those of France and Switzerland, M. Renevier offered the following observations:—

1st. *Lower Greensand.*—Palæontologically the Lower Greensand does not represent the Neocomian of Switzerland, as most geologists have thought; but, on the contrary, exactly corresponds to the series of Aptian beds which M. Renevier has recognized, at the Perte-du-Rhône, between the upper Neocomian (Urgonian) and the Gault. The lower strata of the Lower Greensand (Perna-beds and Crackers) contain a fauna which is quite analogous to that of the Lower Aptian (Rhodanian) of the Perte-du-Rhône, whilst the arenaceous series, about 650 English feet thick, which occurs between the Crackers and the Gault, evidently belongs to the Aptian proper. These two faunas (Aptian and Rhodanian) are, however, much more closely related in England than on the Continent; hence the two series have not hitherto been separated by the English geologists. Lastly, as in Switzerland, the Aptian fauna is somewhat poor; whilst the Rhodanian fauna (Perna-beds and especially the Crackers) is on the contrary very rich.

2nd. *Blackdown.*—The beautifully preserved fossils of Blackdown have always drawn the attention of the palæontologists of England to this locality. The fauna has been sometimes referred to the Lower, and sometimes to the Upper Greensand (Cenomanian); some, of late, have referred it to the Gault; and M. D'Archiac has regarded it as representing all three of the above-cited series.

M. Renevier was enabled to add a considerable number to the known species of Blackdown fossils; but does not offer a definite opinion on the age of the deposit in question. Many of the species are peculiar, but the majority belong also either to the Lower Greensand, the Gault, or the Upper Greensand. The Cephalopods are few, both as specimens and species; and though they are Gault forms, yet the author thinks their evidence to be insufficient to decide the question of the relative age of the deposit. Of the other classes, a nearly equal number of the species are found also in the Upper Greensand and the Gault; and a somewhat less number occur in the Lower Greensand. There is no doubt whatever of the mingling of these species and of their occurrence in the same deposit. [T. R. J.]

On some Jurassic Cephalopoda *from* Wurtemberg. By Dr. Albert Oppel.

[Württembergische Naturw. Jahreshefte, 1856, pp. 104–108.]

1. *Acanthoteuthis antiquus.*—During his late visit to England, the author obtained at Christian Malford* in Wiltshire, a very perfect specimen of *Acanthoteuthis antiquus*†, with which he has since carefully compared some conical bodies, similar to the alveoli of *Belemnites,* that he has obtained from the clays with *Am. Jason* and *Am. ornatus* from Gammelshausen, near Boll; and from the result, he feels assured that the correctness of dividing *Belemnites Puzosianus* from *Acanthoteuthis* is well established, although the inside of the phragmacone of the latter has an organization but little differing from that of the alveolus of a Belemnite.

The phragmacones from Gammelshausen have a silicified inner cone, which tapers at an angle of 25°, possesses a siphuncle and sheath, and is covered with a thin calcareous layer. The latter appears to have a similar structure to that of the Belemnite sheath; its cross-fracture shows a dark crystalline mass. In the English specimens it consists of a white friable substance. The external form, on the contrary, in specimens from both localities is closely similar; and is quite different from the sheath of the Belemnites.

The author points out the importance of the presence of the siphuncle and the parallel sheath-walls in the specimens from Gammelshausen; these not having yet been distinguished in the Christian Malford specimens. In England the *Belemnites Puzosianus* frequently occurs in the same clay with the *Acanthoteuthis antiquus*; which circumstance, in the author's opinion, has led to the association of the parts of the two animals by some authors. In Wurtemberg, however, the *Acanthoteuthis antiquus* alone is found; and this affords an indirect proof of the distinctness of the two forms.

2. *Ammonites planorbis with Aptychus.*—When in England last year, the author saw in Mr. C. Moore's collection a fine suite of *Ammonites,* particularly the *Falciferi* of the Upper Lias, enclosing *Aptychi.* Dr. Oppel also observed in the same collection an "undivided" *Aptychus*‡ in an *Am. planorbis,* Sow. (*Am. psilonotus,* Quenst.). On his return home he determined to examine the *Psilonoti* of Wurtemberg, and the first specimen he split open exhibited an "undivided" or univalve *Aptychus* lying in the body-chamber of the Ammonite, much as in the known species, but evidently not divided by a median fissure. As the *Am. planorbis* is the first Ammonite occurring above the "bone-bed," it is the oldest jurassic species.

[T. R. J.]

* The grey laminated clay with *Acanthoteuthis* belongs to the base of the Oxford Clay; and there are a considerable number of fossils common to it and the "Ornatus-clays" of the Continent.

† Morris's Catalogue Brit. Foss., 1854, p. 289.

‡ See also Mr. Strickland's paper on a univalve *Aptychus* in an Ammonite from the lower lias, Quart. Journ. Geol. Soc. vol. i. p. 234.—Ed.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Geology *of* Banat. By M. J. Kudernatsch.

[Proceedings Imp. Acad. Sciences Vienna, May 8, 1856.]

In this memoir by the late M. Kudernatsch, communicated to the Academy by Dr. Hochstetter, the central mountain-chain of Banat was described as consisting of strata grouped around a huge granitic nucleus which has been erupted through an enormous fissure, and has an altitude of 3000 feet. The gneiss, resting on the granitic mass, is overlaid by sedimentary strata folded into three great anticlinals or saddles (at Steierdorf and at Natra), and three chief basins. These rocks have been traversed in a direction parallel to the long axis of the saddles by fissures now forming valleys, on the bare sides of which the lias, together with the brown and white jura, are seen cropping out and immediately overlying the gneiss. The basins or synclinals are occupied by extensive deposits of lower and upper neocomian limestones, raised up into elevated ranges or forming plateaux, analogous to those of the Karst as regards their funnel-shaped depressions, caverns, &c.

The coal-deposits of Steierdorf and Domau belong to the upper keuper or lower lias sandstone; and wherever the saddles are fissured, these coal-beds are seen to overlie a red sandstone of still unascertained age. Five seams of excellent coal, characterized by remains of *Zamia* and *Pecopteris*, have been found within a thickness of from 24 to 30 feet of strata. These coal-bearing deposits are overlaid by brown and white jura and by cretaceous strata, both rich in organic remains. Sphærosiderite forms regular beds in a liassic shale, and in the calcareous plateaux large accumulations of pisiform iron-ore occur.

The small basin of Szekul was the only known locality of the true carboniferous deposits in Banat before the late M. Kudernatsch had ascertained that they occurred extensively in the imperfectly known south-eastern portion of the Banatian mountains beyond the Almas. These strata, still lying untouched amid extensive primæval forests, may become highly important in the future progress of industrial activity. [Count M.]

On the Metalliferous Veins *of* Pribram, Bohemia. By Prof. Reuss.

[Proceedings Imp. Acad. Sciences Vienna, May 23, 1856.]

In this paper the author communicated the general results of his researches on the relative ages and the origin of the metalliferous veins of Pribram* in Bohemia. These veins appear to form a system of distinct vein-formations, partly of sedimentary origin. The oldest belong to Prof. Breithaupt's "Zinciferous formation;" these are succeeded by the "Plumbo-zinciferous"; more recent formations, such as the "Argentiferous," are only represented by isolated portions.

The great variety of minerals constituting the Pribram veins permits of no doubt of their having been formed at distinctly different periods. By a careful investigation, no less than twenty-four of these genetic periods were made out. Sulphuret of zinc, galena, quartz, and carbonate of iron belong to the most remote of these periods; and the ascending series is closed by calc-spar and iron-pyrites. Most of these minerals have been formed repeatedly at different periods. Thus calc-spar reappears five times, iron-pyrites four times, quartz three times, and galena, sulphuret of zinc (blende), sulphate of barytes, magnesio-calc-spar (brown spar), &c., each twice. The successive formations of the same mineral species are generally so different in shape, mode of grouping, and colour, and sometimes even in their chemical characters, that a somewhat practised eye may distinguish them at first sight.

There are also highly diversified pseudomorphoses, which are very interesting and instructive as bearing witness to the chemical changes undergone by some minerals from the action of successive agents. Some species are the first link of a continuous series of successive modifications; thus the argentiferous and antimoniferous galena have in the course of time given origin to steinmannite, grey sulphuret and white oxide of antimony, native silver, carbonate and phosphate of lead, &c. Grey sulphuret of antimony is the root from which by successive modifications the red sulphuret of antimony, native antimony, and the arseniuret of antimony have been derived. Iron-pyrites, by its decomposition, has furnished materials for ferro-chlorite (eisen-chlorite), acicular iron-ore (nadel-eisenerz), red oxide of iron, &c. The sulphate of barytes, of the older formation, exhibits a series of the most interesting decompositions. [Count M.]

On some Gasteropoda *from the* Alpine Trias. By Dr. M. Hoernes.

[Proceedings Imp. Acad. Sciences Vienna, March 1856.]

In this communication Dr. M. Hoernes described and illustrated—1st, several fossil mollusca recently collected at Unterpetzen, near

* See also M. Kleszcznski on the Mining District of Pribram, Quart. Journ. Geol. Soc. vol. xi. part 2, Miscell. p. 40.

Schwarzenbach,—2nd, others discovered by M. Lipold on Mount Obir, N.W. of Eisenkappel in Lower Carinthia,—3rd, another series from Esino in the Val Pelaggia, on the eastern border of the Lake of Como, which were kindly submitted for the author's examination by M. Escher,—and lastly, some fossils from the Hallstadt strata, lately found by Dr. Fisher, of Munich, at Sandling* and at Seltschen, near Aussee in Styria.

The Esino fossils were found in a dark-grey or black dolomitic limestone in the detrital accumulations (schutt-halden), on the northern slope of the Val Pelaggia. The limestone is intersected by veins of white calcareous spar, and has a slight bituminous smell when struck with a hammer. MM. Escher and Curioni found also Crinoidal joints in this limestone.

The number of species common to the several fossil faunæ here referred to is but small, but may however be regarded as sufficient to indicate that the Hallstadt and the St. Cassian strata are closely related, and that in a palæontological point of view the dolomitic limestones of Esino, Hall (Tyrol), Unterpetzen, &c., are members of the extensive St. Cassian series.

The following table exhibits a synoptical view of the relative occurrence of the Triassic fossils described in Dr. Moritz Hoernes' paper.

	Esino.	Hall.	Obir.	Unterpetzen.	Hallstadt.	St. Cassian.
Ammonites Aon, *Münst.*	...	...	...	*	*	*
—— Gaytani, *Klipst.*	...	...	...	*	*	*
—— Johannis Austriæ, *Klipst.*	...	...	...	*	*	*
—— Jarbas, *Münst.*	...	...	...	*	*	*
Turbo Suessi, *Hörn.*	...	...	...	*	...	...
—— subcoronatus, *Hörn.*	...	...	...	*	...	*
—— depressus, *Hörn.*	*	...	...	...	...	...
Nerinea prisca, *Hörn.*	...	...	...	*	...	...
Natica Lipoldi, *Hörn.*	...	...	*	...	...	...
—— Comensis, *Hörn.*	*	...	...	...	...	...
—— sublineata, *Münst.*	...	...	...	*	...	*
—— Meriani, *Hörn.*	*	...	*	...	...	...
—— lemniscata, *Hörn.*	*	...	...	...	...	...
—— plumbea, *Hörn.*	...	...	...	*	...	?
Nerita Prinzingeri, *Hörn.*	...	*	...	...	...	...
Chemnitzia eximia, *Hörn.*	*	*	...	...	...	...
—— gradata, *Hörn.*	*	...	*	*	...	?
—— Rosthorni, *Hörn.*	...	...	*	*	...	...
—— tumida, *Hörn.*	...	*	...	...	...	...
—— Escheri, *Hörn.*	*	...	...	...	...	...
—— formosa, *Klipst.*	...	...	...	*	...	*

[COUNT M.]

* See also Quart. Journ. Geol. Soc. vol. xi. part 2, Miscell. p. 23.

On the UPPER SEDIMENTARY DEPOSITS *of the* VENETIAN TERRITORY, *and on the* FOSSIL BRYOZOA, ANTHOZOA, *and* SPONGES *contained in them.* By T. A. CATULLO. 4to. 88 pages and 19 lithograph plates. Padua, 1856.

[Dei Terreni di Sedimento superiore delle Venezie e dei fossili Bryozoari, Antozoari, e Spongiari ai quali danno ricetto Memoria di Tomaso Antonio Catullo, &c.]

THIS work, to which the author has devoted much time and research, is almost entirely devoted to the description and illustration of 154 species of Bryozoans, Zoophytes, Sponges, &c. from the Tertiary deposits of the Venetian portion of Italy. But, before entering on the main object of the work, the author devotes a few pages to the geology and geographical extent of these upper sedimentary formations, following the classification proposed by Sir C. Lyell, in preference to that advocated by M. D'Orbigny; because, in his opinion, the objection made to the per-centage of species does not invalidate the stratigraphical distinctions laid down by Sir C. Lyell.

The upper deposits at the foot of the Venetian Alps bear a very close similitude to those analogous formations of Hungary and Austria, composed of strata representing the Pliocene, Miocene, and Eocene epochs. The author observes that Vicentine tertiaries are also in every respect similar to those of the southern part of Russia; and that many years ago he discovered in fragments of nummulitic rock brought from the neighbourhood of Cairo, *Melania costellata, Fusus intortus, Turritella imbricataria,* and other shells very common in the Vicentine beds of that period.

These Italian tertiary deposits well represent, according to the author, Lyell's three divisions; the most ancient (Eocene) being composed of plastic clay, sandy glauconite, and nummulitic limestone, accompanied by the usual marls; the Miocene is represented by marls and molasse; the Pliocene consists of marls and sands; which last admit of a division into Lower and Upper Pliocene. The Eocene series is more developed and more complicated than the others. In a few localities it forms a continuous band, and from the Heights of Frisuli and the Bellunese, it spreads out in the Feltrino, the Vicentino, and other regions, not excepting the Euganean Hills, as the author demonstrated by means of their fossils as early as 1828. The sea, therefore, in which these deposits were formed was of considerable extent. Signor Catullo then furnishes a detailed list of various localities where the nummulitic rock, which forms a large portion of the Venetian state, is visible, and remarks that the same species are everywhere found, except (as is the case in the other periods) where some species are peculiar to one horizon or locality only. Thus the Echinoderms are particularly abundant in the nummulitic rocks, while the grey sandstone (molasse) is remarkably poor in those fossils, although it contains innumerable spines, which may be perhaps referable to some species of the genus *Clypeaster*? On the contrary, the Eocene and the Miocene of the Vicentine are rich in Corals, of which scarcely a trace can be found in the corresponding formations of the Veronese, the Friulano, and the neighbourhood of Belluno.

The author dwells at some length on the basaltic eruptions of the Vicentine, to which the brecciated beds are attributable; and he remarks that, of the corals enveloped in the breccia of Monteviale, Sangonini, Montechio-Maggiore, and a few other localities, some few have been referred by Michelin to the Chalk; but that these exceptional specimens might have been transported by the basaltic eruptions.

The nummulitic zone is at times very complex, being in some localities composed of its most characteristic rocks, whilst in others several of these are wanting. Thus at Brendola, the nummulite-rock overlies a peperite, which in other localities alternates with it, both rocks containing similar eocene fossils; elsewhere, however, as at Sangronini and Ronca, the peperite affords numerous specimens of *Flabellum appendiculatum*, *Orbitoides Prattii**, and other species peculiar to it and not found in the overlying limestone. The plastic clay is not always found underlying the nummulitic rocks.

The author next enters into some details relating to the Middle Tertiary or Miocene beds, as far as he has examined them in the Venetian territory; and states that the age of the hill of molasse to the north of Belluno (Valle dell' Ardo, Libano, Tisoi, Orzes, &c.), is determined by its containing miocene fossils, and by the underlying glauconite. The fossiliferous molasse, so extensive in Switzerland and Piedmont, attains a considerable development in the valleys to the north of Belluno, from whence the author obtained most of his miocene fossils. Leaving these valleys to the right, and advancing towards the northwest, the author found at the Ponte del Gresal that the molasse changes to a marl-rock, or a molasse of very fine grain. He observes, that, if he has formerly given the name of Pliocene to the middle tertiaries of some localities, they must be now referred to the Miocene, because none of those deposits present characters such as to entitle us to consider them as equivalents of the upper subapennine zone, which, from the recent observations of Prof. Doderlein, of Modena, is known to overlie miocene deposits rich in marine remains. Signor Catullo limits himself at present to observing that the fossils from the marl of Asolane are for the most part miocene and not pliocene, as supposed by Sir R. Murchison in the Philosophical Magazine for 1829, as well as in his memoir on the Structure of the Alps, published in 1849.

The author concludes his discourse on the tertiary deposits of the Venetian territory, by observing that the Eocene zone, from its extent, the diversity and peculiarity of its rocks, the thickness of the beds, and the considerable altitude it attains above the sea-level, differs materially from the Miocene zone, which is composed sometimes of molasse, sometimes of marl and marly limestone, interstratified with thin bands of sand or sandy rock, and is of small extent and attains no considerable elevation, unless deposited on a pre-existing eminence, as happens with the beds covering the glauconite of the Bellunese and vicinity of Ceneda.

The fossils described in this memoir were chiefly derived from the

* This Foraminifer is termed "Orbitulites" by Catullo, and included in his "Bryozoari": his *Orbitulites nummuliformis* is also an *Orbitoides*, and so also probably is his *Lunulites subradiata*. Signor Catullo's figure of *Lunulites androsaces* (Michelotti) closely resembles *Nummulites* (*Assilina*) *granulosus*, d'Arch.; and his *L. depressa* has a similar character, judging from the figures.—Ed.

Castellini collection, now forming part of the Museum of Natural History in the University of Padua. [T. D.]

On Post-tertiary Shells *from the* Coast *of* Greece. By Dr. M. Hoernes.

[Proceed. Imp. Geol. Instit. Vienna, January 29, 1856.]

Dr. Hoernes communicated a list of 87 species of marine molluscs, found subfossil near Kalamaki, on the Isthmus of Corinth, and lately sent to the Imperial Museum by M. Th. de Heldreich, Director of the Royal Botanical Garden at Athens. The specimens were found between Kalamaki and Lutraki, at a height of from 30 to 60 feet above the present high-water-mark, imbedded in a mass of shell-fragments, with small rolled pebbles of serpentine and reddish quartz, altogether forming a calcareous sandstone. All the species are still living in the neighbouring sea.

Similar deposits are known to exist along nearly the whole coast of the Mediterranean,—in the Morea, in Rhodes, Cyprus, Sicily, Italy (Puzzuoli), Algeria, Spain, &c. Hence it may be concluded that at an earlier epoch the countries surrounding the Mediterranean have undergone an upheaval, which, as careful investigations seem to prove, has affected the continents of Europe, Asia, and Africa bodily; so that at the epoch known under the name of "Neogene" (Pliocene and Miocene of Lyell), the Atlantic Ocean and the Mediterranean may have extended considerably further than they do now. In the south and south-west of France, in the Mayence and Upper Danube basin, in the basins of Vienna and Hungary, in the plains of Germany, a great portion of Russia, the whole extent of the valley of the Po, and elsewhere, there exist evidences of the waters having covered all these areas. At the same epoch the Caspian Sea was still in immediate connexion with the Euxine, and Africa was an island, the borings undertaken by the Canal-commission having shown that the Isthmus of Suez is for the most part composed of deposits abounding in Neogene fossils. Similar fossils have been found in Algeria and in Oran, so that the whole of North Africa, together with the Sahara, may be reasonably supposed to have formed part of the Neogene sea.

It also appears that the upheaval was extremely slow, all the neogene fauna of Europe exhibiting gradual passages from an extinct fauna to one perfectly agreeing with that of the present Mediterranean fauna. The species of the lowest neogene strata have a subtropical character; those of later date indicate a climate more and more approaching to that existing at present; and of the 87 species from Kalamaki, fifty are identical with forms from the Vienna basin.

From the sinking of the relative level of the sea, as an effect of the upheaval, and the influx of fresh water into limited basins, the true marine species died out and gave room to a new fauna peculiar to brackish water (the *Cerithian* strata); just as changes are now taking place on the shores of the Caspian. At last even these species could no longer exist with the gradually diminishing water-level, and made room for the comparatively few molluscan forms at present inhabiting our dry lands and fresh waters. [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.]

END OF VOL. XII.