THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

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1863.

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

VOLUME THE NINETEENTH.

1863.

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(*Actinozoa.*)

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Nebalia. Woodcut, f. 12	Recent.........	....	90
Palæocarabus Russellianus. Woodcut, f. 1 & 2....................................	Coal-measures	Glasgow	520
Paradoxides Davidis. Woodcut.......	Llandeilo flags	St. David's	276
Peltocaris aptychoides. Woodcut, f. 1.	Llandeilo flags	Dumfriesshire ...	88
—— ? *Harknessi.* Woodcut, f. 2	Llandeilo flags	Dumfriesshire ...	88
—— ? Track of. Woodcut	Llandeilo flags	Chirbury, Salop	94
——. Woodcut, f. 4, 5	Lower Silurian	....	90
Scapheus ancylochelis. Pl. xi.	Lower Lias ...	Lyme Regis	318

VERTEBRATA. (6.)

(*Pisces.*)

Name of Species.	Formation.	Locality.	Page.
Acrodus Flemingianus. Pl. viii. f. 5 ...	Carboniferous ...	Vurcha................	17
——, n. sp.	Carboniferous ...	Chederoo............	16
Saurichthys? Indicus. Pl. viii. f. 6, 7...	Carboniferous ...	Vurcha................	17

(*Amphibia.*)

Name of Species.	Formation.	Locality.	Page.
Anthracosaurus Russelli. Woodcut, f. 1, 2	Coal-measures	Airdrie...............	56
Dendrerpeton Oweni......................	Coal-measures...	Joggins	470
Eosaurus Acadianus	Carboniferous ...	South Joggins......	53

ERRATA ET CORRIGENDA.

Part I.—Proceedings.

Page 42, line 4, *for* fluates *read* fluorides.
" 68, footnote, *add* Appendix, by Prof. T. H. Huxley.
" 79, explanation of woodcut, Fig. 1, after *Anthracomya* insert (*Naiadites*); Fig. 2, for *Naiadites lævis* read *Anthracomya* (*Naiadites*) *lævis*.
" 358, line 11 from bottom, *for* newer *read* older.
" 405, line 2, *for* 3 diameters *read* 2 diameters.
" 456, line 11 from bottom, *for* San-Domingan *read* Central American.
" 499, transpose line 28 to below line 31.
" 502, line 28, *before* occasional *insert* an.
" 536, line 30, *for* Trigen *read* Triger.

[See also the Appendix to Dr. Duncan's paper, p. 456.]

Part II.—Miscellaneous.

Page 3, line 13 from bottom, *for* Kalakvi (Gulgrud) *read* Kalakri (Gulgrad).
" 5, line 7 from bottom, *for* Arabio-Caspian *read* Aralo-Caspian.
" 6, line 1, for Arabio-Ponto *read* Aralo-Ponto.
" 6, line 7 from bottom, *before* ice-actiou *insert* direct.
" 22, line 25, *after* have *insert* been.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 20, 1863.

REPORT OF THE COUNCIL.

In presenting their Annual Report to the Fellows of the Geological Society, the Council have again to congratulate them upon the numerical increase in the Society during the past year, and also upon its financial prosperity.

The augmentation in the number of the Society has occurred through the election of forty-six new Fellows, forty-two of whom have paid their fees. These, with seven previously elected who paid their fees in 1862, make up the unusually large number of forty-nine new Fellows. This increase is probably attributable to the equalization of subscriptions in accordance with a resolution passed at a Special General Meeting held on February 26th, 1862, by which all Fellows elected after March 1st, 1862, pay £2 2*s.* annually, and by which those previously on the books as Resident Fellows pay the same amount, instead of the former scale of contribution.

Against this increase must be placed the loss which the Society has sustained by the death of fifteen Fellows and the resignation of five others. Four Foreign Members have died, and the places of three have been filled up by the election of new Members. The number of extraordinary Members has also been reduced by the death of one Honorary Member.

The total number of the Society at the close of 1861 was 940; at the close of 1862, 969.

No special items have occurred in the expenditure of the year, but, on the contrary, the expenses of the Museum have been considerably reduced; consequently the Income has exceeded the Expenditure by £227 2*s.* 9*d.*

The Funded property of the Society remains the same as at the last Anniversary, viz. £4350.

At a Special General Meeting held on January 8th, 1863, it was resolved:—

I. That the number of Foreign Members be in future limited to forty, instead of fifty as heretofore.

II. That a Class of Foreign Correspondents be instituted, not exceeding forty in number.

III. That the Foreign Members shall be elected out of the list of Foreign Correspondents.

The Council will take an early opportunity of laying before the Fellows the names of a number of gentlemen whom they propose to nominate as Corresponding Members in conformity with the above resolutions.

At the same Special General Meeting it was also resolved that the Meetings of the Society shall be held in the Society's rooms at Somerset House, on and after the Anniversary Meeting next ensuing.

The Council have to announce the completion of Vol. XVIII. of the Quarterly Journal, and the publication of Part 1 of Vol. XIX.

The S.E. sheet, No. 6, of the Greenough Map is now ready for publication, and will be issued shortly. The remaining sheets are in course of preparation, and it is hoped that some of them will be ready at no distant date.

The Council regret to have to announce the resignation of the Secretaryship by Professor Huxley, in consequence of the pressure of his other occupations.

At the end of last Session Mr. Rupert Jones also resigned the office of Assistant-Secretary, which he could not longer hold consistently with his professorial duties at the Military College, Sandhurst. The Council received this resignation with the greatest regret, having reason to feel the highest satisfaction with the excellent manner in which Mr. Jones has for a long term of years performed the duties of his office. Among a great number of candidates for the vacant post, whose recommendations were carefully considered, the Council selected Mr. H. M. Jenkins, whose assiduity and experience in the business of the Society, whilst acting as assistant to Mr. Jones, appear in a high degree to qualify him as an efficient Assistant-Secretary.

The Council have awarded the Wollaston Medal to Professor Gustav Bischof, of Bonn, in recognition of the eminent services rendered by him to Geological Science by his long-continued and laborious chemical investigations on the origin and changes of minerals and rock-substances, as well as by his numerous publications on similar subjects, and especially by the production of his great work on Physical and Chemical Geology; and the balance of the proceeds to Dr. Ferdinand Senft, of Eisenach, to encourage him in the continuation of his meritorious researches in various branches of geology.

Report of the Library and Museum Committee, 1862-63.

The Museum.

The Foreign Collection has been enriched during the past year by numerous donations, including a series of specimens of Devonian Plants and Carboniferous Reptiles from Nova Scotia, presented by

Dr. J. W. Dawson, F.G.S.; a complete set of casts of the *Climactichnites* from the Potsdam Sandstone of Perth, Canada West, presented by Sir W. Logan, F.G.S.; a collection of Fossils from the Estherian Shales of Phœnixville, Pennsylvania, presented by C. M. Wheatley, Esq., M.A., &c.; a suite of Rock-specimens from Italy, presented by Leonard Horner, Esq., F.G.S.; and very recently by a large number of Echinoderms from the Miocene Beds of Malta, presented by Dr. Leith Adams, and shortly to be described by Dr. T. Wright, F.G.S. Specimens from South Africa, South Australia, Mexico, and Vancouver's Island have been presented by Capt. J. Grantham, R.E., the Rev. J. E. Woods, F.G.S., Signor Gennaro Placci, F.G.S., and A. J. Langley, Esq.; and smaller contributions have been received from a number of other donors.

The chief additions to the British Collection are:—A very fine specimen of *Ammonites rusticus* from the Chalk, near Chard, Somerset, from N. W. Spicer, Esq.; specimens of Fossil Plants from Hempstead, presented by W. Pengelly, Esq., F.G.S.; and a series of specimens from the Iron-ore Mines near Ulverston, presented by Miss Hodgson in illustration of her paper on that district.

The following comparative table will show the extent to which the Foreign Fossils in the Society's Collection have been renamed since the last Anniversary.

Fossils named prior to the last Anniversary.

		Drawers.	
Norway	Silurian	5	
Uddevalla, &c.	Postpliocene	2	
Sweden	Silurian	2	
Antwerp	Pliocene	1	
Touraine	Miocene	2	
Paris Basin	Eocene	9	
Normandy	Jurassic	6	
North America	Cretaceous	1	
			—28

Fossils named since the last Anniversary.

Spitzbergen	Carboniferous, &c.	2	
Belgium	Devonian and Carboniferous	1	
Tournay	Carboniferous	1	
Rhenish Provinces	Carboniferous	21	
Hauteville	Eocene	1	
Sulz-les-Bains	Trias	2	
Würtemberg	Lias	1	
Baden	Keuper	1	
Baden	Trias	1	
Stuttgart	Trias	1	
			—32
	Total		60

This progress was made chiefly in the earlier portion of the year, the reduction in the Staff of the Society by the resignation of Mr. Jones and the preparation for publication of a new Alphabetical Supplemental Library-catalogue having, since that time, interfered with the furtherance of so desirable an end as the complete renaming of the Foreign Specimens. It should also be borne in mind that whereas the Museum-expenses in 1861 reached the sum of £128 12*s.* 9*d.*, last year they amounted only to £5 18*s.* 6*d.*

The Committee desire to express their opinion that, considering the reduction in expenses and in the strength of the Staff, the work in the Museum has been satisfactorily performed, and that an important step has been made towards rendering the Museum really serviceable to the Fellows of the Society.

The Council were requested in June 1862, by Dr. P. M. Duncan, F.G.S., to permit his borrowing the specimens of the Silicified Corals from the West Indies in the Society's Museum, for the purpose of an investigation which he has now nearly completed; he will, therefore, shortly describe them in a paper to be communicated to the Society, and your Committee view with satisfaction the probability of this valuable collection being soon completely named and arranged.

Three boxes, ordered by the Council, have been supplied, at the cost of £1 15*s.*, to contain the casts of *Climactichnites* presented by Sir W. Logan.

The Library.

The additions made to the Library since the last Anniversary have rendered necessary the erection of a new set of Book-shelves, at a cost of £9 15*s.* 6*d.*, in addition to the two erected some time back; these have been placed in the Meeting-room with the latter, and are already nearly filled with Periodical Works, the supply of which, by exchange, gift, and purchase, has continued to increase of late.

The Committee especially call the attention of the Society to the presentation of about 870 maps of the Ordnance Survey (6-inch scale) by the Board of Ordnance, through the Director-General, Col. Sir H. James, F.G.S., &c., for the reception of which a new Map-case has been provided at a cost of £8.

The Map-collection has also been increased by the usual addition of a number of French Charts from the Dépôt de la Marine, and by a large Map of the World, geologically coloured by Prof. Jules Marcou, presented by the Publishers.

The Commissioners of the International Exhibition have presented the Catalogues of the Mining, Metallurgical, and Geological specimens from their respective countries.

A new Alphabetical Catalogue, supplemental to the Library-catalogue Supplement published in 1860, is in course of publication, and will be ready shortly. This Supplement, besides containing the titles of about 1000 books and pamphlets added to the Library between June 1860 and June 1862, will also comprise a complete classified Catalogue of all the Periodical Works (also making about 1000 titles) in the Society's Library at the latter date.

When this Catalogue shall have been published, it is in contemplation to substitute for the three printed and two MS. reference-catalogues in the Library a single reference-catalogue which shall contain all that is now comprised in the older set; a book has already been prepared for this purpose in accordance with a recommendation of the Library Committee last year.

New books and pamphlets have been catalogued and placed in the Library, as usual, by Mr. Stair, who has also been of much assistance in preparing diagrams for the Evening-meetings, and in completing the re-arrangement of the Portfolios containing the Society's Collection of Sections, Plans, and Drawings.

H. FALCONER.
WM. J. HAMILTON.
R. CHAMBERS.

Comparative Statement of the Number of the Society at the close of the years 1861 *and* 1862.

	Dec. 31, 1861.		Dec. 31, 1862.	
Compounders		126		135
Residents		225		306*
Non-residents		535†		476‡
		886		917
Honorary Members	4		3	
Foreign Members	49		48	
Personage of Royal Blood	1—54		1—52	
		940		969

* This number includes all Contributing Fellows, irrespective of their place of residence.

† Including Contributing and Non-contributing Fellows;—in the account for this year the former have been included with the other Fellows who pay an Annual Contribution, as explained in the preceding foot-note.

‡ Comprising only the Non-residents who do not contribute; they were elected prior to November 30, 1859.

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1861 *and* 1862.

Number of Compounders, Residents, and Non-residents, December 31, 1861			886
Add Fellows elected during former years and paid in 1862	Residents		2
	Non-residents		5
Add Fellows elected and paid in 1862	Contributors*	32	
	Non-residents elected previously to March 1st	10	
		—	42
			935
Deduct Compounders deceased		3	
Residents ,,		6	
Non-residents ,,		6	
Residents resigned		2	
Non-resident resigned		1	
		—	18
	As above		917

Number of Honorary Members, Foreign Members, and Personages of Royal Blood, Dec. 31, 1861		54
Add Foreign Members elected during 1862		3
		57
Deduct Foreign Members deceased	4	
Honorary Member ,,	1	
	—	5
		52

Number of Fellows liable to Annual Contribution, as Residents and Non-residents, at the close of 1862.

Residents	222
Non-residents	52
Contributors elected since March 1st	32
	306

* Elected subsequently to March 1st, and subject to an Annual Contribution of Two Guineas.

Deceased Fellows.

Compounders (3).

J. B. Birch, Esq.
J. H. Deacon, Esq.
S. F. Wilde, Esq.

Residents (6).

Marquis of Breadalbane.
G. G. Harcourt, Esq.
H. T. Hope, Esq.
J. C. Nesbit, Esq.
W. S. Richardson, Esq.
R. A. Slaney, Esq.

Non-residents (6).

Rev. J. C. Cumming.
Rev. J. B. P. Dennis.
A. Hill, Esq.
W. Peace, Esq.
Dr. T. S. Traill.
R. Trench, Esq.

Foreign Members (4).

Prof. H. G. Bronn.
M. J. M. Bertrand de Doue.
Prof. C. C. von Leonhard.
Prof. L. A. Necker.

Honorary Member (1).

R. Bald, Esq.

The following Persons were elected Fellows during the year 1862.

January 8th.—Robert Harris Valpy, Esq., Enborne, near Newbury; William Shepherd Horton, Esq., 10 Church Street, Liverpool; Charles Sturtivant Wood, Esq., Geological Survey of Otago, New Zealand.

—— 22nd.—Samuel Sharp, Esq., Dallington Hall, near Northampton; George Parkes Wall, Esq., The Hills, near Sheffield.

February 5th.—Captain William Henry Mackesy, 79th Highlanders (Waterford); Harry Seeley, Esq., Curator of the Woodwardian Museum, Cambridge; Thomas F. Jamieson, Esq., Ellon, Aberdeenshire.

—— 26th.—Julius Schvarcz, Ph.D., Stuhlweissenburg, Hungary; George Charlton, Esq., Dukinfield, near Manchester.

March 5th.—William James Dunsford, Esq., 14 Taviton Street, Gordon Square; Charles Henry Gatty, Esq., Felbridge Park, East Grinstead; George Ford Copeland, Esq., 5 Bays Hill Villas, Cheltenham; A. H. Green, Esq., Fellow of Caius College, Cambridge.

—— 19th.—Harvey Buchanan Holl, M.D., Malvern; George W. Hemans, Esq., 32 Leinster Gardens, Bayswater; Edward Romilly, Esq., 14 Stratton Street, Piccadilly; G. Ernest Shelley, Esq., Avington House, Winchester; Elliot Square, Esq., Gresham House, London; Rt. Hon. Edward Cardwell, M.P., Chancellor of the Duchy of Lancaster, 74 Eaton Square; George Wilson Stevenson, Esq., Halifax, Yorkshire.

April 2nd.—Charles Longman, Esq., Hemel Hempstead; Thomas Wyles, Esq., Allesley Park College, near Coventry.

—— 16th.—Edward Petre, Esq., 38 Brook Street; T. McKenny Hughes, Esq., of the Geological Survey of Great Britain.

May 7th.—Edward Fitton, Esq., 6 Gloucester Crescent, Westbourne Terrace; Henry Francis Blanford, Esq., late of the Geological Survey of India; Frederick Hill, Esq., Penhellis, Helston, Cornwall; Charles Rogers, Esq., 16 Beaufoy Terrace, Maida Vale; Rev. Stopford A. Brooke, Fern Lodge, Kensington; John Langley King, Esq., 56 Wells Street, Oxford Street.

—— 21st.—W. G. Lemon, Esq., B.A., Blackheath; E. W. Cooke, Esq., The Ferns, Hyde Park Gate; Edmund Jones, Esq., Basinghall Street.

June 4th.—Rev. D. Honeyman, Antigonish, Nova Scotia; Alexander Macdonald, Esq., Aberdeen.

—— 18th.—John Cumming, Esq., 7 Montague Place, Russell Square; William Topley, Esq., Geological Survey of Great Britain.

November 19th.—James Brunlees, Esq., 84 Addison Road, Kensington; M. Auguste Laugel, Ex-Secretary of the Geological Society of France, Orleans House, Twickenham.

December 3rd.—Edward Hesketh Birkenhead, Esq., Master of the Wigan School of Mines; Alan Lambert, Esq., 2 Portugal Street, Grosvenor Square; Samuel Higgs, Jun., Esq., Penzance; Antonio Brady, Esq., Maryland Point, Stratford, Essex.

—— 17th.—Richard Richardson, Esq., Rhayader, Radnorshire; John Wickham Flower, Esq., Park Hill, Croydon, Surrey.

The following Personages were elected Foreign Members.

Señor Casiano di Prado, Madrid.
Baron Sartorius von Waltershausen, Göttingen.
Professor Pierre Merian, Basle.

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

British Specimens.

Flint-flakes from Croyde Bay, Devon, and from the South Downs; presented by Nicholas Whitley, Esq.

Large specimen of *Ammonites rusticus*, from the Chalk near Chard, Somerset; presented by Northcote W. Spicer, Esq.

Specimens of Fossil Plants from Hempstead, Isle of Wight; presented by W. Pengelly, Esq., F.G.S.

Specimens of Rocks from near Ulverston, Lancashire; presented by Miss E. Hodgson.

Specimens of Carboniferous Rocks from Ayrshire; presented by E. W. Binney, Esq., F.G.S.

Two nodules from the Upper Devonian of West Angle Bay, Pembrokeshire; presented by J. W. Salter, Esq., F.G.S.

Foreign Specimens.

Suite of Nickel-ores; presented by S. T. Ayres, Esq.

Suite of Devonian Plants from New Brunswick; presented by Dr. J. W. Dawson, F.G.S.

A Crystal of Quartz containing a laminated Mineral, from Mexico; presented by H. Christy, Esq., F.G.S.

Fossil Wood and other specimens from Quathlamba Mount, Natal; presented by Captain J. Grantham, R.E.

Tertiary Fossils from Harrow, South Australia; presented by the Rev. Julian E. Woods, F.G.S.

Suite of Estherian Shales, with Reptilian and Plant-remains, from Phœnixville, Pennsylvania; presented by C. M. Wheatley, Esq., M.A.

Large Plaster-casts of *Climactichnites* from Perth, Canada West; and Stand; presented by Sir W. E. Logan, F.G.S.

Specimens of Gold- and Silver-ore from Zacatecas, Mexico; presented by Sign. Gennaro Placci, F.G.S.

Four specimens of Devonian Plants from Nova Scotia; presented by Dr. J. W. Dawson, F.G.S.

Six specimens of Crystals of Gypsum containing Sand, from New Brunswick; four Photographs of Vertebræ of *Eosaurus Acadianus*, and a Cast of the Vertebræ of *Eosaurus Acadianus*; presented by O. C. Marsh, Esq., M.A.

Specimen of Coral from the Gravel of the Meuse, near Namur; presented by Sir F. C. Knowles, Bart., F.R.S.

Specimen of Lead-ore from Monte Vecchia, Sardinia, exhibited at the International Exhibition; presented by W. P. Jervis, Esq., F.G.S.

Specimens of Minerals, Rocks, and Nanaimo Coal from Vancouver's Island, exhibited at the International Exhibition; presented by F. J. Langley, Esq.

Specimens of Granite containing Copper-ores, from near Kingston, Jamaica; presented by J. G. Sawkins, Esq., F.G.S.

Specimens of Rocks from Masulipatam; presented by Captain F. Applegath.

Specimens of Ammonites, &c., from near Niti Pass; presented by Col. Strachey, F.G.S.

Specimens of Rocks and Fossils from the Pampean Formation near Buenos Ayres; presented by C. Darwin, Esq., F.G.S.

Specimen of Carbonate of Lime from the Stalagmitic Floor of the Rebenac Cave, Pyrenees; presented by H. Christy, Esq., F.G.S.

A large collection of *Echinodermata* from the Miocene Beds of Malta; presented by Dr. Leith Adams.

Specimens of Tertiary Plants from the Upper Val d'Arno; presented by Sir C. Lyell, V.P.G.S.

Charts, Maps, etc. presented.

Geologische Uebersichts-Karte von Siebenbürgen, von Franz Ritter von Hauer; presented by F. Ritter von Hauer.

Carta Geologica di Savoja, Piemonte, e Liguria; del Commendatore Angelo Sismonda, 1862; presented by Professor A. Sismonda, For.M.G.S.

Geognostische karte des Königreichs Bayern, herausgegeben auf Befehl des kön. bayerischen Ministeriums der Finanzen. Erste

Abtheilung. Das bayerische Alpengebirge und sein Vorland, in fünf Blättern und ein Blatt Gebirgsansichten; im dienstlichen Auftrage aufgenommen und bearbeitet von G. W. Gümbel, München, 1861; presented by His Excellency the Bavarian Minister.

Carte Géologique des parties de la Savoie, du Piémont et de la Suisse voisines du Mont Blanc, par Alphonse Favre; presented by M. A. Favre.

Maps of the Gold-fields in the Colony of Victoria: Sheet 1, Ballarat Gold-field and Castlemaine Gold-field; Sheet of Ballarat Mining District; Sheet of Castlemaine Mining District; Sheet of Maryborough Mining District; presented by the Hon. G. S. Evans.

Carta Geologica dei Monti Pisani levata dal vero del Cav. Prof. Paolo Savi nel 1832, aumentata e corretta nel 1858; presented by Prof. P. Savi.

Geological Map of the World, by Jules Marcou, constructed by J. M. Ziegler; presented by Messrs. J. Würster & Co.

First Sketch of a New Geological Map of Scotland, with explanatory notes, by Sir R. I. Murchison and A. Geikie, Esq.; presented by Sir R. I. Murchison, K.C.B., F.G.S., and A. Geikie, Esq., F.G.S.

Ordnance Survey of Great Britain. Maps, 6-inch scale:—Lancashire, Index-sheet, Sheets 1 to 118. Yorkshire, Index-sheet, Sheets 1 to 301. Ayrshire, Sheets 1 to 14, 16 to 74. Edinburgh, Index-sheet, Sheets 1 to 25. Fife and Kinross, Index-sheet, Sheets 1 to 41. Haddington, Index-sheet, Sheets 1 to 22. Island of Lewis, Ross-shire, Sheets 1 to 49. Kirkcudbright, Index-sheet, Sheets 1 to 55. Linlithgow, Index-sheet, Sheets 1 to 12. Peeblesshire, Index-sheet, Sheets 1 to 21, 23 to 27. Wigtonshire, Index-sheet, Sheets 1 to 37. Durham, Sheets 1 to 5, 8, 17. Westmoreland, Sheets 35, 40, 41, 42, 44, 45, 48. Dumfriesshire, Sheets 35 to 37, 45, 46, 52 to 54, 58, 63, 68, 69. Berwickshire, Sheets 7 to 9, 13 to 17, 19, 20, 23, and 26.—Ordnance Survey of England. 1-inch scale:—Sheets 91 to 94, 95, N.W., S.W., S.E.; 96, 97, 103, S.W., S.E.; 104, S.W.—Ordnance Survey of Ireland. 1-inch scale:—Sheet 120.—Ordnance Survey of Scotland. 1-inch scale:—Sheets 1 to 9, 11, 32 to 34, 40, 41, 106. Isle of Lewis, Sheets 1 to 7. Presented by the Board of Ordnance through the Director-General, Colonel Sir Henry James, F.G.S.

Forty-nine Maps and Charts published by the Dépôt de la Marine de la France; presented by the Dépôt de la Marine.

Carte Physique et Industrielle de la Néerlande. Sheet 15. Veluwe. Presented by the Minister of the Interior, Holland.

Geological Section through the Tunnels on the Worcester and Hereford Railway, by Alan Lambert, Esq., F.G.S.; presented by A. Lambert, Esq., F.G.S.

Section of a Well at the Tannery of Mr. Lancaster Webb, Stowmarket, Suffolk, and Sections of the Artesian Wells at Grenelle and Passy, near Paris; presented by G. R. Burnell, Esq., F.G.S.

Photographs of Somma and Vesuvius, by J. Graham; presented by James Graham, Esq.

Photographs of Sir C. Lyell and Mr. Darwin; presented by L. Horner, Esq., F.G.S.

The following Lists contain the Names of the Persons and Public Bodies from whom Donations to the Library and Museum have been received since the last Anniversary, February 21, 1862.

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

Antwerp. Palæontological Society of Belgium.

Basel, Natural History Society of.
Berlin. German Geological Society.
——, Royal Academy of Sciences at.
Berwick. Natural History Field-club.
Bogotá. Natural History Society of New Granada.
Bombay Branch of Royal Asiatic Society.
Bordeaux, Linnean Society of.
Breslau. Imperial Leopold-Car. Academy of Naturalists of Germany.
Brussels. Royal Academy of Sciences of Belgium.

Caen. Linnean Society of Normandy.
Calcutta. Geological Survey of India.
——, Bengal Asiatic Society at.
Cambridge (Mass.). American Philosophical Society.
—— ——. American Academy of Arts and Sciences.
Cherbourg, Society of Natural Sciences of.
Christiania, Royal Academy of.

Darmstadt. Geological Society of the Middle Rhine.
Dijon, Academy of Natural Sciences of.
Dorpat, Natural History Society of.
Dublin, Geological Society of.
——. Royal Irish Academy.
——. Royal Dublin Society.

Edinburgh, Royal Society of.

Frankfurt. Senckenberg Natural History Society.

Geneva, Physical and Natural History Society of.

Halle. Saxony and Thuringian Natural History Society.
Hanau. Natural History Society of the Wetterau.
Heidelberg, Natural History Society of.

Italy, Commissioners for, at the International Exhibition.

Kentucky, Geological Survey of.

Lausanne. Société Vaudoise des Sciences Naturelles.
Lisbon, Royal Academy of.
Liverpool, Philosophical Society of.
London, Chemical Society of.
——. Geological Survey of Great Britain and Ireland.
——, Royal Astronomical Society of.
——. Royal Asiatic Society of Great Britain.
——, Art-Union of.
——. British Association.
——. Royal College of Physicians of England.
——. Royal Geographical Society.
——. Geologists' Association.
——, Royal Horticultural Society of.
——. Institute of Actuaries of Great Britain and Ireland.
——. Institute of Civil Engineers.
——, Linnean Society of.

London, Mendicity Society of.
——, Microscopical Society of.
——, Palæontographical Society of.
——, Photographic Society of.
——, Royal Society of.
——. Ray Society.
——. Committee of Council on Education, Science and Art Department.
——. Secretary of State for War.
——, Zoological Society of.
——. Board of Ordnance.

Madison, United States. Wisconsin State Agricultural Society.
Madrid, Academy of Sciences of.
Manchester, Geological Society of.
——, Literary Society of.
Melbourne, University of.
——. Royal Society of Victoria.
——. Mining Surveyors of Victoria.
——. Commissioners of Public Works, Victoria.
Milan, Geological Society of.
Montreal, Natural History Society of.
Moscow, Imperial Academy of Naturalists in.
Munich, Academy of Sciences of.

Neufchatel, Society of Natural Sciences of.
New South Wales, Commissioners for, at the International Exhibition.
New York, State Library of.
——, Regents of the University of the State of.
Nova Scotia, Commissioners for, at the International Exhibition.

Palermo, Agricultural Society of.
Paris. Academy of Sciences.
——. Archeological Congress of France.
——. Dépôt Général de la Marine.
——, Geological Society of.
——, Imperial Commissioner for, at the International Exhibition.
Paris. L'École des Mines.
——. Institute of the Provinces.
——. Museum of Natural History.
Philadelphia. Academy of Natural Sciences.
Plymouth Institution.
Presburg, Natural History Society of.
Puy-en-Velay. Society of Agriculture and Science.

Spain, Commissioners for, at the International Exhibition.
Stockholm, Academy of.
Strasburg, Society of Natural Sciences of.
Stuttgart. Natural History Society of Würtemberg.
St. Petersburg, Imperial Academy of.
——, Mineralogical Society of.

Teign Naturalists' Field-club.
Toronto, Canadian Institute of.
Turin. International Exhibition Commissioners.
——. Royal Institute of Lombardy.
Tyneside Naturalists' Field-club.

Vermont, State-Legislature of.
Vienna, Geological Institute of.
——, Imperial Mineralogical Institute of.
——, Imperial Academy of.

Warwickshire Naturalists' Field-club.
Washington. United States War Department.
——. Smithsonian Institution.
Wellington, New Zealand, Commissioners of, at the International Exhibition.
Wisconsin, State-Legislature of.

Zollverein, Commissioners for the, at the International Exhibition.

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

American Journal of Science and Arts, Editor of the.
Archiac, Vicomte A. d', F.M.G.S.
Athenæum Journal, Editor of the.
Aucapitaine, Baron.

Baily, W. H., Esq., F.G.S.
Barrande, M. J., For.M.G.S.
Bathoe, C., Esq.
Bavarian Minister, His Excellency the.
Beardmore, N., Esq., F.G.S.
Beron, M. Pierre.
Bianconi, Prof. G.
Billings, E., Esq.
Binkhorst, M. Binkhorst van den.
Binney, E. W., Esq., F.G.S.
Blake, E. H., Esq.
Brody, Dr. S.
Burnell, G. R., Esq., F.G.S.

Cheney, T. A., Esq.
Clarke, Rev. W. B., F.G.S.
Colliery Guardian, Editor of the.
Cotteau, M. W. B.
Critic, Editor of the.

Damone, M.
Dana, Dr. J. D., For.M.G.S.
Davidson, T., Esq., F.G.S.
Dawson, Dr. J. W., F.G.S.
Delesse, M., For.M.G.S.
Deshayes, Prof. G. P., For.M.G.S.
Deslongchamps, Dr. J. A. E., For.M.G.S.
Desor, M. E.
Dewalque, M.
Dulau & Co.

Eichwald, Dr. E. d'.
Erdmann, A.
Evans, Hon. G. S., LL.D.
Evans, John, Esq., F.G.S.

Falconer, Dr. H., F.G.S.
Favre, Prof. A.
Fournet, Prof.
Francis, Dr., F.G.S.
Freke, Dr.

Gastaldi, B.
Gaudin, Sig. C. T.
Gaudry, Albert.
Geikie, A., Esq., F.G.S.
Geinitz, Prof., For.M.G.S.
Gibb, Dr. G. D., F.G.S.
Goeppert, Prof., For.M.G.S.
Graham, J., Esq.
Graham, Lieut.-Col.

Haddon, J., Esq.
Haidinger, Dir., For.M.G.S.
Hall, Prof. J., For.M.G.S.
Halloy, M. J. J. d'O. d', F.M.G.S.
Hauer, Ritter von.
Hayden, Dr.
Heer, Dr. O.
Helmersen, Gen. von, For.M.G.S.
Hörnes, Dr.
Horner, Leonard, Esq., V.P.G.S.
Hull, E., Esq., F.G.S.
Huxley, Prof. T. H., Sec.G.S.

India, Secretary of State for.
Intellectual Observer, Editor of the.

James, Col. Sir H., F.G.S.
Jenyns, Rev. L., F.G.S.
Jervis, W. P., Esq., F.G.S.
Jones, Prof. T. R., F.G.S.
Jouvencel, M. P. de.
Jukes, J. B., Esq., F.G.S.

Karrer, M. Felix.
Kjerulf, Dr.
Korizmics, Dr. L.
Krejciho, Dr.

Lambert, A., Esq., F.G.S.
Laugel, M. A., F.G.S.
Lea, Dr. I.

Logan, Sir W. C., F.G.S.
London, Edinburgh, and Dublin Philosophical Magazine, Editor of the.
London Review, Editor of the.
Longman & Co.
Lubbock, J., F.G.S.
Lubbock, Sir John, F.G.S.
Lyell, Sir Charles, V.P.G.S.

Maior, Vicomte de Villa.
Marcou, M. J.
Marsh, O. C., Esq., F.G.S.
Mechanics' Magazine, Editor of the.
Mining and Smelting Magazine, Editor of the.
Morgan, Prof. de.
Morris, Prof., V.P.G.S.
Mortillet, M. G. de.
Murchison, Sir R., K.C.B., F.G.S.

Naumann, Dr., For.M.G.S.
Newman & Co.

Oldham, Dr. T., F.G.S.
Omboni, Dr.
Oppel, Dr.
Owen, Prof. R., F.G.S.

Parthenon, Editor of the.
Perrey, M. Alexis.
Phillips, J. A., Esq.
Pictet, M.
Ponzi, Prof.
Power, E. R., Esq.
Pratt, Dr. H. F. A.
Prestwich, J., Esq., F.G.S.

Quarterly Journal of Microscopical Science, Editor of the.
Quetelet, M.

Ramsay, Prof. A. C., Pres.G.S.
Raulin, M. V.
Reader, Editor of the.
Readwin, T. A., Esq., F.G.S.
Reeve, L., Esq., F.G.S.
Roberts, G. E., Esq.
Rose, Prof. Gustav, For.M.G.S.
Rütimeyer, Dr.

Salmon, H. C., Esq., F.G.S.
Salter, J. W., Esq., F.G.S.
Sandberger, Dr. F.
Savi, Prof.
Scarabelli, Dr. G.
Schvarcz, Dr. J., F.G.S.
Sculptors' Journal, Editor of the.
Sedgwick, Prof. A., F.G.S.
Sharswood, Dr.
Sinnett, F., Esq.
Sismonda, Prof., For.M.G.S.
Smith, J., Esq., F.G.S.
Smithe, Rev. F.
Stoppani, Prof. A.
Strozzi, Marq. C.
Studer, M. B., For.M.G.S.
Suess, Prof.
Symonds, Rev. W. S., F.G.S.
Szabó, Dr. J.

Tennant, Prof. J., F.G.S.
Terquem, M.
Triger, M.
Tylor, A., Esq., F.G.S.

Vignoles, C., Esq., F.R.S.

Wallich, Dr. G. C., F.G.S.
War, Secretary of State for.
Watson, Dr.
Weigel, T. O.
White, Dr.
Whiting, G., Esq.
Wood, S. G., Esq.
Woods, Rev. J. E., F.G.S.
Würster, Messrs. J., & Co.
Wyatt, J., Esq., F.G.S.

List of PAPERS *read since the last Anniversary Meeting, February* 21*st*, 1862.

1862.

Feb. 26th.—On the Drift containing Arctic Shells in the Neighbourhood of Wolverhampton, by the Rev. W. Lister, M.A., F.G.S.

——— On Split Erratic Blocks, by J. Smith, Esq., F.R.S., F.G.S.

——— On the Ice-worn Rocks of Scotland, by T. F. Jamieson, Esq., F.G.S.

March 5th.—On the Glacial Origin of certain Lakes in Switzerland, Great Britain, North America, and elsewhere, by Prof. A. C. Ramsay, F.R.S., Pres.G.S., &c.

March 19th.—On the Sandstones and their associated Deposits in the Vale of the Eden, the Cumberland Plain, and the South-east of Dumfriesshire, by Prof. R. Harkness, F.R.S., F.G.S.

——— On the Date of the last Elevation of Central Scotland, by A. Geikie, Esq., F.G.S.

April 2nd.—On some Reptilian Remains from the Coal-measures of the South Joggins, Nova Scotia, by Prof. Owen, F.R.S., F.G.S.

——— On some Fossil Footprints from Hastings, by A. Tylor, F.G.S.

——— On some Remains of *Chiton* from the Mountain-limestone of Yorkshire, by J. W. Kirkby, Esq.; communicated by T. Davidson, Esq., F.R.S., F.G.S.

——— On the Occurrence of Mesozoic and Permian Faunæ in Eastern Australia, by the Rev. W. B. Clarke, F.G.S.

April 16th.—On the Position of the Pteraspis-beds, and on the Sequence of the Strata of the Old Red Sandstone Series of South Perthshire, by Prof. R. Harkness, F.R.S., F.G.S.

——— On the Western End of the London Basin; on the Westerly Thinning of the Lower Eocene Beds in that Basin; and on the Greywethers of Wiltshire, by W. Whitaker, Esq., F.G.S.

——— On a Freshwater Deposit beneath the Drift near Ulverston, by John Bolton, Esq.; communicated by the President.

May 7th.—On new and large Labyrinthodonts from the Edinburgh Coal-field, by Prof. T. H. Huxley, F.R.S., Sec.G.S.

——— On the Flora of the Devonian Period in North-eastern America, by J. W. Dawson, LL.D., F.R.S., F.G.S.

——— On Upper Eocene Fossils from the Isle of Wight, by Prof. F. Sandberger (in a letter to W. J. Hamilton, Esq., For.Sec.G.S.).

May 21st.—On the Metamorphic Rocks of the Banffshire Coast, the Scarabins, and a portion of East Sutherland, by Prof. R. Harkness, F.R.S., F.G.S.

——— On the Geology of the Gold-fields of Nova Scotia, by the Rev. D. Honeyman; communicated by the President.

——— On some Fossil Crustacea from the Lower Coal-measures of British North America; on *Eurypterus*; on *Peltocaris*; and on some Tracks of Crustaceans in the Lower Silurian Rocks, by J. W. Salter, Esq., F.G.S.

1862.

June 4th.—On the Disputed Affinity of the Purbeck Mammalian genus *Plagiaulax*, by Dr. Hugh Falconer, F.R.S., F.G.S.

——— On some Fossil Plants from Hempstead, Isle of Wight, by Prof. O. Heer and W. Pengelly, Esq., F.G.S.

——— On some Surface-markings on the Sandstones near Liverpool, by G. H. Morton, Esq., F.G.S.

June 18th.—On the Mode of Formation of some of the River-valleys in the South of Ireland, by J. B. Jukes, Esq., F.R.S., F.G.S.

——— Experimental Researches on the Granites of Ireland: Part III. The Granites of Donegal, by the Rev. Prof. Haughton, F.R.S., F.G.S.

——— On the Upper Coal-measures containing a bed of Limestone in Ayrshire, by E. W. Binney, Esq., F.R.S., F.G.S.

——— On the Geological Structure of the Southern Grampians, by Prof. James Nicol, F.G.S.

——— On some Natural Casts of Reptilian Footprints in the Wealden Beds of the Isle of Wight and of Swanage, by S. H. Beckles, Esq., F.R.S., F.G.S.

——— On a Stalk-eyed Crustacean from the Carboniferous Strata near Paisley, by Prof. Huxley, F.R.S., Sec.G.S.

——— On a Section at Junction Road, Leith, by W. Carruthers, Esq.; communicated by S. P. Woodward, Esq., F.G.S.

——— On the Geology of Zanzibar, by R. Thornton, Esq.; communicated by Sir R. Murchison, F.R.S., F.G.S.

——— On the Old Red Sandstone of Fifeshire, by James Powrie, Esq., F.G.S.

——— On the Premolar Teeth of *Diprotodon* and on a new species of that genus, by Prof. Huxley, F.R.S., Sec.G.S.

——— On the Death of Fishes in the Sea during the Monsoon, by Sir W. Denison; communicated by Sir R. Murchison, F.R.S., F.G.S.

Nov. 5th.—Descriptions of some Fossils from India, discovered by Dr. Fleming of Edinburgh, by Dr. L. de Koninck, For.Mem.G.S.

——— On a Deposit containing *Diatomaceæ*, Leaves, &c. in the Iron-ore Mines near Ulverston, by Miss E. Hodgson; communicated by the President.

——— On the Geology of a Part of the Masulipatam District, by Capt. F. Applegath, Madras Army; communicated by the President.

——— On the Association of Granite with the Tertiary Strata near Kingston, by J. G. Sawkins, Esq., F.G.S.; in a Letter to Sir R. I. Murchison, F.G.S., &c.

Nov. 19th.—On the Cambrian and Huronian Formations, with remarks on the Laurentian; by J. J. Bigsby, M.D., F.G.S.

Dec. 3rd.—Description of the Remains of a new Enaliosaurian (*Eosaurus Acadianus*) from the Coal-formation of Nova Scotia, by O. C. Marsh, Esq., M.A.; communicated by Sir C. Lyell, V.P.G.S.

——— On the Thickness of the Pampean Formation near Buenos Ayres, by C. Darwin, Esq., F.G.S.

1862.

Dec. 3rd.—Geological Notes on the Locality in Siberia where Fossil Fishes and *Estheriæ* have been found, by C. E. Austin, Esq., F.G.S.; with a Note on *Estheria Middendorfii*, by Prof. T. Rupert Jones, F.G.S.

Dec. 17th.—On the Skiddaw Slate Series, by Prof. Harkness, F.R.S., F.G.S.; with a Note upon the *Graptolites*, by J. W. Salter, Esq., F.G.S.

——— On Fossil *Estheriæ*, and their Distribution, by Prof. T. Rupert Jones, F.G.S.

——— On the Flora of the Devonian Period in North-eastern America; Appendix; by Dr. J. W. Dawson, F.R.S., F.G.S.

1863.

Jan. 7th.—On the Lower Carboniferous Brachiopoda of Nova Scotia, by T. Davidson, Esq., F.R.S., F.G.S.

——— On the Gravel-deposits of Ludlow, Hereford, and Skipton, by T. Curley, Esq., F.G.S.

Jan. 21st.—On the Upper Silurian "Passage-beds" of Linley, Salop, by George E. Roberts, Esq., and John Randall, Esq.; communicated by the President.

——— On some Crustacean Tracks from the Old Red Sandstone near Ludlow, by George E. Roberts, Esq.; communicated by the President.

——— On the Parallel Roads of Glen Roy, and their place in the History of the Glacial Period, by T. F. Jamieson, Esq., F.G.S.

Feb. 4th.—On a Hyæna-den at Wookey Hole, near Wells, Part II., by W. Boyd Dawkins, Esq., B.A., F.G.S.

——— On the Discovery of *Paradoxides* in Britain, by J. W. Salter, Esq., F.G.S., A.L.S.

——— On the Fossil *Echinidæ* of Malta, by Dr. Thomas Wright, F.G.S.; with Notes on the Miocene Beds of the Island, by Dr. A. L. Adams, 22nd Regiment.

Feb. 18th.—On the Middle and Upper Lias of the Dorsetshire Coast, by E. C. H. Day, Esq.; communicated by Robert Etheridge, Esq., F.G.S.

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

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

It was afterwards resolved,—

1. That the thanks of the Society be given to Prof. J. Morris and J. Carrick Moore, Esq., retiring from the office of Vice-President.

2. That the thanks of the Society be given to Prof. T. H. Huxley, retiring from the office of Secretary.

3. That the thanks of the Society be given to Sir Charles Bunbury, the Earl of Enniskillen, J. Lubbock, Esq., Sir R. I. Murchison, and C. P. Scrope, Esq., retiring from the Council.

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

OFFICERS.

PRESIDENT.

Professor A. C. Ramsay, F.R.S.

VICE-PRESIDENTS.

Sir P. G. Egerton, Bart., M.P., F.R.S. & L.S.
R. A. Godwin-Austen, Esq., F.R.S.
Leonard Horner, Esq., F.R.S.
Sir Charles Lyell, F.R.S. & L.S.

SECRETARIES.

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

FOREIGN SECRETARY.

Hugh Falconer, M.D., F.R.S.

TREASURER.

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

COUNCIL.

John J. Bigsby, M.D.
George Busk, Esq., F.R.S.
Robert Chambers, Esq., F.R.S.E. & L.S.
Sir P. G. Egerton, Bart., M.P., F.R.S. & L.S.
John Evans, Esq., F.S.A.
Rev. R. Everest.
Hugh Falconer, M.D., F.R.S.
R.A.Godwin-Austen, Esq., F.R.S.
William John Hamilton, Esq., F.R.S.
Leonard Horner, Esq., F.R.S. L. & E.
Prof. T. H. Huxley, F.R.S. & L.S.
Sir Charles Lyell, F.R.S. & L.S.
Robert Mallet, Esq., C.E., F.R.S.
Edward Meryon, M.D.
John Carrick Moore, Esq., F.R.S.
Prof. John Morris.
Robert W. Mylne, Esq., F.R.S.
Joseph Prestwich, Esq., F.R.S.
Prof. A. C. Ramsay, F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.
Alfred Tylor, Esq., F.L.S.
Rev. Thomas Wiltshire, M.A.
S. P. Woodward, Esq.

LIST OF

THE FOREIGN MEMBERS

OF THE GEOLOGICAL SOCIETY OF LONDON, IN 1863.

Date of Election.

1817. Professor Karl von Raumer, *Munich.*
1818. Professor G. Ch. Gmelin, *Tübingen.*
1819. Count A. Breuner, *Vienna.*
1819. Sign. Alberto Parolini, *Bassano.*
1822. Count Vitiano Borromeo, *Milan.*
1823. Professor Nils de Nordenskiöld, *Helsingfors.*
1825. Dr. G. Forchhammer, *Copenhagen.*
1827. Dr. H. von Dechen, Oberberghauptmann, *Bonn.*
1827. Herr Karl von Oeynhausen, Oberberghauptmann, *Dortmund, Westphalia.*
1828. M. Léonce Elie de Beaumont, Sec. Perpétuel de l'Instit. France, For. Mem. R. S., *Paris.*
1828. Dr. B. Silliman, *New Haven, Connecticut.*
1829. Dr. Ami Boué, *Vienna.*
1829. J. J. d'Omalius d'Halloy, *Halloy, Belgium.*
1832. Professor Eilert Mitscherlich, For. Mem. R. S., *Berlin.*
1839. Dr. Ch. G. Ehrenberg, For. Mem. R. S., Berlin.
1840. Professor Adolphe T. Brongniart, For. Mem. R. S., *Paris.*
1840. Professor Gustav Rose, *Berlin.*
1841. Dr. Louis Agassiz, For. Mem. R. S., *Cambridge, Massachusetts.*
1841. M. G. P. Deshayes, *Paris.*
1844. Professor William Burton Rogers, *Boston, U.S.*
1844. M. Edouard de Verneuil, For. Mem. R. S., *Paris.*
1847. Dr. M. C. H. Pander, *Riga.*
1847. M. le Vicomte B. d'Archiac, *Paris.*
1848. James Hall, Esq., *Albany, State of New York.*
1850. Professor Bernard Studer, *Berne.*
1850. Herr Hermann von Meyer, *Frankfort-on-Maine.*
1851. Professor James D. Dana, *New Haven, Connecticut.*
1851. General G. von Helmersen, *St. Petersburg.*
1851. Hofrath W. K. Haidinger, For. Mem. R. S., *Vienna.*
1851. Professor Angelo Sismonda, *Turin.*
1853. Count Alexander von Keyserling, *Dorpat.*
1853. Professor Dr. L. G. de Koninck, *Liége.*
1854. M. Joachim Barrande, *Prague.*
1854. Professor Dr. Karl Friedrich Naumann, *Leipsic.*

1856. Professor Dr. Robert W. Bunsen, For. Mem. R. S., *Heidelberg.*
1857. Professor Dr. H. R. Goeppert, *Breslau.*
1857. M. E. Lartêt, *Paris.*
1857. Professor Dr. H. B. Geinitz, *Dresden.*
1857. Dr. Hermann Abich, *Tiflis, Northern Persia.*
1858. Dr. J. A. E. Deslongchamps, *Caen.*
1858. Herr Arn. Escher von der Linth, *Zurich.*
1859. M. A. Delesse, *Paris.*
1859. Professor Dr. Ferdinand Roemer, *Breslau.*
1860. Professor Dr. H. Milne-Edwards, For. Mem. R. S., *Paris.*
1861. Professor Gustav Bischof, *Bonn.*
1862. Señor Casiano di Prado, *Madrid.*
1862. Baron Sartorius von Waltershausen, *Göttingen.*
1862. Professor Pierre Merian, *Basle.*

AWARDS OF THE WOLLASTON-MEDAL

UNDER THE CONDITIONS OF THE "DONATION-FUND"

ESTABLISHED BY

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

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

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

TRUST-ACCOUNT.

RECEIPTS.	£	s.	d.
Balance at Banker's, January 1, 1862, on the Wollaston Donation-fund	31	4	8
Dividends on the Donation-fund for 1862 on £1084 1*s.* 1*d.* Reduced 3 per Cents.	31	6	0
	£62	10	8

PAYMENTS.	£	s.	d.
Award to Prof. Heer, 1862	20	14	8
Cost of Gold Medal awarded to Mr. R. A. C. Godwin-Austen	10	10	0
Cost of two written forms of Award of Proceeds	1	11	6
Balance at Banker's (Wollaston-fund), Dec. 31, 1862	29	14	6
	£62	10	8

VALUATION OF THE SOCIETY'S PROPERTY; 31*st December*, 1862.

PROPERTY.	£	s.	d.
Due from Messrs. Longman and Co., on account of Journal, Vol. XVIII., &c.	47	14	7
Due from Subscribers to Journal	50	0	0
Due for Authors' Corrections in Journal	18	19	0
Balance in Banker's hands	490	14	10
Balance in Clerk's hands	22	8	4
Funded Property :— Consols, at 95 (£ 4350* s. 0 d. 0)	4350	0	0
Arrears of Admission-fees (considered good)	25	4	0
Arrears of Annual Contributions, &c.	110	0	0
	£5115	0	9

DEBTS.	£	s.	d.
Due to Mr. W. West on account of Journal, Vol. XVIII.	72	15	3
Balance in favour of the Society	5042	5	6
	£5115	0	9

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

(Signed) JOSEPH PRESTWICH, *Treas.*

4th Feb. 1863.

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

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions on Quarterly Journal (considered good)	50	0	0			
Due for Authors' Corrections	18	19	0			
Due for Arrears (See Valuation-sheet)	110	0	0			
				178	19	0
Estimated Ordinary Income for 1863.						
Annual Contributions:—						
232 Resident Fellows at £2 2*s.*	487	4	0			
51 Non-resident Fellows at £1 11*s.* 6*d.* ...	80	6	6			
				567	10	6
Admission-fees (supposed)				250	0	0
Compositions (supposed)				200	0	0
Dividends on Consols				131	12	0
Sale of Transactions, Proceedings, Geological Map, Library-catalogues, and Ormerod's Index				50	0	0
Sale of Quarterly Journal				200	0	0
Due from Longman and Co. in June				47	14	7
Due from Bequest-fund on account of Special Expenditure on Map, Museum, and Library, in 1861 and 1862				130	7	3
				£1756	3	4

JOSEPH PRESTWICH, TREAS.

Feb. 5, 1863.

the Year 1863.

EXPENDITURE ESTIMATED.

	£ s. d.	£ s. d.
General Expenditure :		
Taxes and Insurance	35 0 0	
House-repairs	25 0 0	
New Furniture	50 0 0	
Fuel	35 0 0	
Light	35 0 0	
Miscellaneous House-expenses	50 0 0	
Stationery	25 0 0	
Miscellaneous Printing (Abstracts)	30 0 0	
Tea for Meetings	20 0 0	
		305 0 0
Salaries and Wages :		
Assistant-Secretary	200 0 0	
Clerk	120 0 0	
Assistant in Library and Museum	52 0 0	
Porter	90 0 0	
Housemaid	40 0 0	
Occasional Attendants	20 0 0	
Collector	20 0 0	
		542 0 0
Library : Ordinary Expenditure	50 0 0	
Special Expenditure	100 0 0	
		150 0 0
Museum : Ordinary Expenditure		50 0 0
Diagrams at Meetings		10 0 0
Miscellaneous Scientific Expenditure		70 0 0
Publications : Quarterly Journal	550 0 0	
" Transactions	10 0 0	
" Geological Map	50 0 0	
		610 0 0
		£1737 0 0
Balance in favour of the Society		19 3 4
		£1755 3 4

Income and Expenditure during the

INCOME.

	£	s.	d.	£	s.	d.
Balance at Banker's, and at Messrs. Longman's, January 1, 1862				192	6	1
Balance in Clerk's hands				19	18	11
Compositions received, 1862				215	5	0
Arrears of Admission-fees				44	2	0
Arrears of Annual Contributions				40	19	0
Admission-fees for 1862				264	12	0
Annual Contributions for 1862, viz.—						
224 Resident Fellows	£660	19	6			
44 Non-Resident Fellows	69	6	0			
				730	5	6
Dividends on Consols				132	4	4
Publications:						
Longman and Co., for Sale of Journal in 1861	60	9	4			
Sale of Transactions	9	6	3			
Sale of Journal, Vols. 1–6	6	16	2			
" Vols. 7–12	13	12	0			
" Vols. 13–15	24	17	10			
" Vol. 16	33	7	4			
" Vol. 17	62	3	4			
" Vol. 18*	106	7	9			
Sale of Geological Map		6	0			
Sale of Library-catalogues	1	8	0			
Sale of Ormerod's Index	1	16	0			
				320	10	0
				£1960	2	10

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

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

Feb. 3, 1863.

	£	s.	d.
* Due from Messrs. Longman and Co., in addition to the above, on Journal, Vol. XVIII., &c.	£47	14	7
Due from Fellows for Journal-subscription	50	0	0
Balance due from Bequest-fund on account of expenditure on Map, Library, and Museum	130	7	3
	£228	1	10

Year ending December 31st, 1862.

EXPENDITURE.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	31	2	4			
Fire-insurance	3	0	0			
House-repairs	12	18	3			
Fuel	30	14	0			
Light	32	14	7			
Miscellaneous House-expenditure	72	0	11			
Stationery	19	15	9			
Miscellaneous Printing	41	1	2			
Tea for Meetings	18	19	1			
				262	6	1
Salaries and Wages:						
Assistant-Secretary	169	10	9			
Clerk	90	0	0			
Assistants in Library and Museum	103	2	0			
Porter	90	0	0			
Housemaid	40	0	0			
Occasional attendants	21	0	6			
Collector	29	16	9			
				543	10	0
Library				88	19	7
Museum				5	18	6
Diagrams at Meetings				3	10	0
Miscellaneous Scientific Expenses, including Postages				46	2	0
Publications:						
Geological Map	7	0	0			
Transactions	7	4	11			
Proceedings and Abstracts	7	15	6			
Journal, Vols. VII.–XII.	1	6	9			
„ Vols. XIII.–XV.		18	9			
„ Vol. XVI.		14	6			
„ Vol. XVII.	2	19	11			
„ Vol. XVIII.	468	13	2*			
				496	13	6
Balance at Banker's, Dec. 31, 1862				490	14	10
Balance in Clerk's hands				22	8	4
				£1960	2	10

* Since making up this balance-sheet, an account from Mr. W. West of £72 15*s.* 3*d.* for lithograph-printing connected with the Journal (vol. xviii.) has been received. This increases the cost of that volume to £541 8*s.* 5*d.*, and reduces the surplus on the year to £227 2*s.* 9*d.*, and the cash-balance to be brought forward to £440 7*s.* 9*d.*—J. P.

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

20TH FEBRUARY, 1863.

AWARD OF THE WOLLASTON MEDAL.

AFTER the Reports of the Council and the Committees had been read, the President, Professor A. C. RAMSAY, delivered to Mr. HORNER the Wollaston Medal, awarded to Professor GUSTAV BISCHOF, of Bonn, addressing him as follows:—

Mr. HORNER,—It is now my pleasing duty to place in your hands the Wollaston Medal, and to request that you will cause it to be conveyed to our distinguished Foreign Member, Professor Gustav Bischof, of Bonn, in testimony of the high esteem in which the Fellows of the Geological Society of London hold his services to geology, more especially as shown in his work entitled 'Lehrbuch der chemischen und physikalischen Geologie'*—a book known and valued by the physical geologists of the whole world, and which, as the first great work on the subject, now renders, and in future times will still render, the name of Bischof classical in geology.

Mr. HORNER replied as follows:—

Mr. PRESIDENT,—It will give me much pleasure to forward this Medal to my old and distinguished friend, as an honour so well merited by long and great services rendered to an important department of our science. It is now more than thirty years since I had the advantage of becoming personally acquainted with Professor Bischof, during a long residence at Bonn. He was then actively engaged in those observations in the field, and experiments in his laboratory, by which, through the labours of many years, he has thrown so much light on chemical agencies concerned in the formation of mineral substances, in the phenomena and products of volcanos, and in filling mineral veins. It was about that time that he

* A translation of this work has been published by the Cavendish Society, under the title 'Elements of Chemical and Physical Geology,' 1854–59.

published his observations on the emanations of carbonic acid gas in the district of the Eifel and adjoining lands, and his treatises on hot and thermal springs and on a natural history of volcanos. In later years he has shown how all theories on metamorphism, and how the justice of the application of that term, must be tested by the strict laws of chemical action; and he is constantly referred to as an authority by those whose attention is directed to that most obscure and most difficult subject.

Award of the Wollaston Donation-fund.

The President next addressed Sir Roderick Murchison, as the representative of Professor Senft, as follows:—

Sir Roderick Murchison,—Into your hands I now deliver the balance of the Wollaston Fund, and the diploma of our Society to that effect, with the request that you will cause them to be conveyed to your old and valued friend Professor Ferdinand Senft, of Eisenach, with the assurance that the Geological Society of London have specially conferred this honour upon him to testify their sense of the value of his work in the difficult subject of the classification of rocks, as shown in his late publication entitled 'Classification und Beschreibung der Felsarten,' and also in the hope that it may prove useful in enabling him still further to prosecute his important researches.

Sir Roderick replied in the following manner:—

Mr. President,—You have well brought forward the main grounds on which the Council has awarded the Wollaston Fund to Professor Senft. On my own part I beg to say that this award has given to me, and all my associates who are acquainted with that excellent man, the most sincere pleasure. From visiting, accompanied by himself, the environs of his residence at Eisenach, some of us have formed a true admiration of his labours as a field-geologist, as well as of his powers as an author of valuable works on classification.

As Dr. Senft obtains only a very small pecuniary requital for his zealous labours in teaching a large school, the pupils of which receive good lessons from him in our science, our assistance, small as it is, will, I know, be useful in enabling him to carry out with increased vigour his scientific researches, the last of which is a work of deep interest to those who are occupied with the study of the recent changes on the surface of the globe, and is entitled 'Die Humus-, Marsch-, Torf- und Limonitbildungen, als Erzeugungsmittel neuer Erdrindelagen,' or an inquiry into the nature and origin of peat- and turf-accumulations, and their relations to the newer geological formations.

As this donation is accompanied by a diploma, signed by you, Sir, as our President, my friend Dr. Senft will, I am sure, consider that by this act we confer an honour upon him which, I feel confident, he will highly value and most gratefully acknowledge.

THE ANNIVERSARY ADDRESS OF THE PRESIDENT,

Professor A. C. Ramsay, F.R.S., &c.

It has been a frequent custom with the Presidents of this Society to pass in review the principal memoirs that have been published during their years of office, thus giving a sketch of the progress of the science during that period. I would willingly follow this useful practice, were it not that the want of leisure induces me to avail myself of that easier course which some of our Presidents have adopted, namely, to expound what they considered the best view of an important or favourite subject; and, in doing so, those who listen to or read addresses may probably see reason to congratulate themselves that the method I adopt is one reason why my observations will be brief. But first it is my duty to read the following obituary notices, some of which refer to gentlemen who were among our most distinguished foreign Members.

Richard Trench, son of the Very Reverend the Dean of Westminster, was born at Botley, in Hampshire, on February 18, 1836. He received his early education at Rugby, and was afterwards entered at Trinity College, Cambridge, where he took his degree of B.A., and where, in attendance on the lectures of Professor Sedgwick, he first acquired a taste for geology. In the year 1858 he was appointed one of the Assistant-Geologists on the Geological Survey of Great Britain, and in the following year he was elected a Fellow of this Society. During the two years he remained on the British Survey, he was employed surveying the Oolitic strata near Banbury, and the Eocene beds on and around Bagshot Heath, gaining and retaining the esteem and love of his colleagues by his intelligence and zeal, and the manly frankness, gentleness, and heartiness of his disposition. When, in 1860, he left us to join the Geological Survey of India, there was no one of his colleagues who did not part from him with unwillingness; and the news of his early death was received with unfeigned sorrow. On the Geological Survey we still often speak of his pleasant ways, and regret that one who promised well sunk under a rapid illness ere there was time for that promise to be fulfilled. He died on the 27th of May, 1861, at Calcutta, aged twenty-five.

Dr. Carl Cæsar von Leonhard, a Privy Councillor, and for many years a Professor in the University of Heidelberg, was born in 1779, at Rumpenheim, near Hanau. In early life, after studying at Marburg and at Göttingen, he was attached to the public service; but a strong predilection for the natural sciences led him to change his career, and devote himself exclusively to their furtherance. In the first years of this century he was labouring in the field of mineralogical literature, and published at Dresden, in 1805–10, his useful manual ‘Handbuch einer allgemeinen topographischen Mineralogie’; whilst a few years later he printed, with Selb, a volume of mineralogical studies (Nürnberg, 1812).

In 1816 he was appointed Professor at Munich, and received the honour of being elected into the Academy of that place. In conjunction with Kopp, he then published another work on mineralogy, 'Propädeutik der Mineralogie,' Frankfort, 1817; and soon after his appointment to the Professorship at Heidelberg, in 1818, he turned his attention more fully to geological subjects, and wrote at intervals a series of instructive works which have exercised no little influence on the studies and thoughts of the young, especially in German Universities. The 'Charakteristik der Felsarten,' 1823, was in its time a very valuable contribution, as was also, in the unsettled state of opinion on the basaltic rocks, his work entitled 'Die Basalt-Gebilde in ihren Beziehungen zu normalen und abnormalen Felsmassen,' 1823.

His 'Lehrbuch der Geognosie und Geologie,' 1835, made its way to all parts of Germany; the 'Handbuch der Oryktognosie' also passed through several editions; and his more popular works on Geology and the Mineral Kingdom have been largely circulated and translated into foreign languages.

Meanwhile, from 1807 to 1830 as sole editor, and in conjunction with Bronn from 1830 to the time of his death in January 1862, he edited the admirable 'Jahrbuch für Mineralogie und Geologie,' which is known throughout the scientific world as a repertory of original papers, reviews, and interesting letters from some of the most prominent *savants* of Europe.

Von Leonhard's services as a teacher and writer were acknowledged by the diplomas and honorary titles conferred on him by many learned societies, and by numerous orders bestowed on him by his own and by foreign reigning monarchs. In 1817 he was elected a Foreign Member of this Society, and died last year at Heidelberg, at the advanced age of eighty-three.

Robert Bald was born at Culross, in Perthshire, in 1776, and for a long time occupied a high position as a mining engineer. In 1817 he became a Fellow of the Royal Society of Edinburgh. He was also one of the original non-resident members of the Wernerian Society, and contributed to its memoirs. One of these papers was "On the Coal-formation of Clackmannanshire," which was read at three successive meetings in 1809–10. Besides an account of the Coal-field, it contains a careful description of the Boulder-clay and alluvial deposits of the country. In 1819 he read another remarkable paper on the same district, showing the effect of a series of faults by which the Coal-measure strata are depressed to the south between the Ochil Hills and the sea. In 1821 he read a paper before the Wernerian Society, entitled "Notices regarding the Fossil Elephant of Scotland," in which he described the discovery of a tusk in a cutting in Boulder-clay, a few miles to the west of Edinburgh. The fossil, when found, was so fresh that one of the workmen carried it secretly to an ivory-turner, from whom it was rescued only after it had been cut into three pieces, which were in process of being converted into chessmen. This, as far as I am aware, is the earliest record of the occurrence of organic remains in the Boulder-clay of Scotland. He was also the author of various other memoirs on geological, engineering, and mining subjects, some of which were contributed to the 'Edinburgh Encyclopædia.' In 1810 he was elected an Honorary Member of this Society, and spent his last years at Alloa, where he died, in December 1861, in his eighty-sixth year.

The Rev. James Cumming, M.A., F.R.S., Professor of Chemistry, Cambridge, was born in the parish of St. James's, Westminster, October 23, 1777; and it is related by one from whom I quote, who knew him well, that as a child in arms he happened to be present at Lord George Gordon's riots. In 1797 he entered at Trinity College, where he was elected Scholar in 1800, and graduated as Tenth Wrangler in the following year. In 1803, he was elected a Fellow of his College, and Professor of Chemistry in 1815; and in 1816 he became a Fellow of the Royal and Geological Societies of London. He was a successful experimenter; and it is said that about the year 1819, when he repeated Oersted's famous magnetic experiments, he observed, "Here we have the principle of an electric telegraph." His last course of lectures was interrupted by illness in the spring of 1860, though he still continued to work in his laboratory. His chief work was a 'Manual of Electro-Dynamics' (1827), and he contributed various papers to the 'Cambridge Philosophical Transactions.' In 1819, Professor Cumming was presented to the Rectory of North Runcton, where he died, last year, in the eighty-fifth year of his age, loved and admired by all who knew him for his genuine qualities both of heart and head.

John Collis Nesbit was born at Bradford, Yorkshire, in 1819. When quite a boy, he attached himself to chemical pursuits, and at an early age was placed under the guidance of the celebrated Dr. Dalton in Manchester, where his family had gone to reside. When of age, he removed to London, and established at Kennington his School of Chemistry and Agriculture, and became well known for his lectures on agricultural chemistry. In 1845 he was elected Fellow of the Chemical and Geological Societies, and was the author of several chemical treatises. In 1848 he gave a memoir to this Society "On the Presence of Phosphoric Acid in the subordinate members of the Chalk Formation," in which he showed that on the Upper and Lower Greensand the use of artificial phosphatic manures had not proved beneficial for agricultural purposes, for this reason, that they themselves often contained a sufficiency of phosphoric acid. Indeed, he specially devoted his attention to the application of chemistry to geology, and in France he was instrumental in indicating to the French Government the localities where fossil manures could be profitably worked—a notice of which appeared in the 'Comptes Rendus,' 1857. In the same year the agricultural world recognized his labours by presenting him, through the Farmers' Club, with a valuable microscope and a service of plate. He died March 30, 1862, aged forty-three.

Dr. Heinrich G. Bronn, Councillor and Professor at the University of Heidelberg, Knight of the Grand-Ducal Order of the Lion of Baden-Zahringen, was born at Ziegelhausen, near Heidelberg, and passed the greater part of his youth at that place. In his twenty-second year he published a work on botany, of such excellence that it procured for him a prize and the degree of Doctor from the faculty of Medicine at Heidelberg. In the next ten years he zealously employed himself, while in the Mineral Office at Heidelberg, in palæontological research, treasuring up materials to be used in his later works. At this time, too, he commenced his travels, and, hammer in hand, examined the then little-known formations of Upper Italy. His geological descriptions of that country, combined with his specification of the Tertiary fossils, show his accuracy as a geologist and critical palæontologist of no common order. But his first great work was the 'Lethæa Geognostica,' published in 1835–37, which at once placed him in the foremost rank of European palæontologists of the day.

In this work he laid down the results of the observation and experience of years, giving a survey of the successive geological epochs in a manner that powerfully aided the study of our science in Germany. Its contents have since become common property, from the numerous popular works that have drawn their materials from its stores; and though, in the progress of science, the knowledge it contains has been extended and modified, it still remains one of the foundations of German stratigraphical geology.

It is needless, in this place, to enumerate all the various works of which Bronn was the author, embracing, as they do, memoirs on the geology and palæontology of the Apennines and Pyrenees, and of various districts in France and Germany; but there is one of them, 'The History of Nature' (Geschichte der Natur), which deserves especial notice. In this work, the first part of which was published in 1842, beginning at the beginning, in true German style, he first gives a brief digest of astronomical phenomena, then of chemical and physical geology, and of the state of physical geography, thus opening the general subject before proceeding to the second part, where, more completely in his own domain, he treats of the first appearance of species and their development in time and space. In one of the chapters of this work, Bronn, coinciding with Cuvier, maintains the immutability of species, allowing, at the same time, many instances of degeneracy, deformity, crossing, and possible mutation. To him such mutations merely resolved themselves into the development of races, varieties, and sub-species. Accordingly, he was directly opposed to the ideas of Lamarck and Geoffroy St. Hilaire, looking, as he then did, upon each species as a direct act of creation. The third part of the 'History of Nature' includes the "Index (Part I. Nomenclator Palæontologicus, Part II. Enumerator Palæontologicus) Palæontologicus," published in conjunction with H. von Meyer and Göppert. By far the greater part of this work was executed by Bronn; and it must have required no ordinary amount of enthusiastic steadfastness of purpose to execute a labour involving the systematic reduction of all the lists of fossils published in works in many languages that dealt with geological and palæontological subjects. Not, however, a thankless task; for the book is in the hands of every geologist—even though, with all his sifting, it was impossible to avoid multiplying the apparent number of species, which, in different books and in different countries, went by different names. This record of scientific labour was recognized by the Scientific Society of Haarlem, which awarded to Bronn a prize-medal. What is still more important, it received the universal approval of geologists.

In a later work, on the 'Laws of Development of the Organic World' (1858), he again reverted to the questions discussed in the 'History of Nature.' Reasoning on the entrance, distribution, and grades of life in the various formations, he arrived at the result that there has been a gradual development from imperfect to more perfect forms of life, modified, however, by external conditions of soil, light, temperature, food, &c., so that the organisms formed by a certain productive power only endured when capable of adapting themselves to existing conditions. This power, which he recognized as a means for the continuous production of individual and original species, was, according to him, affected by the steady increase of dry land, which helped to vary the conditions of existence so as to favour a various and progressive organization. On the whole, then, the later opinions of Bronn with regard to the development of life seem to have been of a mixed character (now not uncommon among palæontologists since the publication of Darwin's great work), which, while it allows a variation of species so excessive that it may even result in the production of new genera, says, "Hitherto shalt thou come, and no further." When leaders go so far, their successors are likely to go beyond. Notwithstanding these differences of opinion, Bronn executed the first German translation of Darwin's work on the 'Origin of Species'; and, from personal intercourse with my late esteemed friend, I can testify to his admiration of the wide range of knowledge, power of observation, and logical reasoning of the English philosopher.

Bronn's last work was 'The Classes and Orders of the Animal Kingdom' ('Klassen und Ordnungen des Thierreiches'), in which palæontology and modern zoology are combined in one system of natural history. It was interrupted by his sudden death on the 5th of July, 1862, at the age of sixty-two.

In 1851 Bronn was elected a Foreign Member of the Geological Society, and in 1861 he was awarded the Wollaston Medal. Every one who enjoyed the privilege of his acquaintance will remember his amiability, earnestness, and candour. I, for one, shall never forget the kindness with which he received a wandering geologist, and, beguiling the time with pleasant conversation, showed him the geological peculiarities of the neighbourhood of Heidelberg.

Bertrand de Doue (Jacques Mathieu) was born on the 23rd of October, 1776, at Le Puy Cantal, in the old province of Velay.

His father, who destined him for his successor in commerce, sent him to England, where, having passed three years at school in

Birmingham, he returned to his own country, and, without neglecting his commercial career, he took a gratuitous part in many public offices, thus rendering important services to his native town during more than half a century. Science had always for him lively attractions, and, notwithstanding his public duties, he successfully cultivated several sciences—the theory and practice of agriculture, archæology, mathematics, and especially meteorology and geology, in both of which he made important observations.

The geological description of the neighbourhood of Puy, in Velay, which he published in 1823, made known to geologists points of the highest interest in the history of volcanic phenomena, so characteristic of that part of France. A number of facts, all new at the time, were then observed by him, with rare penetration, and described with a clearness, precision, and elegance which make his work still classical in geology. He was also the author of a memoir on the fossil bones of Saint-Privat-d'Allier and the basaltic district in which they were found, published in 1829 in the 'Annals of the Agricultural Society of Puy' and in Brewster's 'Journal of Science.' At the time of his death he was engaged upon a new edition of the former work.

His power of observation was not less manifest in his meteorological studies. During a long series of years he observed the currents of wind both on the surface of the earth and in the region of the clouds, and he detected in their respective directions a constant relation which he entitled the law of *interversion.*

Thus, by the force of native genius alone, Bertrand de Doue rose to distinction, and, among other honours, became President of the Society of Agriculture, Sciences, Arts, and Commerce of Puy. In 1828 he was elected a Foreign Member of this Society. He was as much distinguished by the excellence of his heart as of his head, and he won the affections of all who knew him by his gentleness and goodness. He died last year, aged eighty-six.

Dr. Thomas Stewart Traill was born on the 29th of October, 1781, at Kirkwall, in Orkney, of which place his father was minister. He graduated in Medicine in the University of Edinburgh; and in 1832 he was appointed to the Chair of Medical Jurisprudence, which he filled until his death. He contributed a number of mineralogical and other memoirs to the 'Transactions' and 'Proceedings' of the Royal Society of Edinburgh,—and two to this Society, published in our 'Transactions,' the first entitled "Some Observations on the Salt-mines of Cardona made during a Tour in Spain in the Summer of 1814," the second, "On Magnetic Iron-sand mixed with much Iserine, found at Seacome Ferry, in Cheshire." He was one of the oldest Fellows of our Society, having been elected in 1813. He continued his lectures to within twelve days of his death, and died at the age of eighty-one.

By the death of the Marquis of Breadalbane the sciences of mineralogy and geology have lost a true friend. Possessed of very extensive domains in Perthshire and Argyleshire, he employed skilful mineral-surveyors to examine and describe these vast Highland tracts. One of these surveys was conducted by Mr. Odernheimer, of Hesse-Cassel; and it was in consequence of the efficiency of the labours of this gentleman that he was afterwards selected to be the Surveyor of the Peel River Company in the extensive grants held by it in New South Wales. Lord Breadalbane expended very large sums in improving the machinery and in extending the subterranean works in his lead-mines of Tyndrum; and though frequently advised as to the heavy losses he was incurring, he always replied, with a noble generosity, that the works supported a large body of men and their families, and must be kept up. These works were for some time superintended by Mr. Thost, who read before the Society a short account of the mineralogical features of the Breadalbane rocks, which was published in the sixteenth volume of the Quarterly Journal. In these mineral surveys Lord Breadalbane himself took an active part, hammer in hand, and was often the first to detect the outcrop of copper-ore, and in one instance of a small portion of gold. Even when engaged in his favourite amusement of deer-stalking, he always had an eye to the varied character of the rocks, and never missed a remarkable junction. Those who, like Sir Roderick Murchison, have been his companions in the chase can testify to the truthfulness of this statement.

Whatever Lord Breadalbane intended to do, he did it thoroughly and, if occasion required, magnificently. Thus, when the Queen visited Scotland for the first time, his reception of Her Majesty at Taymouth Castle was truly royal; and again, when the Sovereign and Her lamented Consort inspected the Volunteers at Edinburgh, he brought thither such a body of followers that they were considered the finest and most stalwart men of that splendid review. In every sense of the word Lord Breadalbane was a great nobleman. Having for many years served the Queen as Lord Chamberlain, he was as highly esteemed by Her Majesty and Her Consort as he was beloved by his associates for his fine social qualities. His unbounded hospitality will long be remembered by many a foreigner, as well as by crowds of our countrymen of all classes.

Though he made no pretensions to science, he delighted in surrounding himself with its leading cultivators; and he earned the praise of naturalists by his endeavours to introduce the animals of other climes, including the Llama of South America, which he conceived might be useful in Britain. To him also we owe the re-introduction of the great Capercailzie, or Cock of the Woods.

In the year 1840 he was chosen to preside over the Meeting of the British Association at Glasgow; and no one who was present can forget the success of that vast gathering.

All those persons who knew him well can affirm that he was as honest and patriotic as he was straightforward and high-minded in his career through life. Sincere in his attachments, he was naturally so deeply affected by the loss of his accomplished wife, in August 1861, that from that moment he never recovered his former elasticity of spirit. So, after arranging all his affairs and putting his house in order, as if he were preparing for the great change, he went abroad in the autumn of last year, and, after trying a few palliative remedies in the waters of Germany, he died, at Lausanne, on the 8th of November, in the 67th year of his age.

I propose now to discuss the

Breaks in Succession of the British Palæozoic Strata.

By *breaks in succession* I understand those physical interruptions in stratification marked by the unconformity of an upper formation to one immediately underlying it, or, when such visible unconformity is wanting, by a sudden change in the fossils characteristic of the underlying and overlying formations; and I therefore only apply my argument to those cases in which the upper formation is next in time to that which underlies it, according to our present knowledge of the order of succession.

In these remarks I lay no claim to originality for the facts recorded, which are part of the common stock of knowledge of geologists; but I am not aware that, in any special memoir, they have ever been prominently classified. The train of reasoning founded thereon has also, I suppose, been floating more or less in many minds. With me it is a result of long personal knowledge of phenomena in the field, and of the memory of what I have thought, read, and learned in conversation and debate; and as, in writing what follows, I have only consulted books when my memory seemed at fault, if any one finds ideas to which he thinks he can justly lay claim, I beg he will believe I have borrowed from him.

Before launching into the subject I have only to add that the species estimated as common to any two formations are from tables compiled by myself, partly from Morris's catalogue and others in various memoirs, and partly, for the Silurian and Devonian rocks, from data furnished by Mr. Salter, and, for the Permian strata, by Mr. Davidson. It will not materially affect my argument should these estimates not be always strictly correct. For a long time palæontologists were busy generally in subdividing, but are now chiefly engaged in condensing the number of described species; and though it is to be hoped they may ultimately diminish the number of names, and though it is probable they may prove that more are common to various formations than published lists now show, yet it is probable that the mass of the species will still be considered as essentially distinct in any two formations in which I state that they are so, according to the common interpretation of the term species. But constant varieties will do quite as well for my purpose.

Laurentian Gneiss.—First, then, I begin with the more ancient rocks of the North Highlands, and in doing so I treat the order of superposition proposed by Sir Roderick Murchison as completely established; it happens that the question forms part of my argument, and I therefore take this opportunity of again bearing testimony to his correct rendering of facts which, in my opinion (and I know the ground well), only require to be seen to be believed.

The oldest-known rock in Britain is the Laurentian gneiss in the north-west of Scotland *. On this, certain strata lie which have been termed Cambrian. They are quite unmetamorphosed, and rest in the highest degree unconformably on the denuded convolutions of the intensely metamorphosed gneiss. The interval of time, therefore, that elapsed between the conclusion of the formation of the gneiss and the beginning of the deposition of the overlying conglomerate was geologically of the longest; for I believe that, in this as in other cases, 1st, the metamorphic structure was developed deep beneath the surface, and, 2nd, these rocks were upheaved, contorted, and greatly denuded before the newer strata were formed above them. Therefore, except that they occur together, there is no immediate connexion between the underlying and overlying formations; and *the vastness of the intervening denudation proves that the* interval represented by the unconformity must have been of extreme length.

The extremely metamorphic state of the Scottish Laurentian rocks makes it highly improbable that fossils should be found in them. But in a thick band of limestone in their supposed equivalents in Canada, Sir William Logan considers that he has found the remains of Corals,—an opinion in which I agree. If this be so, the "Primordial Zone," in a literal sense, vanishes; and the supposed absence of fossils in the Cambrian rocks of Scotland † may have no higher value in palæontology than the absence of organic remains in the Bunter sandstone of England.

It is also not quite certain, though it is probable, that the Cambrian rocks of Scotland are the equivalents of those of England and Wales, for this reason, that while in Wales there is perfect conformity and a gradual passage from the Cambrian rocks into the Lingula-flags, in Scotland the Lingula-flags are absent, and the equivalents of the Llandeilo beds lie quite unconformably on the Cambrian strata. Sir Roderick Murchison has drawn special attention to this unrepresented interval ‡; and, as I shall bye-and-bye show that in Caernarvonshire the Llandeilo beds are probably unconformable to the Lingula-series, it is not surprising that in Sutherland Llandeilo beds should lie unconformably on what are believed to be Cambrian strata. If so, this unconformity is closely connected, as I shall show, with the great break in the succession of species between the so-called Primordal Zone and the Llandeilo flags.

Lingula-flags.—The Lingula-flags of Wales § contain a small but well-marked assemblage of fossils, consisting, as at present known, of about 6 genera and 20 species of Trilobites ‖, 1 *Hymenocaris*, 3 Brachiopods (2 *Lingulæ* and an *Orthis*), and 1 Bryozoon (*Dictyonema*)¶.

* See Memoirs and Map by Sir Roderick Murchison and Mr. Geikie.

† As yet, they have scarcely been searched. ‡ Siluria, 2nd ed., p. 197.

§ From 5000 to 6000 ft., where thickest.

‖ *Dikelocephalus*, *Agnostus*, *Olenus* (7), *Conocephalus*, *Ellipsocephalus*, and *Paradoxides*.

¶ I omit the Annelides, as they do not affect my argument.

Tremadoc Slate.—Above the true Lingula-flags lie a set of strata long ago named by Professor Sedgwick the Tremadoc Slate; and late researches have brought to light in these beds a series of fossils which Mr. Salter has proved are mainly distinct from those of the Lingula-flags below, and of the Llandeilo and Bala beds above them. Thus 11 genera of Trilobites occur in the Tremadoc Slate, which, excepting 4* (*Dikelocephalus*, *Conocephalus*, *Olenus*, and *Agnostus*), are generically distinct from those of the Lingula-flags. The species are entirely distinct. At present the Pteropod *Theca* is first known in these beds, together with *Bellerophon*, *Conularia*, *Orthoceras*, and *Cyrtoceras*; and of all the forms not Trilobitic, *Lingula Davisii* and *L. lepis* are the only species common to the two formations.

Llandeilo and Caradoc Beds.—The community of the ordinary species in the Llandeilo and Caradoc or Bala beds induces me to treat them as one group, though it may be possible to subdivide them in the cabinet, by help chiefly of certain Trilobites, into Lower and Upper Llandeilo and Caradoc strata. The prodigious development of fossils in these rocks has no parallel in the underlying British formations,—a circumstance of great importance, especially when we consider that they are to a very great extent new generically, and almost entirely specifically. But, notwithstanding this sudden change, no visible unconformity has yet been detected where (for instance, in the neighbourhood of Ffestiniog and Tremadoc) the Lower Llandeilo beds lie directly on Tremadoc Slate. I shall, however, presently show that such an unconformity may with reason be suspected; and though it is difficult, or perhaps impossible, to separate Lingula-, Tremadoc, and Llandeilo beds (all chiefly slaty) in mapping, it is not the less evident that in these strata we have three perfectly distinct zones of organic remains, and therefore, in common terms, three distinct *formations*, each much more definitely separated by fossils from the others than, for instance, the different subdivisions of the Wenlock and Ludlow beds, each of which can be mapped.

Now all known evidence tends to prove that in Wales the Tremadoc Slate is an exceedingly local formation, and for various reasons. It is only certainly known in Merionethshire; and in Pembrokeshire, though carefully searched for by Mr. Salter, none of its fossils occur. Neither is it clearly known in Caernarvonshire; it is certainly absent in Anglesey; and in Scotland, rocks supposed to be Llandeilo flags lie quite unconformably on supposed Cambrian strata. A fragmentary formation, such as these Tremadoc beds seem to be, indicates one of three things.

1st. The formation may have been deposited over the whole area, but was subsequently disturbed, and in great part removed by denudation, before the deposition of the Llandeilo flags; or,

2nd. The Lingula-flags were partly upheaved before the deposition of the Tremadoc Slate, and only those Lingula-beds that still remained below water had Tremadoc slates deposited above them in direct succession.

* The remaining seven of these are *Angelina*, *Asaphus*, *Cheirurus*, *Ogygia*, *Ampyx*, *Psilocephalus*, and *Niobe*.

3rd. A certain area of sea-bottom had no strata deposited upon it for a long period of time.

In the first case, so large a denudation implies unconformity and a great interval between the last Tremadoc bed and the first of Llandeilo age, and we have thus a coincidence of lapse of time and change of genera and species.

In the second case, if there were *in places* direct succession between Lingula and Tremadoc beds, why, on a given horizon, does the Lingula-flag fauna disappear? And the third supposition also by no means helps us out of the difficulty of a complete change of life in those areas where the three formations occur in direct order of superposition.

The question thus arises, why are they so perfectly distinct? Though in the present state of our science we cannot clearly solve this question, I hope, ere closing this Address, to lend a little aid towards its future solution.

One point, if true, is important, and bears strongly on this question. I believe that the Llandeilo flags *must* lie as unconformably on the underlying strata in Wales as they do in Scotland; and a close analysis of the structure of the country strengthens this belief. Thus, in Merionethshire the Lingula-flags are from 5000 to 6000 feet thick; in Caernarvonshire, near Llanberris, they are only about 2000 feet thick, having, in a space of about 11 miles, lost 4000 feet in thickness, either by thinning of the whole mass or by *overlap*. The latter seems probable; for in Anglesey, and perhaps even on the Menai Straits, the Llandeilo and Bala beds lie directly on Cambrian strata, both Lingula- and Tremadoc Slates being absent. The same is the case in Ireland.

But the Caernarvonshire and Anglesey areas are so near that this sudden disappearance of all the Lingula-flags in a few miles proves an overlap so rapid that I can scarcely doubt that it implies an actual unconformity of upper on lower strata; and the lapse of stratigraphically unrepresented time thus indicated is associated, in my mind, with a total change of fauna between the Tremadoc formation and the overlying Llandeilo flags; or, in other words, the period of which we have no fossils preserved, represented by the unconformity, was so long that all the old life had become, for some reason, thoroughly remodelled before the deposition of the Llandeilo flags began.

The same kind of reasoning applies to the difference of species in the Lingula-flag and Tremadoc beds.

Llandovery or Pentamerus-beds.—The evidence of the physical and palæontological relations of the Llandovery beds to the underlying strata is in part more direct.

In North Wales, in Montgomeryshire and Merionethshire, the Lower Llandovery beds, being sandy, are easily separable from the slaty Bala beds beneath, and there is no very direct evidence of unconformity between them; but in South Wales, near Llandovery*,

* Observed and mapped by Mr. Aveline.

there is proof at Noeth-grug of a slight unconformity between them and the black slates on which they lie.

The Upper Llandovery rocks, however, behave in a very different manner. These range interruptedly from Marloes Bay in Pembrokeshire through Caermarthenshire to Builth, the Longmynd, and the typical Silurian country of Shropshire; and everywhere they rest quite unconformably on older rocks, lying sometimes on the denuded edges of the Lower Llandovery beds, sometimes on Caradoc Sandstone, and at Builth and the Longmynd on the highly contorted and denuded Llandeilo and Cambrian strata.

The lists of the Geological Survey show that about seventy species of fossils are known in the Lower and Upper Llandovery strata. These, taken together, are so distinctive that it has been proposed to elevate the strata in which they occur into a Middle Silurian series; and, at all events, their stratigraphical and palæontological relations are so important that I give the following analysis of the fossils of the Lower Llandovery beds, followed by more condensed statements of the palæontological relations of the Upper Llandovery beds and Wenlock shale.

	Wenlock, &c.	Upper Llandovery.	Lower Llandovery.	Caradoc.
Illænus Bowmanni	......	......	*	*
—— Thompsoni	......	*	*	
Calymene Blumenbachii	*	*	*	*
Orthis porcata	......	......	*	*
—— lata	......	......	*	
—— calligramma	*	*	*	*
—— perforata	*	*	*	*
—— elegantula	*	*	*	*
Atrypa crassa	......	......	*	
—— reticularis	*	*	*	
—— marginalis	*	*	*	*
Leptæna sericea	......	*	*	*
—— scissa	......	*	*	
—— transversalis	*	*	*	*
Pentamerus oblongus	......	*	*	
—— lævis	......	*	*	
—— undatus	*	*	*	
Strophomena antiquata	*	*	*	*
—— depressa	*	*	*	*
—— Pecten	*	*	*	*
Cyclonema crebristria	......	*	*	*
Eunema	......	......	*	
Turbo	......	......	*	
Murchisonia Pryceæ	......	*	*	
Bellerophon acutus	......	......	*	*
—— bilobatus	......	......	*	*
—— dilatatus	*	*	*	
Conularia	*	*	*	*
	13	20	28	16

The foregoing Table shows that, according to existing British lists, there are twenty-eight Lower Llandovery species. Of these, sixteen have survived from the prodigious numbers (if all were named, probably more than 500 species) found in the Caradoc and Bala beds; four are peculiar; twenty pass into the Upper Llandovery rocks, thirteen of which also pass into the Wenlock shale.

While therefore a fraction more than a half of its fossils are found also in Lower Silurian rocks, the disappearance of so large a proportion of Caradoc species proves a very great change of conditions. Considering the relative numbers in the two formations, it is too much to suppose that the older fauna was destroyed by the invasion of a few new species from another area, although, if the beds be conformable to each other, this is probably an obvious though not the most likely explanation. The suspicious unconformity between Caradoc and Llandovery beds in South Wales points in the direction that in reality there is a gap, due to upheaval and denudation, unrepresented by strata, between the two formations, and that on re-submergence only a few of the ancient Caradoc forms survived, to mingle with newer forms at first almost equally limited in number.

The Upper Llandovery beds have yielded as yet about sixty species, twenty of which occur in the Lower Llandovery rocks. Eight species belonging to the latter have disappeared, and only twelve Upper Llandovery forms are known in the Caradoc Sandstone.

The absolute unconformity of the Upper Llandovery beds on all below, coupled with a great change of species, is another remarkable coincidence, and is clearly connected with a lapse of unrepresented time; for the Lower Silurian strata were, in our area, in places metamorphosed, intensely contorted, upheaved, and extremely denuded before the deposition of the Upper Llandovery beds began. Such events involve the lapse of a period of time (unrepresented by strata) which it is almost impossible to exaggerate; and I believe that we see the result in the loss of old species and the appearance of new, in proportions comparable to the differences between the fossils of the newest Miocene and oldest Pliocene beds and the life of the present day. The change in this respect is, however, far less both in genera and species than that which took place between the Lingula- and Tremadoc and Llandeilo beds; and therefore, possibly, the smaller changes represent shorter periods of stratigraphically unrepresented time.

Wenlock Shale, &c.—If we now examine the relation of the Wenlock Shale to the Upper Llandovery beds, we shall find that, out of fifty-six species, twenty-eight, or one-half, pass upwards into the former, which frequently overlaps the Llandovery beds in such a manner as to leave no doubt of an unconformity that must again indicate a period of unrepresented time, after which we have the vast development of life of the undoubted Upper Silurian epoch, during which 5000 or 6000 feet of strata were deposited in a period of apparently slow and steady depression.

Furthermore it is evident, from the sandy character of most of the Llandovery strata, from the conglomeratic nature of part of the upper beds (derived from the waste of the Lower Silurian rocks), from the comparative thinness, local character, and repeated unconformities of its members, extending even to the Tarannon Shale, that they were formed during an epoch of oscillation of level, and therefore that its component parts only represent fragments of a great intermediate epoch that elapsed between the close of the deposition of the Caradoc Sandstone and the beginning of that of the Wenlock Shale.

We have now seen that in the whole Silurian series there are six very distinct sets of strata, and five stratigraphical breaks between them, as follows:—

Lingula-flags.
 Break very nearly complete both in genera and species, and probable unconformity.
Tremadoc Slate.
 Break very nearly complete both in genera and species, and probable unconformity.
Llandeilo and Caradoc beds.
 Large break, especially in species, and probable unconformity.
Lower Llandovery beds.
 Break and decided unconformity.
Upper Llandovery beds.
 Break and strong unconformity.
Wenlock Shale, &c.

Each of these breaks, in my opinion, necessarily implies a lost epoch, stratigraphically quite unrepresented in our area, and the life of which is only feebly represented in some cases by the fossils common to the underlying and overlying formations. But to this important subject I shall return when I have summed up the evidence respecting the breaks in succession in the higher members of the Palæozoic series.

Old Red Sandstone and Devonian Rocks—Some of the phenomena connected with the Devonian rocks and Old Red Sandstone are more difficult to unravel with precision than those of Silurian age, for several reasons.

1st. It is understood to be the opinion of one of our best geologists that in England the true Devonian rocks are the equivalents, in another area, of the Upper Silurian beds themselves; and this supposition is not weakened by the circumstance that in Cornwall the Devonian beds lie directly on Lower Silurian strata. Against this opinion I think we may urge, with reason, the almost total absence of the species common in the acknowledged Upper Silurian districts in this country; while in other regions, the fossils of which are almost identical with those in our Devonian beds, the strata in which these fossils occur are found lying above Upper Silurian beds, and notably in North America there is an unconformity between them, which I have seen.

2nd. Though our Devonian rocks and Old Red Sandstone are both of dates that come between the Upper Silurian and Carboniferous epochs, it by no means follows that they are *throughout* of precisely the same geological age; for, while in South Wales and Shropshire the Old Red Sandstone directly succeeds and seems to pass into the Ludlow beds, the Devonian rocks in the south-west of England rest on Lower Silurian strata. Again, in our islands, not only have we few or no terms of comparison between them derivable from fossils *, but also their lithological characters are remarkably distinct†.

3rd. In the opinion of several geologists of note, our Old Red Sandstone proper ought to be broken up as a group and attached partly to the Silurian and partly to the Carboniferous series.

Under these circumstances, the remarks I venture to make must be brief for want of definite data, which can only be obtained after the areas have been carefully surveyed with the light that recent discovery has thrown on the subject, and with the aid of new and better topographical maps.

These areas for the Old Red Sandstone are England and Wales, Scotland, and the south of Ireland, and Devon and Cornwall for the Devonian rocks.

In Shropshire and in neighbouring districts in South Wales there is no sign of unconformity, nor any sudden break between the Ludlow rocks and the Old Red Sandstone. On the contrary, they pass into each other, this passage being accompanied by a rapid but not quite sudden disappearance of the uppermost Silurian fossils, in a manner that suggests, not that there was any disturbance of the strata, accompanied by unconformity, but rather that, by some lesser but still broad change in physical geography, the succeeding conditions were in some manner rendered adverse to a plentiful Silurian life ‡.

Again, when we rise to the top of the Old Red Sandstone round the Forest of Dean and the greater part of the South Wales coal-fields, we find that there is no sign of absolute unconformity between it and the Carboniferous series, although in Pembrokeshire the limestone does creep across the Old Red Sandstone in a manner suggestive of overlap rather than of break and unconformity. If then there be perfect conformity, through the intervening Old Red Sandstone, between the Upper Silurian and Carboniferous Rocks, how did it happen that the life of the two periods was so perfectly distinct?

1st. The old reply would have been that the Silurian life was destroyed at the commencement of the Old Red Sandstone epoch, and that bye-and-bye, above the same area, the Carboniferous epoch was ushered in by a special and completely new creation. But the idea that special faunas were created and annihilated periodically *en masse* has so long ceased to be the creed of most English geolo-

* In Russia, however, Devonian fossils and Old Red Sandstone Fishes are said, by Sir R. I. Murchison, to occur in the same bed.

† In North America the Old Red Sandstone of the Catskill Mountains lies above the Devonian rocks; but perhaps this only represents our Upper Plant-bearing Old Red Sandstone.

‡ See Sir R. I. Murchison's 'Siluria,' and Sir H. De la Beche on the "Formation of the Rocks in South Wales," &c., Memoirs of the Geological Survey, vol. i. p. 51.

gists that I need not argue the question, especially with those who understand the details of the intermediate Devonian fauna.

2nd. Some one geologically quite as heterodox, in the modern reading of the term, may declare that when the Silurian life was driven out of this area, it is possible that it may have continued to live elsewhere as late as our Carboniferous epoch; but when the latter began, it so happened that our area was repeopled, not from a Silurian district, but from some other region, where life of a Carboniferous type was rife; and this kind of argument has frequently been enforced by the statement that, if the modern Australian life were fossilized, we might mistake it for that of part of the Oolitic epoch *.

Such a statement is most difficult to deal with in the present state of the science; for the arguments against it can scarcely be reduced to demonstration, and instinctive feeling must not be mistaken for truth. If it be true indeed that, "for anything geology or palæontology are able to show to the contrary, a Devonian fauna and flora in the British Islands may have been contemporaneous with Silurian life in North America, and a Carboniferous fauna and flora in Africa," there will, in the opinion of some, be a risk that the very foundations of geological orthodoxy are so sapped and shaken that the whole column must tumble about our ears, if that column be based upon a doctrine of palæontological succession, which, as now understood, has thus become "a mockery, a delusion, and a snare." I shall return to the question towards the close of this Address, merely at present remarking that the well-known Australian case vanishes, when examined, into the region of loose generalization; for geology and palæontology deal chiefly with sea-bottoms, and if we compare that of the Australian sea with those of Oolitic age, we shall find that, though the former holds *Trigonia*, *Lingula*, *Terebratula*, and Cestraciont Sharks, yet these form but a very small percentage of a vast fauna, easily distinguishable as of late Tertiary, that is to say, of modern type. If fossilized, in fact, there would be no more danger of our confounding an existing Australian and an Oolitic period because of the *Trigonia*, *Terebratula*, &c. of the former, than there is of confounding an Oolite and a Carboniferous formation because of the *Terebratulæ*, the *Rhynchonellæ*, the *Spiriferæ*, and the *Nautili* in both.

3rd. It may be that mere time had effected the change in species and genera *in other areas*, during the period in which the Old Red Sandstone was deposited under conditions locally unfavourable to life, such duration of time being much enhanced, if it can be proved that the Old Red Sandstone consists of two or more unconformable members.

That the Old Red Sandstone of Shropshire and Wales was not deposited in an area of general and unbroken depression is almost, if not quite, demonstrable; and if so, in this case change of life is

* I use this argument here at random. It is equally applicable to every other case of geological superposition and succession of life, but it is needless to repeat it in each instance.

connected, as usual, with breaks in stratigraphical succession. It was long ago stated, by Sir Henry De la Beche, that the upper sandy and conglomeratic part of the Old Red Sandstone in Wales overlaps, westward, the lower marly portion, or, in other words, that the beds which seem to pass into the Carboniferous rocks overlap those strata which seem to pass into the Ludlow beds. Though he does not seem to have considered this worthy of mapping, it now, in conjunction with other information, seems to indicate actual unconformity between the two halves of the Old Red Sandstone—that is to say, a complete break in succession.

In the south-west of Ireland a physical break of this kind has been described by Mr. Jukes, where, at the base of the so-called Old Red Sandstone, from 7000 to 10,000 feet of red beds adhere conformably, or nearly conformably, to the Ludlow rocks, and from 3000 to 4000 feet lie upon these beds as unconformably as it is possible for one set of beds to lie on another, and so pass regularly up into the Carboniferous Limestone. Here, therefore, is an enormous lapse of time, of which there is no stratigraphical representative known in Ireland ; for the Silurian rocks and the unconformable lower portion of the so-called Old Red Sandstone were upheaved and denuded in the most extreme manner before the deposition of the upper part, and neither in fossils nor in physical relations is there any connexion between them.

In Scotland also there is still more ample evidence of stratigraphical breaks during the deposition of rocks that have all been massed as Old Red Sandstone.

In Caithness the lowest beds lie quite unconformably on Silurian gneiss, and therefore the only evidence of anything like the Shropshire beds of passage is derived from the discovery, at Ulbster, of *Pterygotus* in the lower strata under the flags—an important fact, only made known to me two days since by Sir R. I. Murchison.

In the beds next in the Caithness series (so-called Middle Devonian) several of the Fishes are of the same genera with those in the Upper Old Red Sandstone of Ireland with its Plants and *Anodon* ; which division, Mr. Jukes observes, passes conformably into the Carboniferous Limestone, and, in his opinion, forms the lowest member of the Carboniferous strata.

Further south, in Forfarshire, it has been shown that the Pterygotus-beds (supposed to be beds of passage) again occur, and that these are overlain unconformably by Upper beds of the Old Red Sandstone.

But recent investigations by Mr. Geikie show that it is in the Pentland and Lammermuir hills that the most perfect evidence occurs of breaks in succession. There certain red strata on the horizon of the Pterygotus-beds lie conformably on the highest recognized Ludlow rocks, and these have always, as in Ireland, been massed with the Old Red Sandstone. On these the red and yellow sandstones, bedded felstones and ashes of the Pentland hills lie in strong unconformity ; and on these again the Upper Old Red Sandstone strata (Dura Den beds ?) lie in a second strong unconformity, and pass conformably under and into the base of the Carboniferous series. The base, therefore, of this Old Red Sandstone series is, it appears, conformable to the Ludlow rocks, and the top to the Carboniferous, and there are two strong unconformities between. The geological succession is therefore singularly broken and incomplete. I agree with Mr. Jukes that the classification of the Old Red strata requires to be remodelled; but, however this may be, it is clear, from the long-continued denudations that preceded each unconformity, that enormous gaps exist in the recognized scale of British Old Red strata, lapses of unrepresented time, the results of which we partly find in changes of life.

Devonian Rocks.—Excepting that they are arranged in a given order of superposition, there is little to be said respecting the relation of the fossils to the stratigraphical relations of the Devonian rocks of the south-west of England. When, many years ago, that area was mapped, extreme analyses in geological surveying had scarcely been introduced; and in that country, consisting so largely of granite and gneiss, contorted greywacke and limestone, no one attempted on maps to split up the Devonian series into distinct subformations. So exceedingly disturbed are the strata, that without a new survey it is to this day impossible to say what unconformities may or may not exist among its members. Neither, till the country is remapped, is it possible to make out accurately the exact zoological relations of the subdivisions; and the data I now present are only approximate, being the result of an examination of Devonian lists with Mr. Salter, who placed his intimate knowledge of the ranges of palæozoic forms at my disposal.

First, then, the Devonian fossils are distinct from those of the Silurian rocks of the district—a circumstance easily accounted for when we know that they lie directly and unconformably on Lower Silurian strata.

This, therefore, makes it impossible to prove that in Devon or Cornwall the lowest Devonian rocks exist. In North America, where such beds lie directly on Upper Silurian strata, it is plain that the latter suffered extensive erosion before the deposition of the former, this physical break being accompanied by a marked break in organic succession. There is thus reason to believe that, if our Upper Silurian strata were in contact with the Lower Devonian rocks of Devon and Cornwall, the same broken relations would exist between them; for, of the several hundreds of Upper Silurian forms, it is said that only about six species occur in the Lower Devonian rocks, perhaps not more than 1 per cent. Thus, therefore, we have a zoological break, all but total, between two formations, accompanied probably by a vast lapse of time unrepresented by any strata in Devonshire, and only *possibly* represented by the so-called unfossiliferous Lower Old Red Sandstone of Ireland, Scotland, and Wales.

There being, in Mr. Salter's opinion, no marked zoological line between our Lower and Middle Devonian rocks, I have massed them, and divided the series as follows.

1. Marwood and Pilton beds = the Coomhola Grits of Mr. Jukes and Carboniferous Slate of Sir R. Griffith.

2. Upper Devonian strata.
3. Middle and Lower Devonian.

The result of an elaborate analysis from Tables prepared for the purpose is, that of known Middle and Lower Devonian fossils there are about 61 genera and 170 species; and of these about 23 species only pass into the Upper Devonian division, or about $13\frac{3}{4}$ per cent.

The Upper Devonian beds yield about 30 genera and 70 species; and of these, 24 (or about 34 per cent.) pass into the Marwood beds, which in Devonshire have heretofore given about 31 genera and 65 species, of which 14 species, or about 21 per cent., pass into the Carboniferous rocks. Judged by the imperfect data of mere percentages, it appears then that the Upper Devonian are less intimately connected with the Lower Devonian than with the Marwood beds, and that the Marwood beds are zoologically more nearly related to the Upper Devonian than to the Carboniferous strata. In the south-west of Ireland the Coomhola Grits and Carboniferous Slate pass downward into Old Red Sandstone, and upward into Carboniferous Limestone; and they are considered by Mr. Jukes either to be the lowest part of the Carboniferous series, or else to form a distinct group together with the upper half of the Irish Old Red Sandstone, which is stratigraphically quite unconnected with the lower half. Further, it must be remembered that for many years, in Devon and Cornwall, Silurian and Devonian rocks were all massed together, and called by one name. But we know that there must be an unconformity discoverable between the Lower Silurian and Devonian rocks, if properly searched for; and analogy would lead us to expect, from the strong breaks in organic succession, that the same broken stratigraphical relations—lapses of unrepresented time—must exist between the various members of the typical Devonian series, just as they certainly occur in what geologists consider their equivalents, the Old Red Sandstones of Scotland and of Ireland.

Carboniferous Series.—I have already stated that, of 65 species from the Marwood beds, only 14, or about 21 per cent., pass into the Carboniferous rocks; while, if we take the whole of the Devonian series, only 11 out of about 240 species, or rather less than 5 per cent., are common to the Devonian and Carboniferous ages.

If we now analyse the divisions of the Carboniferous series, it is not easy in Britain at present to get evidence of anything like universal unconformity of one part on another, though there are proofs of local disturbances. Thus in South Wales, Lancashire, Derbyshire, and Yorkshire, the Carboniferous series has generally been described as conformable from bottom to top. It is true that in Lancashire Mr. Hull suspects unconformity between his Middle Coal-measures and the Gannister beds, and that Mr. Marcus Scott has shown an unconformity in the Coal-measures of Coalbrook Dale. I have also myself seen the Millstone-grit resting unconformably on the Mountain-limestone of the Forest of Dean; and overlaps of Upper on Lower Carboniferous rocks take place in Scotland and almost everywhere. But in spite of these cases, in a formation like the true Coal-measures, which evinces frequent oscillation of level, it is at present difficult to connect changes of fauna with any special gap in time accompanied by extreme unconformity; for these changes may perhaps be due to mere local variations of conditions encouraging for a time the presence of special marine, estuarine, and freshwater or terrestrial faunas or floras in certain areas. The strongest positive exception to this seems to be in the rocks below and in those above the Millstone-grit (where we have at least one unconformity in Dean Forest); for the decidedly marine forms (*Brachiopoda*, &c.) of the true Coal-measures in Coalbrook Dale and elsewhere are nearly all distinct from those of the Carboniferous Limestone. The same kind of break in organic succession is found in Scotland, where, however, the coals in the Limestone-series point to a set of conditions closely resembling those that prevailed during the formation of the ordinary Coal-measures, and in that country no proof has yet been adduced of any break in the stratification.

Permian Strata.—When, however, we come to the Permian series, the proofs of a remarkable physical break are unmistakeable. The evidence of this in Britain is so well known that to bring it to recollection I have only to state that the Rothliegende lies as it were at hap-hazard on all our formations, from the Lower Silurian of Malvern to the uppermost Coal-measures of the middle and north of England. In part of the Rothliegende a few of the Plants of a very meagre flora are common to the Coal-measures; and when we come to the marl-slate and limestone, all the Fish are distinct from those of Carboniferous age. Of more than 170 genera and many more than 1000 species of Carboniferous forms of marine life, only a few survive to pass into the Permian series. Mr. Davidson is of opinion that about half the Permian *Brachiopoda* are Carboniferous species,—a much larger allowance than any one else has given. But this would only give 10 or 11 species, and, adding other forms of shells still doubtful, probably not 15 per cent. of the whole Carboniferous fauna is common to the two epochs. As in former cases, I connect this great break in the succession of species with a lapse of time in our area, stratigraphically unrepresented, during which most of the Carboniferous species died out or changed; a few survived, preserving their identity, and the others, according to Mr. Darwin's views, are modified descendants of older forms.

It is well known to some that I entertain peculiar opinions respecting the glacial origin of those boulder-beds which here and there form so large a part of the Rothliegende; and I cannot help connecting the smallness of the number of our Permian species, *and their dwarfed character*, with a cold episode in this portion of the geological record, analogous to that which seems to have produced a dwindling of life in the northern hemisphere during the newer Pliocene glacial epoch.

After this comes the great break between the Palæozoic and Mesozoic strata, a part of the subject on which I will not at present enter.

General Considerations.—If we now review the stratigraphical and palæontological relations of the British strata, from the Laurentian to the Permian rocks, we find that

From the Laurentian to the top of the Silurian rocks there are	6 physical breaks.		
In the Old Red Sandstone	2	„	„
In the Carboniferous strata, probably at least	1	„	„
Between the Carboniferous and Permian	1	„	„
	10 in all.		

Except in one case where the rocks are almost barren, these breaks are accompanied by great and remarkable changes in the number and nature of the fossils, sometimes of the genera, and always of the species. The coincidence is certain; and the question must present itself to every informed mind, Why does this arise?

Within the memory of most of us the ready answer would generally have been given, that each formation, the fossils of which are distinct from those below and above, was complete in itself, and presented a perfect view of the relics of the marine life of the world for a given period; that this life, by a distinct act of omnipotence, was suddenly extinguished, and as suddenly replaced by a universal new creation when the succeeding deposits began.

The doctrine of per-centages common to two or more formations, especially in the Tertiary strata, has so completely destroyed this old notion, that I need not argue it here.

The idea of the sudden destruction of entire faunas has again often been expressed in another form:—viz., that certain given periods were brought to an end by tremendous and universal convulsions, which were the direct means of the destruction of all or nearly all the life of the globe. Then, this temporary chaos having come to an end, a new creation and new unconformable formations were commenced with the return of order. Such opinions, common not long ago and not yet quite extinct, are founded, often unconsciously, on the assumption that the succession of known formations, and therefore of life, is altogether or nearly complete. That it did not require chaotic convulsions to destroy the old life and usher in the new, is plain from the circumstance that the Oolitic epoch in a vast area came to an end without any violent disturbance of the strata; for the Oolitic formations seem to have been quietly, and nearly horizontally raised above the water (whence the origin of the Purbeck and Wealden beds), and as quietly let down again. But the diversity of the Oolitic and Cretaceous fossils is as complete as if accompanied by violent disturbance and unconformity. The accompaniment of this diversity is *time*, so strongly expressed in the old delta, which tells of the drainage of a vast continent, followed by the swallowing up of that land by the sea. The study of the Tertiary strata has, however, been the chief means of destroying the belief in the disappearance of faunas being necessarily accompanied by sudden convulsions; and therefore the worn-out theory sinks steadily, and will shortly disappear. I need not argue it further than to indicate the cause of its deserved decline.

The modern school of geology, as I have this day argued, more and more leans to the opinion that the series of formations is anything but complete, and that many links in the chain of evidence are missing. This belief helped to establish the idea that individual species have died out and been gradually replaced, as slowly as species are now dying out and now coming in, not only in epochs represented by the various known formations, but also during those periods of unrepresented time witnessed by unconformities. This belief equally applies to the old idea of a special creation for each species, or to the views so clearly urged by Darwin; but it seems to me to have a special significance if we believe, with him, that species acted on by various influences pass slowly from one form into another, and therefore that partial or complete diversity of fossils in any two formations generally marks a greater or less interval of time.

If we now, by way of test, pass the Silurian formations in review, it is evident that they were deep-sea deposits, with the exception perhaps of part of the Llandovery beds, which were formed during repeated oscillations of level. The Upper Llandovery beds especially were, in part, formed so near shore that, in the Longmynd country, they bear almost the characters of a beach. From a consideration of these circumstances the question easily arises, What relation is there between the absolute length of time occupied during the deposition of any one of the greater Silurian formations and the time that elapsed between its close and the commencement of the formation next in succession? Take, for instance, the Caradoc or Bala beds, in which the comparative uniformity of the fauna from bottom to top shows that the strata were deposited under nearly uniform conditions in a period of slow and steady depression of the sea-bottom. But where such conditions were seriously interrupted, we find either direct evidence of unconformity or strong presumptive evidence of a break of that nature—phenomena implying a great change of physical conditions and a long lapse of time. Supposing, therefore, Mr. Darwin's hypothesis to be correct, it may be asked whether, under the changing conditions coincident with disturbance of strata, there may not have been influences at work that entailed a more rapid development of new species out of old, and of old species into new genera, than those that existed during an epoch when the conditions in a given area remained comparatively unchanged. The notion is simply this:—A change in the relative distribution of sea and land took place, so great perhaps that the creatures that inhabited one area were driven slowly from stage to stage into other latitudes, so that, under circumstances which varied with *comparative* rapidity, if it so happened that their descendants (mingled probably with species from other stocks) returned into the same area, their forms had changed entirely or in part. Or, in another possible case, frequent oscillation of level produced such frequent changes of condition that, in the end, a like result came about, the intermediate stratigraphical stages being lost.

The question has great weight; but I do not see that it is likely soon to be solved, chiefly for want of a sufficient amount of precise data. The most analogous case that occurs to me at present is that of the Drift; for there is reason to believe that all, or nearly all, the Molluscan life that immediately preceded the deposition of the glacial strata has survived very extensive physical operations which involved remarkable changes of climate, accompanied by deep submergence and re-elevation of enormous areas. Both in this case and in that of the Oolitic and Cretaceous strata formerly cited, one of the elements of the question involves great elevation and depression of wide areas, and therefore serious changes of conditions. In the older one there is no proof of any change of climatal conditions, and yet the change of life is complete; and in the latter there is the strongest evidence of extreme variation of climate without extinction of Molluscan species. Sufficient time to promote the change was perhaps present in the first case, and wanting in the second.

Contemporaneity of Strata.—I now come to another question connected with physical breaks.

It is stated that over wide European and other areas, even as far off as North America, the same kind of physical breaks occur as in the British Islands, and sometimes at what are considered to be the same points in the geological scale. The question has therefore often been raised (I have already adverted to it), Are we justified in considering formations to be altogether or approximately contemporaneous that contain the same general assemblages of fossils in areas wide apart?

The answer has sometimes been given in the negative, on the minor ground that the two ends of the same bed are not necessarily precisely contemporaneous, and on the larger issue that the existence of the same species in strata far apart proves that they are not of the same age, because it would take a long time for species that originated in one area to travel into another. The minor point presents no serious difficulty; but the larger one, which is an extension of the same line of argument, is more difficult to dispose of.

It appears to me, however, that such reasoning is in error simply because the reasoner is apt unintentionally to consider a whole formation, perhaps from 1000 to 7000 feet thick (as in the case of the Bala beds and the Hudson River group), as if it were *a bed or a thin set of beds representing a particular sea-bottom at a particular time*, whereas the Bala beds represent a great many thousands of sea-bottoms more or less regularly piled on each other very slowly. The question must therefore arise, in connexion with duration of species, whether under any circumstances the possible time, for instance, that it might have taken to transmit species from the English to the American area is likely to be comparable to the amount of time represented by the interval between the lowest and the highest Bala strata, *or even of a longer period*; for if formations commonly believed to be approximately contemporaneous are not so, then the process of transmission of a group from one area to another might be prolonged indefinitely, so that, as supposed hypothetically by Professor Huxley, a Silurian, a

Devonian, and a Carboniferous fauna might all exist in different areas at the same time. Experience, as yet, affords no clue to the rate of geographical transmission of groups of genera and species; but, in the case of a large fauna, such as that of the Caradoc or Bala beds, I incline to think that the enormous thickness of the formation represents a range in time probably vast enough within its own limits to allow (where conditions were good) of transmission, with or without some amount of modification, over very large areas, so that a strong family likeness would exist in distant regions, and some of the strata in supposed contemporaneous formations would run so many chances of being actual equivalents that the likelihood that none of them are so is reduced to a minimum. Further, if the idea put by Professor Huxley be just, it appears to me that in the piles of formations built up in Britain, on the Continent, and in America, the chances are overwhelmingly strong that in each or in some one area there might be a *recurrent fauna*,—which is not the case. To this I attach great weight.

Furthermore, many considerations, partly stated, lead me to suspect that we must look to the lapse of time unrepresented by strata, as the chief cause, or, rather, as the necessary accompaniment, of the influences that produced the great difference in species between any two formations one of which lies unconformably on the other, whether we adopt the old view of gradual extinction and replacement by special creation, or Mr. Darwin's more philosophical argument of descent with modification. In other words, believing that the causes that produced physical changes were much the same in former times as now, both in kind and intensity (speaking generally, when spread over long epochs), *then the upheaving, contorting, and dislocation of the strata, and the vast denudations they underwent before resubmergence, generally represents a period of time longer than that occupied respectively by the deposition of the formation disturbed, or of that which overlies it unconformably.*

In the present state of knowledge these things cannot be proved, but we may strongly suspect them to be probably true; and if they are so, then it follows that *the periods of time stratigraphically unrepresented during the Palæozoic epoch were much longer than those of which the various formations of that epoch bear witness*; and I throw out these suggestions in the hope that as data accumulate, and thought is expended, a true solution of the question may be arrived at.

It was my intention when I began this Address to have gone over the evidence of the same kind that applies to the Secondary and Tertiary formations, some of the problems to be solved there presenting difficulties that do not occur in the Palæozoic rocks of Britain. Time, however, will not permit me to do so; but, if I find that what I have now said is not unacceptable, I may return to the subject on a future occasion.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 5, 1862.

The following communications were read:—

1. Descriptions *of some* Fossils *from* India, *discovered by* Dr. A. Fleming, *of* Edinburgh. By Dr. L. de Koninck, F.M.G.S., Professor of Chemistry and Geology in the University of Liège.

[Plates I.–VIII.]

A memoir by my friend Mr. Davidson, in vol. xviii. p. 25 of the Quarterly Journal of the Geological Society, contains the description of the fossil *Brachiopoda* discovered in the Punjaub by Messrs. A. Fleming* and W. Purdon. The determination of these fossils could not have been confided to better hands. A great number of the species were susceptible of being identified with European and American Carboniferous species, some are new, and others do not possess the palæozoic aspect which a somewhat experienced palæontologist easily perceives among the fossils of the Carboniferous period. That which occurs in connexion with the *Brachiopoda* may be remarked likewise among the fossils of other classes which accompany them, and the description of which has been confided to me by their discoverer. Among these fossils, certain species belong to genera that have hitherto only been found in the Secondary formations, and occur principally in the lower groups of that great geological period. Such, above all, are the *Ceratites*, which appear

* See also Quart. Journ. Geol. Soc. vol. ix. p. 189.

to be tolerably abundant in a rock of the Punjaub Salt-range, and are remarkable from the fact that they are all new to science. But for this last circumstance, one might have entertained serious doubts relative to their geological position, although Dr. Fleming had ascertained by personal examination that they occurred in the same beds as those which contained the Carboniferous *Producti* and *Spiriferæ*. At all events there is still this remark to make, that the rock which contains the *Ceratites* has not shown me (at least, in relation to the specimens confided to my examination) any traces of those other Palæozoic genera. It is therefore to be desired that new observations should be brought to confirm those already made by the learned Edinburgh Doctor, who was the first to throw some light on the geological constitution of the ancient kingdom of Runjeet Sing.

The larger number of specimens that I have had at my disposal belong to Dr. Fleming, and have been deposited by him in the Calcutta Museum, while the remainder are preserved in the Museum of the Geological Society of London. Altogether there are forty-nine species; but, among these, five were in too bad a state of preservation to admit of being determined with certainty, and consequently have neither been figured nor described. The others, which form the subject of this communication, may be divided in the following manner:—

I. ANTHOZOARIA.

1. Isastræa arachnoïdea, *De Kon.*
2. Clisiophyllum Indicum, *De Kon.*
3. Lithostrotion basaltiforme, *Conyb. & Phill.*
4. Lithostrotion irregulare, *Phill.*
5. Michelinia favosa, *Goldf.*
6. Alveolites septosa?, *Fleming.*

II. ECHINODERMATA.

7. Philocrinus cometa, *De Kon.*
8. Cidaris Forbesiana, *De Kon.*

III. MOLLUSCA.

A. Bryozoa.

9. Polypora fastuosa, *De Kon.*
10. Fenestella megastoma, *De Kon.*
11. Fenestella? Sykesii, *De Kon.*
12. Retepora? lepida, *De Kon.*
13. Phyllopora? Haimeana, *De Kon.*
14. Phyllopora? cribellum, *De Kon.*

B. Lamellibranchiata.

15. Anomia Lawrenciana, *De Kon.*
16. Pecten Flemingianus, *De Kon.*
17. —— Asiaticus, *De Kon.*
18. —— crebristria, *De Kon.*
19. Solenopsis imbricata, *De Kon.*

C. Gasteropoda.

20. Dentalium Herculeum, *De Kon.*
21. Bellerophon decipiens, *De Kon.*
22. —— orientalis, *De Kon.*
23. Bellerophon Jonesianus, *De Kon.*
24. Macrocheilus depilis, *De Kon.*
25. —— avellanoïdes, *De Kon.*
26. Nerinæa?, n. sp.?

D. Cephalopoda.

27. Ceratites Flemingianus, *De Kon.*
28. —— Murchisonianus, *De Kon.*
29. —— Hauerianus, *De Kon.*
30. —— planulatus, *De Kon.*
31. —— Lyellianus, *De Kon.*
32. —— latifimbriatus, *De Kon.*
33. —— Buchianus, *De Kon.*
34. —— Davidsonianus, *De Kon.*
35. —— Lawrencianus, *De Kon.*
36. Goniatites? Gangeticus, *De Kon.*
37. Nautilus Burtini, *Galeotti.*
38. —— Flemingianus, *De Kon.*
39. Orthoceras vesiculosum, *De Kon.*
40. —— rachidium, *De Kon.*
41. —— decrescens, *De Kon.*

IV. PISCES.

42. Acrodus, n. sp., closely related to *A. lateralis*, Ag.
43. Acrodus Flemingianus, *De Kon.*
44. Saurichthys? Indicus, *De Kon.*

All the fossils sent are from the western end of the Punjaub Salt-range, and from its prolongation down the right bank of the Indus, as far as Kaffir Kote, which is a rich locality for most of the fossils.

1. Isastræa arachnoïdea, De Kon. Pl. II. fig. 2.

This coral is in subgibbous masses, whose subequal calyces are of a polygonal shape, but more often hexagonal, of small depth, and terminated by obtuse mural edges: the rays, to the number of from 28–30, are crenulated on their edges, all departing from the centre of the calyx and radiating towards the margins, where they become slightly thickened.

It will be interesting to determine by new observations whether this species really occurs in strata of the Carboniferous period, because the genus to which it belongs has not been hitherto discovered lower than the Muschelkalk.

2. Clisiophyllum Indicum, De Kon. Pl. II. fig. 4.

The shape of this coral is that of a very elongated cone, showing frequent, but slightly marked concentric interruptions, or *rugæ* of growth.

The vertical ridges or partitions are very thin, and number about 300 all round the circumference. Examined with the lens, one perceives in the interseptal cells very thin and numerous partitions, which are marked exteriorly by very fine longitudinal striæ. The floors of the chambers are numerous, and smooth in their central portions. The oval shape of the transverse section of the specimen which I have just described appears to depend on a kind of accidental malformation. The diameter is about 6 centimètres. The large number of partitions with which this species is furnished allows of its being distinguished without difficulty from all its congeners.

3. Lithostrotion basaltiforme, W. D. Conybeare and W. Phillips, Outlines of Geol. of England and Wales, 1822, p. 259.

Notwithstanding that the Indian specimen consists only of a siliceous cast, in a very indifferent state of preservation, I do not think that I can be mistaken in identifying it with the English species just mentioned.

4. Lithostrotion irregulare, Phill. Geol. of Yorkshire, 1836, vol. ii. p. 202, pl. 2. figs. 14 & 15.

This species is represented by a specimen identical in its characters with those found in the Carboniferous Limestone of Yorkshire. The diameter of the calyces is from 14 to 16 millimètres.

5. Michelinia favosa, Goldf. Petref. Germ., 1826, vol. i. p. 4, pl. 1. fig. 11.

A single specimen discovered by Dr. Fleming is identical in all its characters with those of this species from the neighbourhood of Tournay. The only and insignificant difference that it presents consists in the rather greater extent and the rather more regular disposition of the vesicular cells. The diameter of the calyces is between 4 and 10 millimètres.

6. Alveolites septosa ?, Fleming. Pl. II. fig. 1. Brit. Anim. 1828, p. 529.)

This specimen appears to me to possess all the characters of the species to which I have referred it; but as I have not had the advantage of being able to compare it with the English examples, there remains in my mind a slight doubt as to their specific identity.

7. Philocrinus cometa, De Kon. Pl. II. fig. 5.

While describing this species, I shall indicate the characters of the new genus which I am obliged to create for its reception. These characters consist chiefly in the existence of five basal plates of a quadrangular form, alternating with five rows of radial plates, to the number of two for each ray. The second plate is cuneate, and supports two series of brachial plates, also two in number; each of these, finally, giving support to two series composed of a great number of brachial plates, thus producing about twenty free arms. All the other plates are soldered one to the other, and form the calyx.

In the species which I am describing, the calyx is a little gaping, the external surface is perfectly smooth, and the arms are composed of at least fifty articulations. The surfaces of these joints or plates not being parallel to each other, it results that the dorsal or external portion of the rays appears to be ornamented by a zigzag sculpture. I could find no trace of fingers.

Philocrinus has but two radial plates, and is thus distinguished from the genera *Encrinus* and *Millericrinus*, which have three. The dimensions of the *Philocrinus cometa* are as follows:—length of the calyx 25 millimètres; diameter 24 millimètres; length of the arms 6–8 centimètres.

8. Cidaris Forbesiana, De Kon. Pl. IV. figs. 1 & 2.

I am acquainted with but seven spines of this species, which have much analogy with those of *C. Braunii*, Desor, from St. Cassian; they are tolerably large, fusiform, terminated by a rather sharp point, depressed on one side, and furnished with from sixteen to eighteen longitudinal series of small spiniform tubercles. They are rather less marked on the flattened side than on the remainder of the surface. The tubercles are often connected together by their bases, and seem then to be derived from parallel keels or longitudinal ribs. The neck of the spine is large and smooth, the milled ring or annulation does not project much, the head is short and narrow, and the articulating facet smooth. Length 5–6 centimètres; diameter 12–15 millimètres.

Among the Punjaub fossils I have met with some fragments of stems which seem to have belonged to two different species of *Poteriocrinus*, but which it has been out of my power to determine specifically. One of these specimens was accompanied by the *Productus spinulosus*, Sow., the presence of which is a proof of their Carboniferous age.

9. Polypora fastuosa, De Kon. Pl. I. fig. 4. (Description des Anim. Foss. de la Belgique, 1844, p. 7, pl. A. fig. 5.)

I have not been able to perceive any difference between the Indian specimen and those which I discovered in the Carboniferous Limestone of the environs of Ecoussinnes. A portion of the first, accidentally worn by some mechanical agency, has enabled me to see that the pores, with which its anterior surface is ornamented, served as orifices to small tubes, which are feebly incurved, have their origin on the axis of the principal branches, and diverge obliquely upwards on each side, as shown in the enlarged portion represented by the figure, 4 *a*. From the Productus-limestone of Moosakhail?

10. Fenestella megastoma, De Kon. Pl. II. fig. 3.

I am not more certain relative to the generic determination of this species than I was of the preceding one. I place it by preference in the genus *Fenestella* on account of its resemblance to the *F. crassa* of M'Coy. It is composed of rays which are subparallel with each other, and of which the visible surface (probably the posterior one) is garnished with very small longitudinal striæ, observable by means of a lens, and similar to those which ornament one of the surfaces of some other species. The principal branches bifurcate at intervals, and are connected together by means of perpendicularly disposed, transverse bars. These accessory branches have the same dimensions as those of the principal ones. The *fenestrales* so produced are longer than wide, and their shape is that of a parallelogram with rounded angles. Three radiating series have a length of 1 centimètre. This species differs from *F. crassa* by the much more shortened shape of its *fenestrales* and the distance of its principal branches.

11. Fenestella? Sykesii, De Kon. Pl. I. fig. 1.

It is with some doubt that I have placed this species in the genus *Fenestella*. I have been led to do so from the complete absence of all trace of pores and striæ on the surface of the specimen examined, although it was perfectly well preserved. This Bryozoon is fan-shaped, irregularly plaited, composed of a number of rays soldered one to the other, the direction of which is indicated solely by a feeble thickening, and especially by the series of small, circular openings which border them. The arrangement of the openings demonstrates sufficiently that the rays bifurcated once, or several times, during the development of the polyzoarium, and that this bifurcation is the principal cause of its rapid enlargement. These openings are almost all of the same size, and are a little more than half a millimètre in diameter. One may generally count seven in the breadth of a centimètre.

12. Retepora ? lepida, De Kon. Pl. I. fig. 5.

It is with some doubt that I place this species in the genus *Retepora*, because I have been unable to perceive the smallest traces of pores on the single specimen I have examined. It is not impossible that it belongs to *Fenestella* or to some other closely connected genus. It consists of a kind of very thin fan-shaped network, composed of a great number of small branches, the numerous bifurcations of which enable it to widen rapidly; these small branches, which are all alike, are externally furnished with small, undulated, longitudinal striæ, visible only by the assistance of a hand-magnifier. They are connected by means of small transverse bars, which are thinner than the branches, and almost perpendicular to them, but are rarely parallel to each other, and are perfectly smooth on their surface. The *fenestrales* produced by these intersections are almost all quadrangular, and about as high as wide. The largest are 1 millimètre wide, each way.

13. Phyllopora? Haimeana, De Kon. Pl. I. fig. 3.

The calcareous plate of this species is rather thicker than that of the following, but its shape is almost the same. The openings, with which it is covered, are much larger; they are circular, and also somewhat funnel-shaped. Their disposition is much less regularly quincuncial; one can count but 4 or 5 for every centimètre. Only a single specimen is known.

14. Phyllopora ? cribellum, De Kon. Pl. I. fig. 2.

This species is formed of a calcareous plate, irregularly undulated, very thin, and pierced with a number of small oval apertures tolerably regularly and quincuncially disposed; eight of these apertures, taken on the same line, occupy a length of 1 centimètre. The remainder of the surface is entirely smooth. I have seen but a single specimen.

15. Anomia Lawrenciana, De Kon. Pl. IV. figs. 7, 8, 9.

This is certainly one of the most curious shells brought from India by Dr. Fleming. This gentleman having expressed a desire to dedicate it to Sir H. Lawrence, Chief Commissioner of the Punjaub, who had so greatly facilitated the exploration of the Salt-range, I have hastened to comply with this wish; and the giving it this name will, at the same time, recall the period of its discovery.

As is the case with the greater number of its congeners, this species has nothing very regular in its shape. In fact, none of the three specimens that I have been able to examine resemble each other, although it is easy to recognize at first sight that they belong to the same species. In all of them the upper valve is conical; but in the first two (figs. 7 & 8) this cone is truncated, while in the third the summit is slightly inclined on one side, and recalls the shape of certain species of *Pileopsis* (fig. 9). The shell is very brilliant, and has all the appearance of that of a recent species. Its surface is covered with a great number of irregular striæ and wrinkles, produced by the successive growth of the shell. These wrinkles serve here and there as a basis for little tubes, similar to those which rise from certain *Producti*. The distribution of these tubes is rather irregular, as one may perceive by a glance at the figures. The test is laminated and extremely thin.

I have been able to examine the lower valve in a single specimen only; it is circular in form, entirely smooth, and feebly grooved in the middle. This character probably depends on the shape of the object to which the shell has been attached towards its centre. Four small, circular tubes (fig. 7 *b*) may be perceived, of a rather darker colour than the rest of the shell; they appeared to me to have been the bases of small internal tubercles.

The diameters vary too much to be indicated here; they can be easily taken from the figures, which have been drawn with the greatest care.

16. Pecten Flemingianus, De Kon.. Pl. IV. fig. 4.

This species is of medium size, longer than wide, and suboval in shape. Its surface is ornamented with a small number (8–9) of slightly marked, radiating ribs; the space between the ribs is almost entirely smooth. Nothing can be seen on it besides some lines of growth, which are hardly perceptible to the naked eye. The ears are small, triangular in shape, and their surface is smooth.

The length of the only known specimen is 16 millimètres, and the width 14 millimètres.

17. Pecten Asiaticus, De Kon. Pl. IV. fig. 6.

This species, which is much larger than the following, is a little wider than long, and slightly, but rather regularly convex. Its surface is ornamented with twelve or fifteen radiating ribs, especially apparent towards the middle of their length, but partially disappearing towards the margin. In each furrow formed by these ribs there are from three to five much thinner ribs, less regular than the principal ones, and also more marked in the lower and central parts of the valves. The lines of growth are hardly visible even by the help of a hand-magnifier. The ears are small and rectangular, and are covered with small striæ parallel with the cardinal edge. The beak is tolerably prominent. This species possesses at first sight some analogy with the *P. plicatus*, Phill.; but, upon careful examination, it is easily distinguishable by its small ribs, which are totally absent in the latter species.

The length is 4 centimètres, and the width 4½ centimètres.

18. Pecten crebristria, De Kon. Pl. IV. fig. 5.

The shape of this small *Pecten* is almost completely circular; its valves are slightly, but regularly convex. The surface is covered with a large number of small, radiating ribs, often bifurcated, of unequal thickness, and irregularly distributed upon the whole surface of the valves. The lines of growth are feebly expressed, and are only well seen with the lens. The ears are small and rectangular.

The length of the only known specimen is 16 millimètres, its breadth is 14 millimètres.

19. Solenopsis imbricata, De Kon. Pl. IV. fig. 3.

This species is transverse, and almost three times as long as wide. Its anterior side is very short, and its margin rather regularly semicircular; the posterior side is bounded by a curve, approximating to an ellipse. The ventral edge is feebly sinuated. The beaks are very small, and hardly project above the dorsal border. The surface is smooth; one may observe six or seven imbricated lamellæ parallel to the ventral edge; they have been formed by the successive growth of the shell. The valves are depressed and very shallow.

The length of the largest of the two known specimens is 17 millimètres, and the width 44 millimètres. From the Productus-limestone of Vurcha.

20. Dentalium Herculeum, De Kon. Pl. IV. figs. 10–12.

This species is remarkable on account of its great size and the considerable thickness of its shell. It has the greatest analogy with my *D. ingens* of the Carboniferous Limestone of Visé. Like that species, its surface is covered with irregular striæ of growth, and is rendered rugose by their presence; these striæ are a little oblique to the axis, and show that one edge of the aperture of the shell must have been slightly produced. They differ by the regular, conical shape, and by the greater thickness of the shell of *D. Herculeum*, as shown by the transverse sections represented in Pl. IV. figs. 10 *a* & 12 *a*, and the longitudinal section, fig. 11. The section, fig. 12 *a*, offers again another peculiarity, consisting in the presence of a very prominent longitudinal fold, which transforms the interior of the shell from a circular into a semicircular form. This shape is merely accidental, and is exhibited only by a single specimen among the seven submitted to my examination.

The largest of these specimens was 7 centimètres long, and $1\frac{1}{2}$ in diameter on the side of the aperture; but it is probable that complete specimens attained at least 15 centimètres in length.

21. Bellerophon decipiens, De Kon. Pl. III. fig. 1.

This is one of the most remarkable of all the species with which I am at present acquainted; it is a little longer than wide, and its surface is almost smooth. The dorsal band produced by the buccal sinus is very narrow, and very slightly apparent. The ribs of growth are very wide, and it would have been difficult to distinguish them had not the long exposure to atmospheric agency slightly abraded the surface of the specimen figured. By this deterioration the ribs have been distinctly separated by very narrow and shallow furrows, which one might imagine excavated by a graver, and of which the figure indicates very well the shape and direction. They number sixteen on each side, and are curved in the shape of a half-circle, in such a manner that they join again by a very acute angle to the dorsal furrow. One may conclude from this disposition that the buccal slit must have been deep, and that the lower portion of the mouth has been slightly scooped out by a very well marked sinus. There is no umbilicus, and the shell is very thick. The height of the only known specimen is 6 centimètres, its length 5½. The ribs are generally 4 millimètres long.

22. Bellerophon orientalis, De Kon. Pl. III. fig. 3.

This species is much smaller and rather less globular than the next. It is higher than wide; its surface is ornamented with small, transverse ribs of growth, produced by very fine and close striæ, and forming a tolerably acute angle with the dorsal band. This band terminates in a very narrow and shallow furrow, by which *B. orientalis* is easily distinguishable from *B. tenuifascia*, a species with a prominent band, to which it has in other characters the greatest analogy. The only specimen I have examined is 15 millimètres long by 12 millimètres wide.

23. Bellerophon Jonesianus, De Kon. Pl. III. fig. 2.

This species is globular in form, and as high as wide. When young, its surface is covered with small, transverse, imbricated ribs, produced by the successive growth of the shell, as is easily observable in the specimen represented by fig. 2 *a*, of which a portion of the last coil of the spire and the callus of the aperture have been taken off. The ribs, which on the last whorl are (in the adults) transformed into large, but slightly marked wrinkles, form an open angle with the dorsal keel, which projects very slightly, and is but 1 millimètre in breadth. The several whorls completely overlap each other; the umbilicus is nearly obsolete; the lip (*peristome*) is tolerably thick near the umbilicus, and slightly reflected. The buccal callosity is very much extended, and covers over nearly the last whorl of the shell. The test is thick, and the dorsal slit narrow and deep.

This species has a great analogy with *B. hiulcus*, from which it differs by the much narrower form and the more considerable number of its ribs of growth, as well as by the slight width and the projection of its dorsal keel.

Of eight specimens examined, the largest are 5 centimètres high, and as much wide; the opening of the mouth is about 2 centimètres high. From the coarse calcareous shale of the Productus-limestone of Chederoo.

24. Macrocheilus depilis, De Kon. Pl. VII. fig. 3.

Notwithstanding that I am acquainted with but an internal cast of this species, I have not feared to describe it, and to give to it a new name. In fact, this cast, by its elongated shape, its spiral angle, and the convexity of its whorls, differs from all its congeners at present known to me. The only specimen that I have examined is composed of four whorls, but it is probable that it originally possessed eight or nine.

Its length is 6 centimètres. The last whorl must have occupied, of itself, almost half the length of the shell. It is 3½ centimètres long, its diameter is 28 millimètres, and the spiral angle equals 39°.

25. Macrocheilus avellanoïdes, De Kon. Pl. III. fig. 4.

Shell subfusiform, with an acute spire composed of six or seven inflated whorls, which are rather flattened on the sutural side. The last whorl is very large, and occupies more than half the total length of the shell. The aperture is elongately suboval, and possesses no callosities. The surface is smooth ; the test tolerably thick, especially towards the sutures. Its spiral angle is about 70°.

Of the two specimens of this species, the one possesses a length of 3½ centimètres, and the other of 4½ centimètres. The last coil of the spire of the latter is 27 millimètres in diameter and 30 millimètres in length.

This species approximates to *M. Schlotheimi*, d'Arch., but differs from it by its spiral angle, by the length of its last whorl, and by the absence of all ornament upon its surface.

26. Nerinæa ?, n. sp. ?

Among the fossils confided to me by Dr. Fleming is the internal cast of a Gasteropod, which appears to possess the characters of *Nerinæa*, but which I am unable to determine ; none of the species described by A. d'Orbigny, M. Eudes-Deslongchamps, and others resemble it.

The Punjaub specimen possesses the last six whorls of the spire, the total length being 8 centimètres ; the diameter of the last coil is 4½ centimètres. This last has a siphon parallel to its lower edge, probably produced by a tooth of the mouth. It is besides adorned with from six to seven tubercles. The axis of the columella is very thick ; the angle produced by the spire is 25°.

It is probable that this species is not Carboniferous. The greyish-white colour of the limestone of which the cast is formed, and the crystalline nature and whitish colour of the still-adhering fragments of the shell, lead me to suppose that there is here an error to rectify, to which I therefore call the attention of Indian palæontologists.

27. Ceratites Flemingianus, De Kon. Pl. VII. fig. 1.

This magnificent species, which I dedicate to the learned gentleman to whom we are indebted for its discovery, is the largest of all those that are known up to the present time. Unfortunately, Dr. Fleming found but a fragment, representing apparently the body-chamber and the larger portion of the chamber behind it.

This shell must have been composed of spiral coils laterally compressed, with a rounded back; the length of the coils equalled about twice the height. They were feebly embracing, and their transverse section represents tolerably well the half of an ellipse, of which the great axis is equivalent to four times the length of the small one (see Pl. VII. fig. 1 *a*).

The surface is covered with a great number of transverse, irregular ribs, which are sometimes very thin, at others thicker; they are produced by the successive growth of the shell, and are crossed by small spiral ribs, which are regular and parallel, numbering about sixty on each side. The result of this disposition is, that the surface appears as if enveloped by a network composed of meshes of equal breadth, but of irregular length, depending on the size of the transverse ribs which produce them. The shape of the cells is most peculiar: the upper lateral lobe is very deep and tolerably wide, and occupies about one-fifth of the total height of the spiral coil; it is remarkable from the great number of small denticulations with which it is provided. The lower labial lobe is acutely funnel-shaped, and does not present the smallest trace of denticulations. The three saddles which connect these lobes are rounded, and present nothing peculiar. The only species of *Ceratites*, hitherto known, which bears any affinity with the one here described is the *C. parvus*, v. Buch. The transverse ribs of this last are more numerous, and the longitudinal ones are wanting. In addition to this, the conformation of the chambers is entirely dissimilar in the two species.

The entire diameter of this species is 25 centimètres (10 inches); the height of the mouth is 6½ centimètres, and the width 4 centimètres. The last spiral coil covers the preceding one to the extent of half a centimètre. This and the next species occur in a brownish-yellow sandstone, while the greater number of the following *Ceratites* were found in a rock of a calcareous nature.

28. Ceratites Murchisonianus, De Kon. Pl. VIII. fig. 1.

I am acquainted with but half the shell of this large and fine species, upon which I have not even been able to discover any traces of chambers; but these must have borne some analogy with those of the preceding species. It is probable that the only fragment known represents in itself the last air-chamber, and that it is from this cause the septa are wanting. This specimen bears evidence that the coils of the spire were slightly compressed on their sides, that their dorsal portions were rounded, that they were feebly embracing, and that they produced a large umbilicus. The surface is covered with rather large transverse ribs, which occupy only the sides of the shell, and are in no way prolonged on the back, which, seen in profile, forms a very regular curve. The ribs are not of equal width; they bifurcate or trifurcate without any order, and are eighteen in number on the specimen figured. As those near the mouth are smaller than those which precede them, it is probable that the sides of the first whorls of the spire were strongly ornamented, as may be often remarked among the Ammonites.

The fragment described possesses a diameter of 18 centimètres; the height of the last whorl is 6½ centimètres, and its thickness 5 centimètres.

29. Ceratites Hauerianus, De Kon. Pl. III. fig. 5.

This species, of which I have unfortunately met with but a single fragment among Dr. Fleming's fossils, has much resemblance to the *Goniatites Haidingeri*, v. Hauer, which may very possibly be likewise a *Ceratites*, since in the latter the chambers are extremely numerous, and composed of a great number of very narrow lobes and saddles; those that occur towards the middle of the spiral coil are a little wider than the others; they are five in number. Unfortunately the specimen is so much defaced that it is impossible for me to describe exactly the shape of the parts of its whorls, which have each eight divisions at least. The back is keeled and tolerably sharp. The thickness of the shell must have been about 2½ centimètres. The mouth, seen in front, must have had a subtriangular shape, as is shown in fig. 5 *a*.

30. Ceratites planulatus, De Kon. Pl. V. fig. 1.

This fine species, of which I have had the advantage of being able to study one complete and adult example, is distinguished from all those that follow by the angular shape of its dorsal portion. However, this shape does not exist in the young specimens, and is only produced at a certain age of the animal (which is the case also with some *Nautili* and *Ammonites*), as is demonstrated by figs. 1 *c* and 1 *d*.

The surface is almost smooth and shining, and is ornamented with fine, radiating striæ and undulations produced by the successive growth of the shell. The umbilicus, in the shape of a very widened funnel, allows the several coils of the spire of the shell, five or six in number, to be easily perceived; they mutually overlap each other at about three-fourths of their height. The number of the chambers is from 30 to 32 for each coil of the spire; the last chamber is very large, and occupies one-half of the shell. The lobes are shallow and finely crenulated; the lower lateral lobe is connected with the umbilicus by means of a sinuous curve entirely free from denticulations; the dorsal lobe is divided in two by a small elevation, very angular at the summit, and serving for the passage of the siphuncle. The saddles are rounded, and of a moderate elevation. The largest diameter of this species is 8½ centimètres, that of the umbilicus 18 millimètres; the height of the mouth is 4 centimètres, its thickness 19 millimètres, and the width of the back at the extremity of the mouth 4 millimètres. The shape of this species bears some resemblance to the *C. semipartitus*, Montf., but differs essentially from it in the shape and number of its lobes.

31. Ceratites Lyellianus, De Kon. Pl. VI. fig. 1.

This species is one of the largest among those which have been discovered by Dr. Fleming; its surface is entirely smooth, its back is rounded, and the umbilicus large. The number of its chambers must have been from eighteen to twenty. The lateral lobes are three in number, and are similar in shape; their denticulations are relatively small, and number five or six. The whorls of the spire slightly overlap each other.

The total diameter must have been about 12 centimètres in the specimen figured, that of the umbilicus 4 centimètres. The height of the last whorl is 5 centimètres.

32. Ceratites latifimbriatus, De Kon. Pl. VII. fig. 2.

Shell discoidal, with a strongly rounded back, and remarkable from the form of the denticulations of its lobes; these are generally four in number; but in examining them with a lens one distinguishes on their edges other supplementary indentations, which make each joint resemble a little tooth of *Carcharias*. The coils of the spire overlap each other from about two-fifths of their height. The surface is entirely smooth. Besides the dorsal lobe (of which I have not been able to completely observe the shape, on account of the bad state of preservation of this portion of the specimen), it possesses three other sufficiently deep lobes, all of about the same shape. The corresponding saddles are rounded, and have their sides almost parallel between the lobes. It is easily distinguishable from *C. Lawrencianus* by the absence of the auxiliary lobes. The number of the chambers must have been fifteen or sixteen for each whorl of the spire. The diameter of the shell is from 9 to 10 centimètres, that of the umbilicus is $2\frac{1}{2}$ centimètres, and the greatest thickness of the shell is 3 centimètres. From the Productus-limestone of Vurcha.

33. Ceratites Buchianus, De Kon. Pl. VI. fig. 4.

This species is so nearly related to the succeeding one that I should have willingly dispensed with it, had not its umbilicus been proportionally much larger; the spiral whorls, also, overlap each other only to the extent of about one-third, while in *C. Davidsonianus* they commence to overlap each other at three-fifths of their height. Besides this, the surface is ornamented with a tolerably large number of well-marked, radiating undulations, a character not seen in that species. The shape of the chambers is a little different, and the sinuosities of its lobes and saddles less deep than those observed in *C. Davidsonianus*. The diameter of the largest of the three specimens that have come under my notice is $5\frac{1}{2}$ centimètres, that of the umbilicus is one-third as much. From the Productus-limestone of Vurcha and Kaffir Kote.

34. Ceratites Davidsonianus, De Kon. Pl. VI. fig. 2.

This species has much affinity to the one following, but differs in its size, as well as in the shape of its chambers. It is discoid, and possesses but a small umbilicus. Its surface is smooth, and the terminal chamber very large, occupying about one-half the last whorl of the spire. Its lobes and saddles are analogous to those of *C. Lawrencianus*, but the former are much less deep, and the saddles much more rounded than in that species; and the part which is connected with the umbilicus is composed of a larger number of dentations.

Of this species I have been able to examine one perfect specimen, which is probably adult, and is but 6 centimètres in diameter. The height of the mouth is about 3 centimètres, and the width 1 centimètre. The diameter of the umbilicus is also 1 centimètre. It forms part of the series in the Museum of the Geological Society of London. From the Productus-limestone of Vurcha.

35. Ceratites Lawrencianus, De Kon. Pl. VI. fig. 3.

This fine species is remarkable on account of the form of the lobes and saddles which bound the chambers. Its general shape is that of a flattened disc whose margin is rounded. Its surface appears to have been smooth, the test not having left any trace of striæ or furrows on the internal cast, which is all I have here to describe. The spiral coils are strongly overlapping, and leave but a very small umbilicus. The dorsal lobe is very large, and divided into two by a small median saddle; it is much less deep than the lateral lobes, but its width and indentations, which are five or six in number, strongly resemble those of the last lobes; it is connected with the upper lateral lobe by a slightly elevated saddle, narrow and rather acute: the inferior lateral saddle is, on the contrary, very high, but much more wide at its base than the former, and but little elevated; it is connected with the margin of the umbilicus by seven or eight indentations, which assume the character of auxiliary lobes.

I am acquainted with no species with which this one is comparable, unless it be the *C. Davidsonianus*, which differs from it in the much more rounded shape of its saddles.

The approximate number of its chambers is about thirty; the total diameter is 10 centimètres, and that of the umbilicus 14 millimètres: the height of the last whorl of the spire is $5\frac{1}{2}$ centimètres, and its thickness about 3 centimètres; whilst the height of the preceding coil is but 28 millimètres, and its thickness 18 millimètres. The distance which separates the back of the last coil but one of the spire from that of the last is $3\frac{1}{2}$ centimètres.

36. Goniatites ? Gangeticus, De Kon. Pl. V. fig. 2.

I have placed this species among the *Goniatites* for the sole reason that I have been unable to discover any indentations on the edges of the lobes or chambers. It is highly probable that the denticulations have been destroyed by the atmospheric agencies to which the specimen had been exposed. This species is rather strongly compressed and *planorbiform*; its first spiral whorls are only half overlapped by those that succeed them. The umbilicus is wide, and its diameter is equivalent to about one-third of the entire diameter of the shell; its back is very convex, and the surface appears to have been smooth. The number of its chambers is from twenty to twenty-two; their height is about twice their width: the dorsal lobe is divided into two by a little prominent linguiform septum. The lateral lobes are narrower than the saddles which produce them; both are rounded, and in no way resemble those of Carboniferous *Goniatites*, which are almost always angular.

The specimen figured is but 4 centimètres in diameter; the height of the last spiral whorl is 16 millimètres, and the width 8 millimètres; the diameter of the umbilicus is 15 millimètres.

37. Nautilus Burtini, Galeotti. Pl. VIII. fig. 3. (Mém. couronnés de l'Acad. de Bruxelles, t. xii. pl. 4. fig. 4, p. 140.)

After comparing this *Nautilus* with some specimens of the species described by Galeotti, derived from the Eocene sands of the neighbourhood of Brussels, I have not been able to find any distinguishing character between them. It is therefore probable that the specimen figured in this memoir has not been derived from the Carboniferous system, but from some Nummulitic bed which occurs in the Punjaub. This is also Dr. Fleming's opinion, who did not find it *in situ*, but on a heap of carboniferous stones destined for road-repairs *.

38. Nautilus Flemingianus, De Kon. Pl. VIII. fig. 2.

This species is remarkable on account of the lateral tubercles with which the last whorl of its spire is furnished. If I may judge from the dimensions of the single fragment which I have been able to examine, its size must have been considerable. At first sight it presents some resemblance to the *N. tuberculatus*, Sow., but is easily distinguishable by the shape of its tubercles and by the distance of its chambers. In *N. Flemingianus* these tubercles are much elongated, and placed on alternate chambers, while in the species described by Sowerby the tubercles are more rounded at their base, forming a kind of crown round the umbilicus; they are besides more prominent, and present nothing regular in their distribution with reference to the chambers. They are very perceptible on the first whorls of the spire of the latter, but are there scarcely apparent in *N. Flemingianus*. The chambers of this species have their lateral and dorsal margins feebly sinuous, and the fragment figured shows four coils of the spire. By completing the last whorl, one is able to prove that it must have been composed of about forty chambers, and that its greatest diameter was about 19 centimètres; viewed in front, the last visible chamber presented an elevation of 6 centimètres, whilst that of the one behind it was not more than 3 centimètres in height; their width is a little greater; their shape in the same position is that of an oval, irregularly compressed on the two opposite sides (see Pl. VIII. fig. 2 *a*). The siphuncle is scarcely visible, but appears to be rather large, and is situated towards the upper third of the height. The coils of the spire do not overlap one another. From the Productus-limestone of Vurcha.

39. Orthoceras vesiculosum, De Kon.

This species is very remarkable on account of the calcareous

* The following note was found attached to the specimen:—
"This fossil was found among the débris of Carboniferous Limestone. It probably, however, has weathered out of Nummulitic limestone."

globules which its chambers contain; these globules or concretions, which appear to have been produced by small vesicles, are not very regular either in shape or number; their existence might have been considered as accidental, if several specimens had not presented the same character.

The shape of this *Orthoceras* is almost entirely cylindrical; its length must therefore have been very considerable. The external surface is completely smooth, whilst the interior of the air-chambers is rough, and as if covered with shagreen. The chambers are regular, and the distance between the septa is equivalent to, or rather more than, a fifth of the diameter of the shell. The siphuncle is very large and central: I have not been able to assure myself whether it is cylindrical or moniliform.

The principal fragment observed possesses a length of 7 centimètres, and is composed of five equidistant chambers. The diameter of the shell is 5 centimètres, while that of the siphuncle is 1½ centimètre. The test which forms the latter is about 2 millimètres thick.

40. Orthoceras rachidium, De Kon.

The specimens representing this species are deprived of their shell. The length must have been very great, the growth of the diameter having been relatively feeble during the development of the animal. The principal specimen, composed of eleven or twelve air-cells, of the uniform length of 1 centimètre, measures 12 centimètres. Its smallest diameter is 3½ centimètres, and its largest 4 centimètres. No ornament or sculpture can be seen on its surface. The siphuncle is very large, and resembles that of the *O. cochleatum*, Schl., to which this species is closely allied.

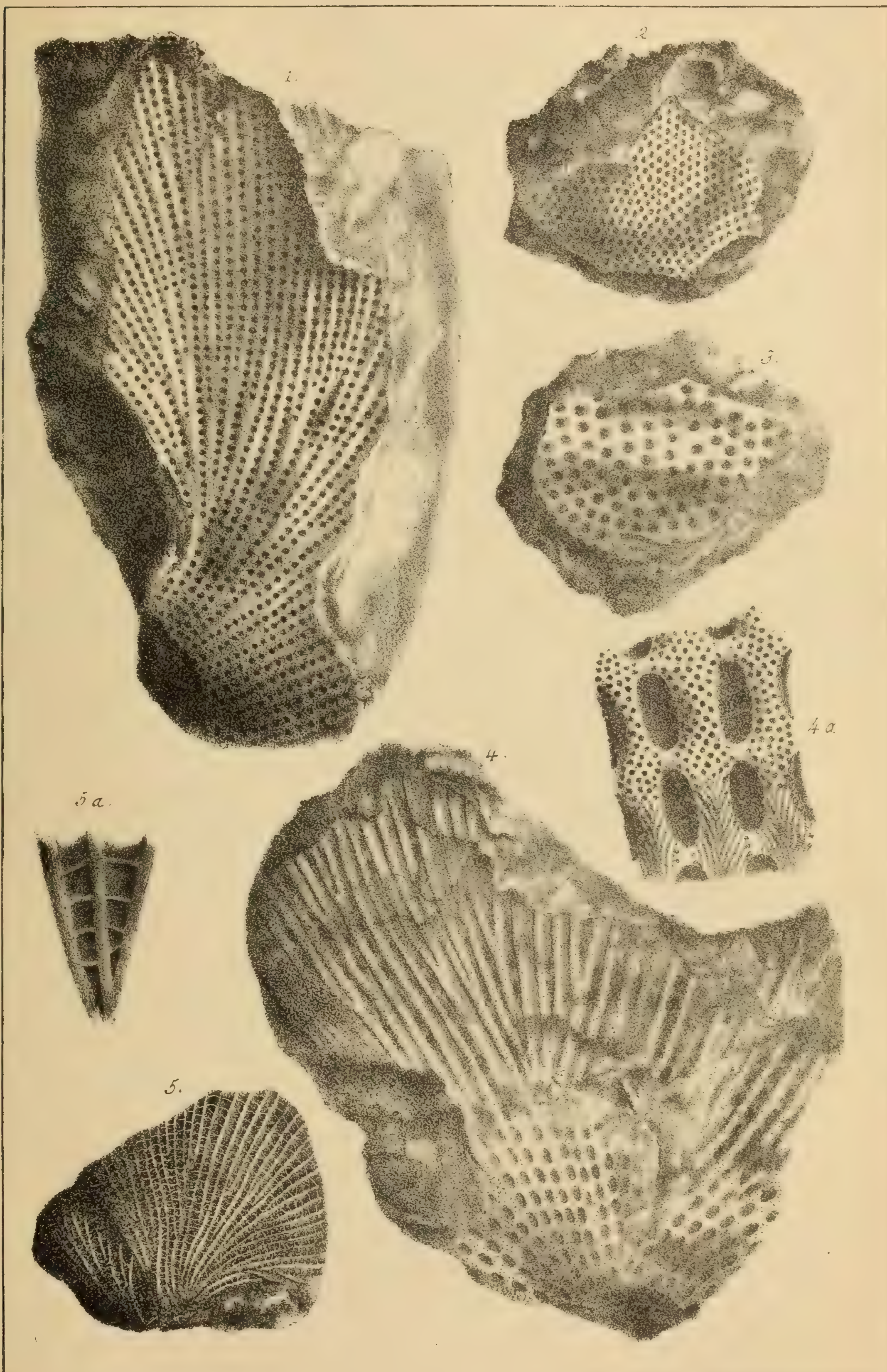
One of the specimens is accompanied by *Productus semireticulatus*, Martin; there can consequently exist no doubt as to its geological age. From the Productus-limestone of Subbee.

41. Orthoceras decrescens, De Kon. Pl. VIII. fig. 4.

Shell of a very elongated, conical shape. The internal cast alone is known; it has the surface entirely smooth, the transverse section perfectly circular, and the siphuncle central and rather narrow. The diameter of the terminal chamber is 2½ centimètres; that of the sixth chamber is 2 centimètres. The entire length of the specimen is 12 centimètres, of which the last chamber occupies eight. The five known chambers are remarkable on account of a regular decrease in their length, so that, whilst the sixth chamber is 12 millimètres in length, the fifth is but 10, and the second not more than 5. It is this conformation, which I have seen in no other species, that has suggested the name by which I have designated the one here described. From the Productus-limestone of Moosakhail.

42. Acrodus, n. sp.

This species is very closely allied to *Acrodus lateralis*, Ag. It is smaller than the one next described, of a much more elliptical shape, and less transverse at its basis. From the coarse limestone of Chederoo.



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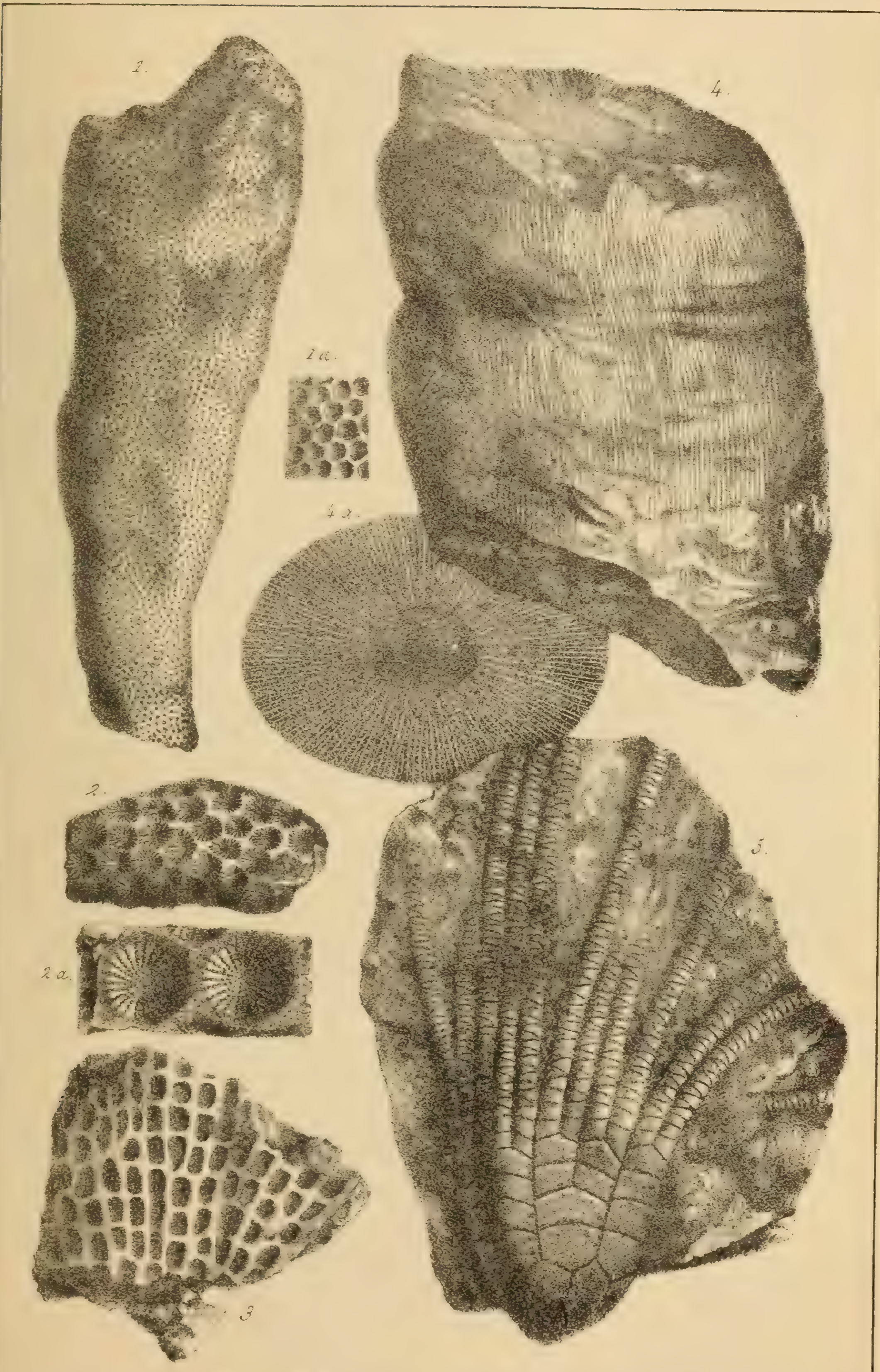

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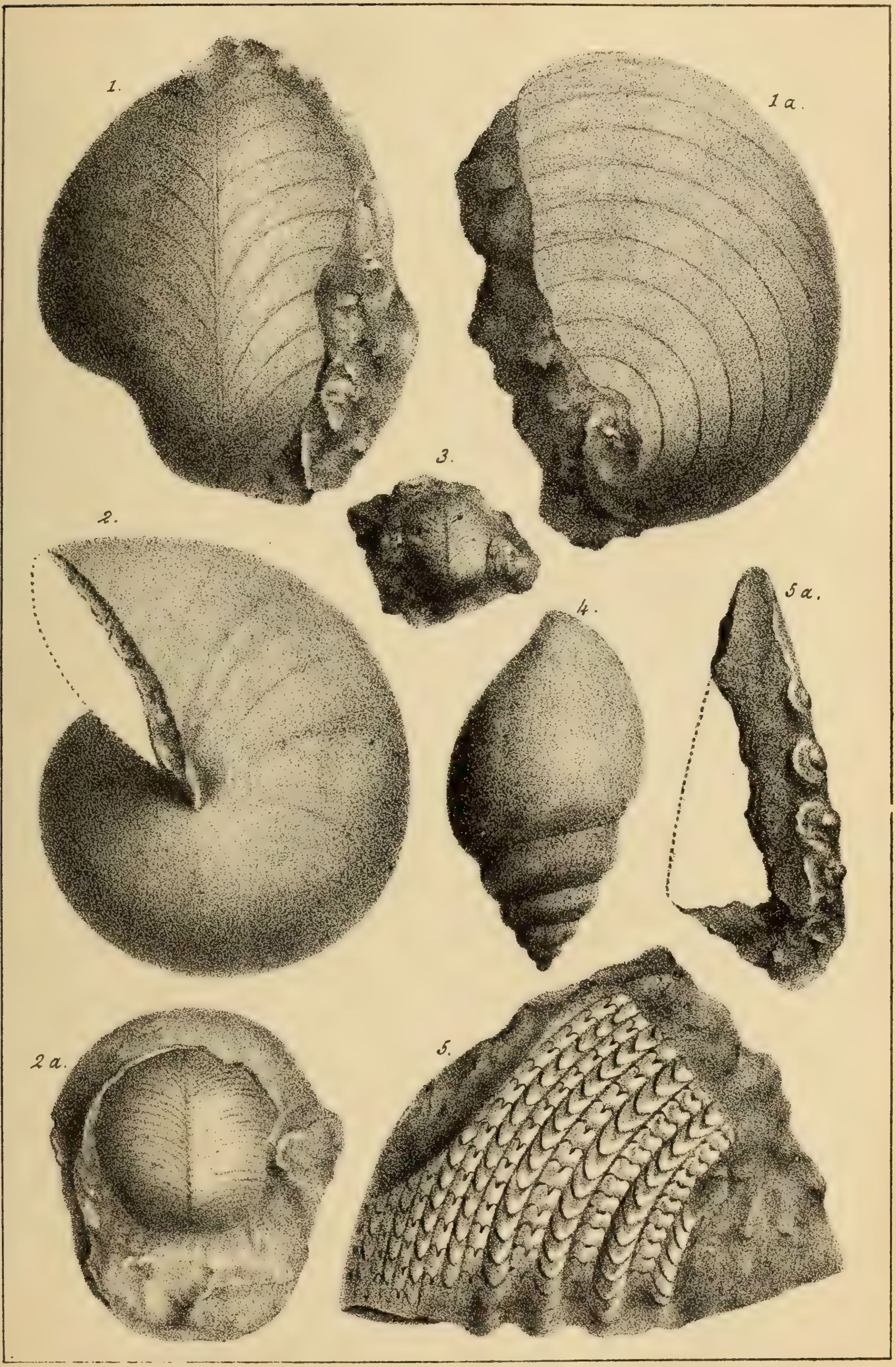

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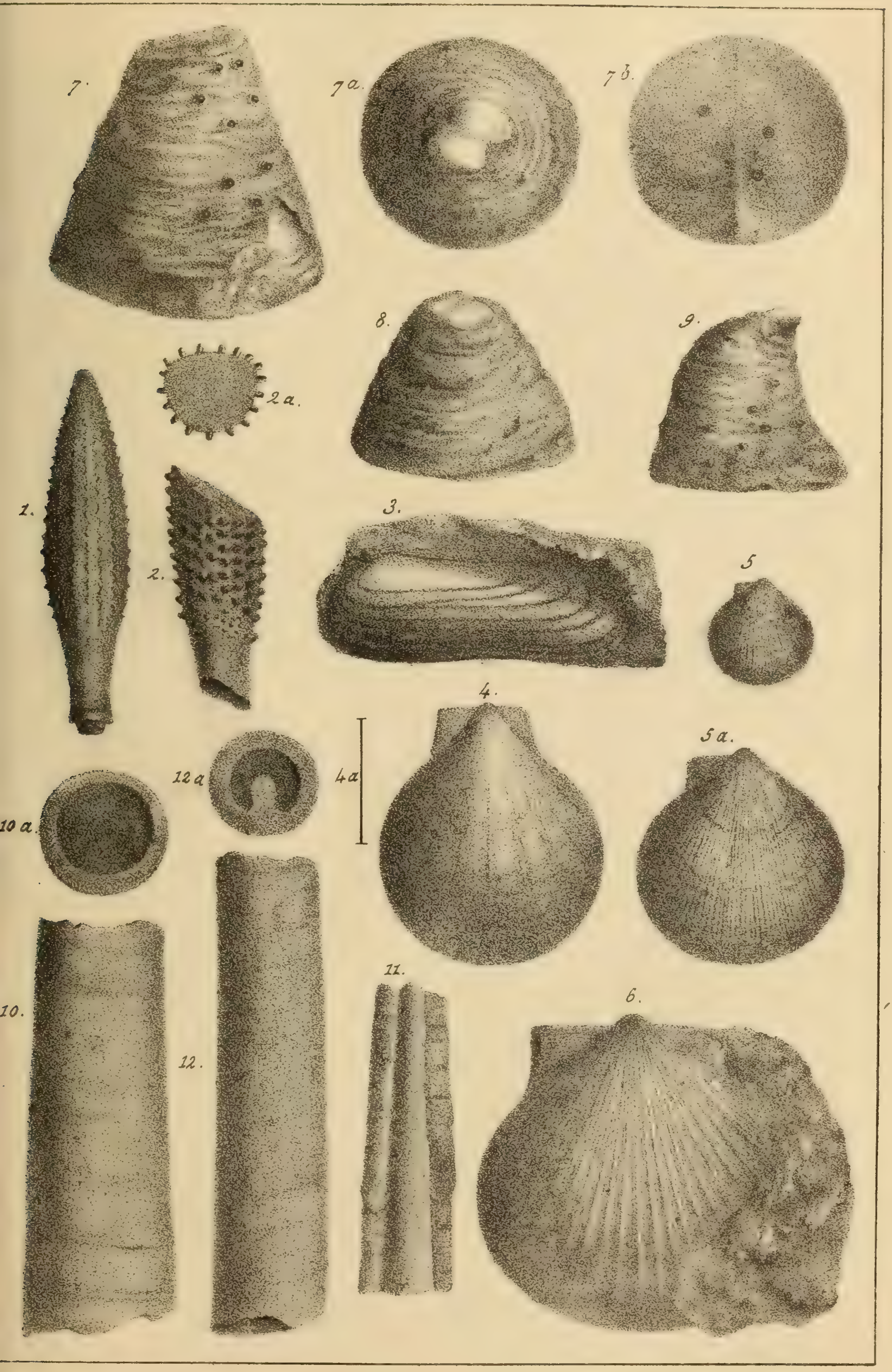

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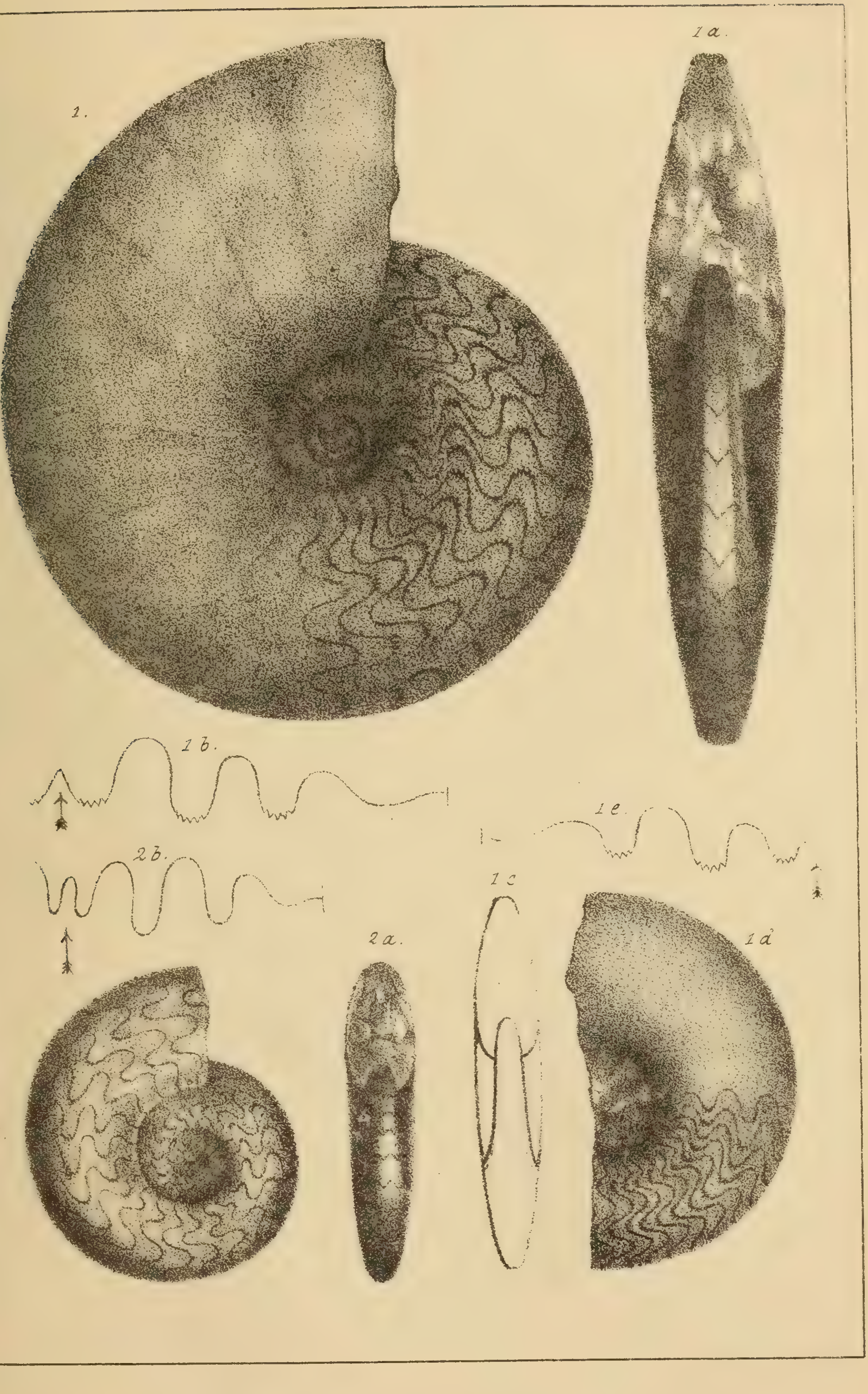

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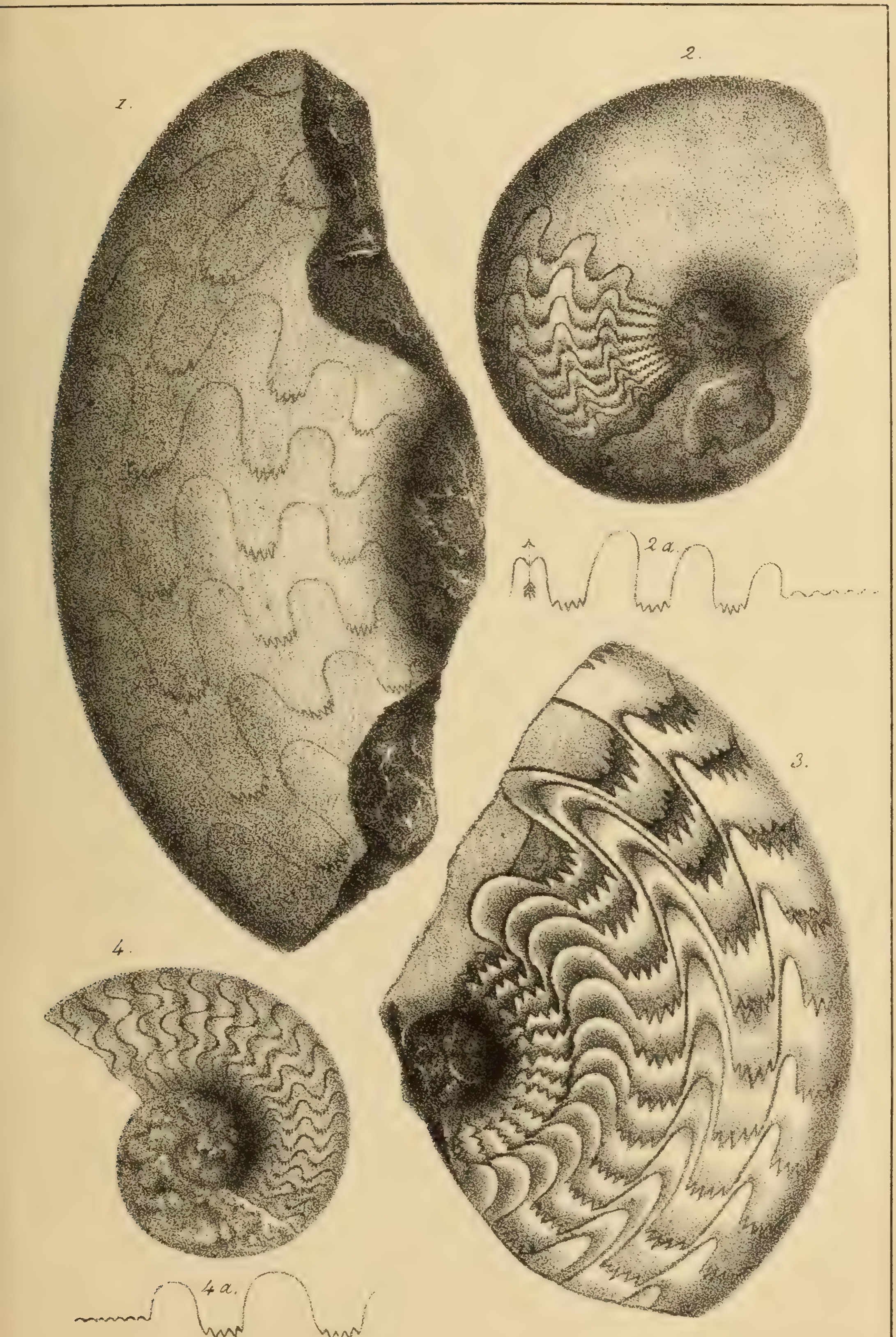


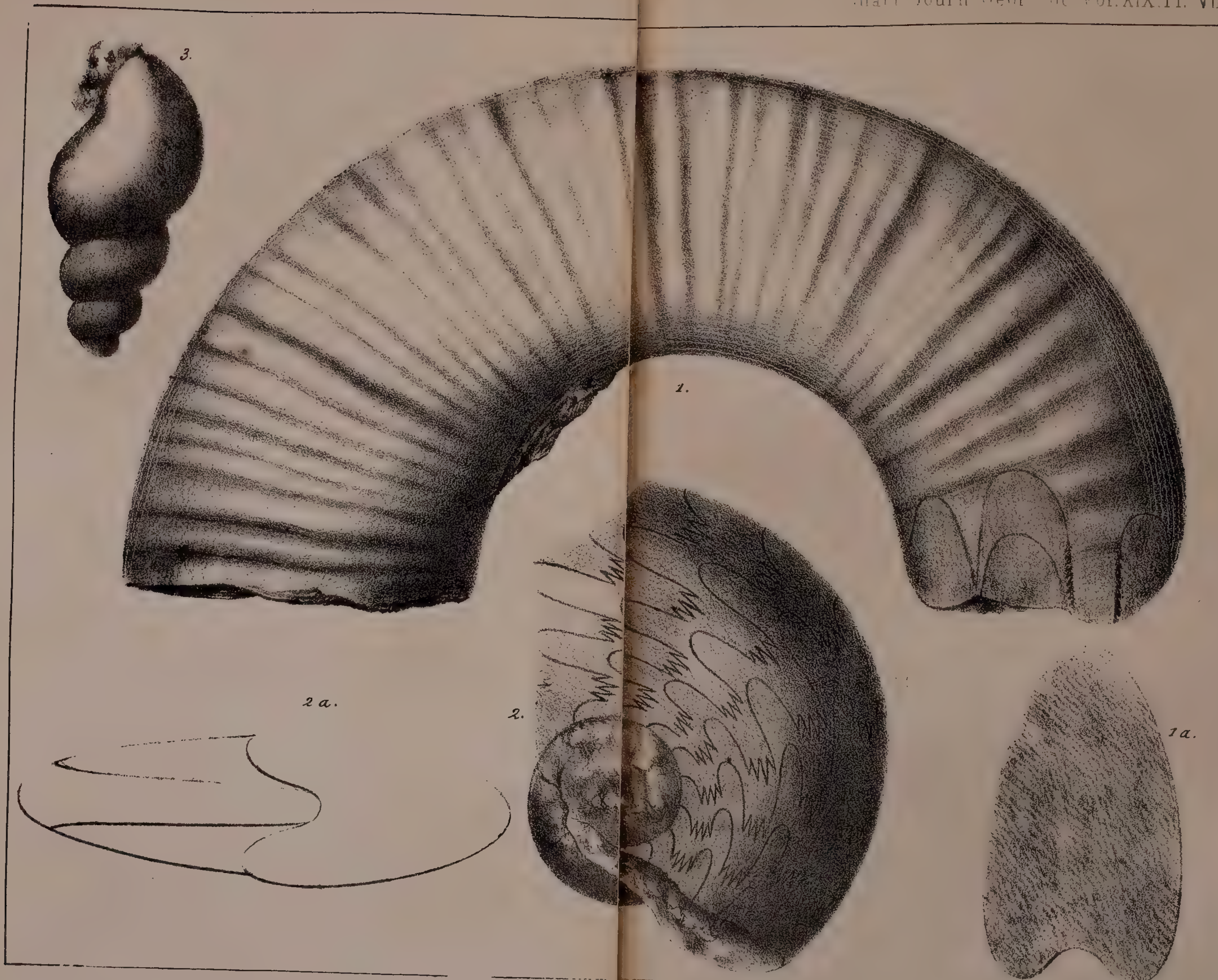
Lith. H. Dessain, Liège

PUNJAUB FOSSILS.

PUNJAU

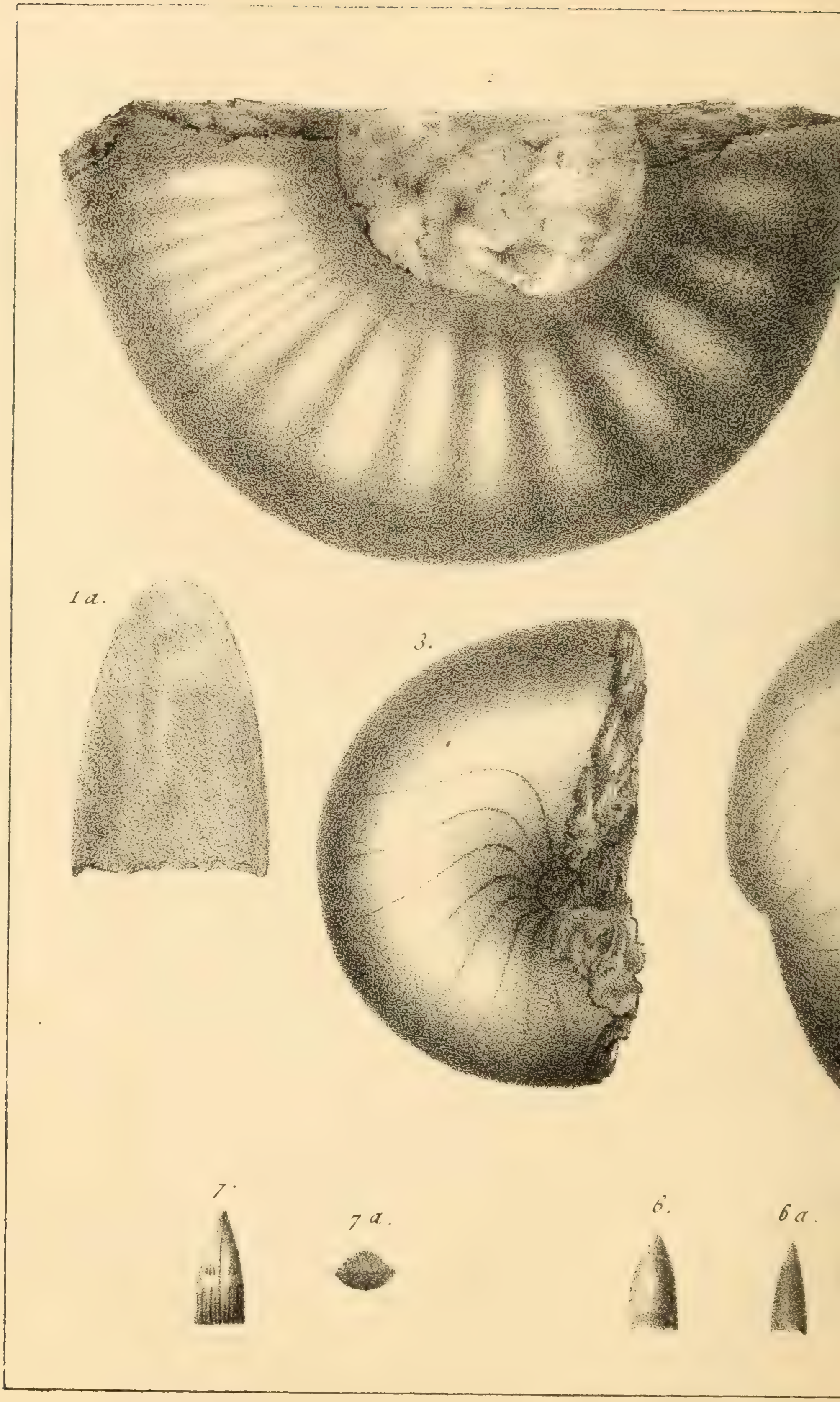
Lith: H. Dessain, Liege

FOSSILS

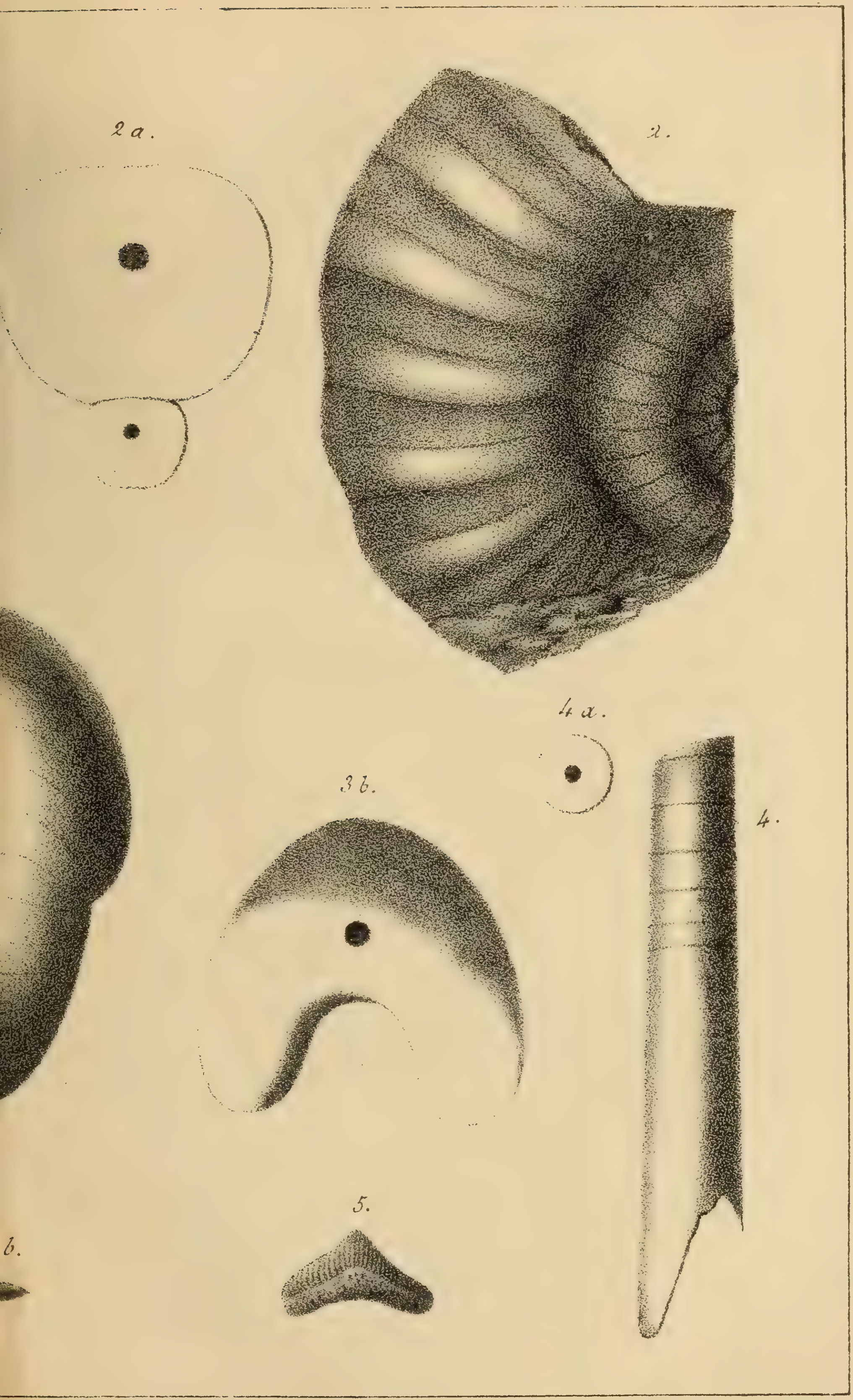


Lith. H. Dessain, Liege.

PUNJAUB FOSSILS



PUNJAU



Lith: H. Dessain, Liege.

OSSILS.

Lith: H. Dessain, Liége.

PUNJAUB FOSSILS.

43. Acrodus Flemingianus, De Kon. Pl. VIII. fig. 5.

Teeth of a subtriangular shape when seen in front, and subellipsoidal when seen from above. Enamel very shining, of a dark-brown colour, occupying almost half the entire length of the tooth, and producing on it a pointed eminence. The surface is furrowed by small, longitudinal striæ, which are gently bent towards the culminating point of the tooth; they are strongly marked at the base, and become almost completely obliterated on the crest of the enamel. The basis is very much compressed, slightly arched in the centre, and tolerably porous.

Two specimens of these teeth, one 15 millimètres wide by 8 long, the other 7 millimètres wide, are in the collection of the Geological Society.

This species has some affinities with the *A. Gaillardoti*, Ag. They differ principally by the much more arched shape of the base in this species. From the Productus-limestone of Vurcha.

44. Saurichthys ? Indicus, De Kon. Pl. VIII. figs. 6, 7.

The teeth which I attribute, with some doubt, to the genus *Saurichthys* (established by Agassiz), on account of their compressed shape, are very small, very shining, and of a brownish colour. Of the two specimens examined, one is 2, the other 6 millimètres in length. This last is strongly striated at its basis, and resembles that of *S. Mougeoti*, Ag., and is a little more compressed than the other, of which the surface is entirely smooth. Both have the upper extremity very pointed, the sides sharp, and transverse section suboval. From the Productus-limestone of Vurcha.

EXPLANATION OF PLATES I. to VIII.

(The specimens are in Dr. Fleming's collection, or in the Geological Society's Museum.)

Plate I.

Fig. 1. *Fenestella ? Sykesii*, De Kon., front view, natural size.
2. *Phyllopora ? cribellum*, De Kon., natural size.
3. *Phyllopora ? Haimeana*, De Kon., natural size.
4. *Polypora fastuosa*, De Kon., natural size.
4 *a*. An enlarged portion of the same.
5. *Retepora ? lepida*, De Kon., natural size.
5 *a*. An enlarged portion of the same.

Plate II.

Fig. 1. *Alveolites septosa* ?, Flem., natural size.
1 *a*. An enlarged portion of the same.
2. *Isastræa arachnoïdea*, De Kon., natural size.
2 *a*. Two calyces of the same, three times the natural size.
3. *Fenestella megastoma*, De Kon. Front view, natural size.
4. *Clisiophyllum Indicum*, De Kon., natural size.
4 *a*. A transverse section of the same.
5. *Philocrinus cometa*, De Kon., natural size.

Plate III.

Fig. 1. *Bellerophon decipiens*, De Kon., natural size, seen from the side of the back.
1 *a*. The same, seen in profile.
2. *Bellerophon Jonesianus*, De Kon., natural size, seen in profile.
2 *a*. Another specimen, natural size, seen in front, and showing the ribs with which the species was ornamented when young.
3. *Bellerophon orientalis*, De Kon., natural size, seen from the dorsal side.
4. *Macrocheilus avellanoïdes*, De Kon., natural size.
5. *Ceratites Hauerianus*, De Kon., natural size, seen in profile.
5 *a*. The same, seen from the side of the mouth.

Plate IV.

Fig. 1. *Cidaris Forbesiana*, De Kon., complete spine, natural size.
2. Fragment of a spine of the same species, showing a variety with well-marked granules, natural size.
2 *a*. Transverse section of the same.
3. *Solenopsis imbricata*, De Kon., natural size.
4. *Pecten Flemingianus*, De Kon., twice the natural size.
4 *a*. Line indicating the natural size.
5. *Pecten crebristria*, De Kon., natural size.
5 *a*. The same enlarged, twice the natural size.
6. *Pecten Asiaticus*, De Kon., natural size.
7, 8, 9. *Anomia Lawrenciana*, Fleming.
7. Specimen of the natural size, seen in profile.
7 *a*. Another specimen, natural size; upper side.
7 *b*. The same, showing the lower valve.
8. The same, seen in profile.
9. Another specimen of the natural size, seen in profile.
10, 11, 12. *Dentalium Herculeum*, De Kon.
10. Specimen of the natural size.
10 *a*. Upper opening of the same.
11. Another specimen of the natural size, divided in two in the direction of the length, so as to show the thickness of the shell and the shape of the cavity.
12. Third specimen, natural size.
12 *a*. Upper opening, furnished with a tooth or internal keel.

Plate V.

Fig. 1. *Ceratites planulatus*, De Kon., natural size, seen in profile.
1 *a*. The same, seen from the side of the mouth.
1 *b*. Lobes of the same.
1 *c*. Another young specimen, seen in front.
1 *d*. The same, seen in profile.
1 *e*. Lobes of the same.
2. *Goniatites? Gangeticus*, De Kon., natural size, seen in profile.
2 *a*. The same, seen in front.
2*b*. Lobes of the same.

Plate VI.

Fig. 1. *Ceratites Lyellianus*, De Kon., natural size, seen in profile.
2. *Ceratites Davidsonianus*, De Kon., adult specimen of the natural size, seen in profile.
2 *a*. Lobes of the same.
3. *Ceratites Lawrencianus*, De Kon., natural size, seen in profile.
4. *Ceratites Buchianus*, De Kon., natural size, seen in profile.
4 *a*. Lobes of the same.

PLATE VII.

Fig. 1. *Ceratites Flemingianus*, De Kon., half the natural size, seen in profile.
1 *a*. Transverse section of the same, half the natural size.
2. *Ceratites latifimbriatus*, De Kon., natural size, seen in profile.
2 *a*. Contour of the same, seen in front.
3. *Macrocheilus depilis*, De Kon., natural size, back view.

PLATE VIII.

Fig. 1. *Ceratites Murchisonianus*, De Kon., specimen seen in profile, half the natural size.
1 *a*. Transverse section of the same, reduced.
2. *Nautilus Flemingianus*, De Kon., specimen seen in profile, half the natural size.
2 *a*. Transverse section of the first two coils of the spire, reduced, and showing the place of the siphon.
3. *Nautilus Burtini*, Galeotti, half the natural size, seen in profile.
3 *a*. Back view of the same.
3 *b*. Last septum of the same.
4. *Orthoceras decrescens*, De Kon., natural size, seen in profile.
4 *a*. Transverse section of the same.
5. *Acrodus Flemingianus*, De Kon., natural size, seen in profile.
6. *Saurichthys*? *Indicus*, De Kon., three times the natural size, seen in profile.
6 *a*. The same, front view.
6 *b*. The same, upper side.
7. *Saurichthys*? *Indicus*, var., De Kon., three times the natural size, seen in front.
7 *a*. Transverse section of the same.

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2. *On a* DEPOSIT *containing* DIATOMACEÆ, LEAVES, *&c.*, *in the* IRON-ORE MINES *near* ULVERSTON. By Miss E. HODGSON.

[Communicated by the President.]

(Abridged.)

CONTENTS.

Introduction.
Tarns.
Cavernous Nature of the Ground.
Swallow-holes.
a. Lindale Moor.
b. Poaka Beck.
Sections.
Diatomaceæ and Plants.

Introduction.—In the ‘Quarterly Journal of the Geological Society,’ vol. xviii. p. 274, &c., there is a paper by John Bolton, Esq., “On a Deposit with Insects, Leaves, &c.,” met with in or near the Iron-ore Mines of Lindale, in Low Furness, North Lancashire; which deposit, for reasons stated in the paper, is presumed to be of great antiquity.

Before determining either the age of the deposit, or its origin, it seems important that geologists should be made acquainted with some circumstances connected with the district, which would rather induce one to interpret it as being a cavern-deposit, carried down to these depths by means of currents,—the currents passing through what are called “Swallow-holes,”—the cavernous and otherwise open state of the ground being favourable to such an interpretation, and the nature of the deposit itself likewise tending to strengthen that belief.

The deposit when first brought up is soft, damp, clammy to the touch, of a dark colour * and nauseous smell, and is capable of being cut through with a knife. Even after remaining at the mouth of the shaft of the Water-way (No. 11) four years, the part of it partially covered with other material retained its soft, moist condition. Kept dry for a time, it assumes a much lighter, greyish appearance.

Tarns.—The Tarns, or small lakes, laid down on the Ordnance-map are not wholly unworthy of notice. "Standing Tarn," a small sheet of water, situated about a mile to the south-west of Lindale, has no surface-inlet or -outlet; but it has a very open subterranean outlet, which is stemmed by the farmers with straw and mud.

A Tarn about two miles south of Lindale, called "Longlands Tarn," has also a wide aperture of escape leading underground; chaff thrown in there has been detected in the Stainton-mines, three-quarters of a mile distant. Such an experiment would prove that there is an open passage throughout the distance, and this I believe to be the general character of the ground; water seldom infiltrates, but courses uninterruptedly on its way. Thus, water pumped into a "Swallow-hole" near the Stainton-mines flowed unfiltrated to Gleaston-mill, a mile further south. Almost all the mines are troubled with water—not merely top-water, but 'under-water,' rushing along at great depths, over which the engines seem to have little power.

Cavernous nature of the ground.—The facts above stated will be no matter for surprise, when the cavernous state of the ground is taken into consideration.

The caverns occur in the earth or Drift overlying the Mountain-limestone †. On an accompanying Map (fig. 1), traced from the Ordnance-sheets Nos. 11 and 16, the situations of the respective caverns are attempted to be shown.

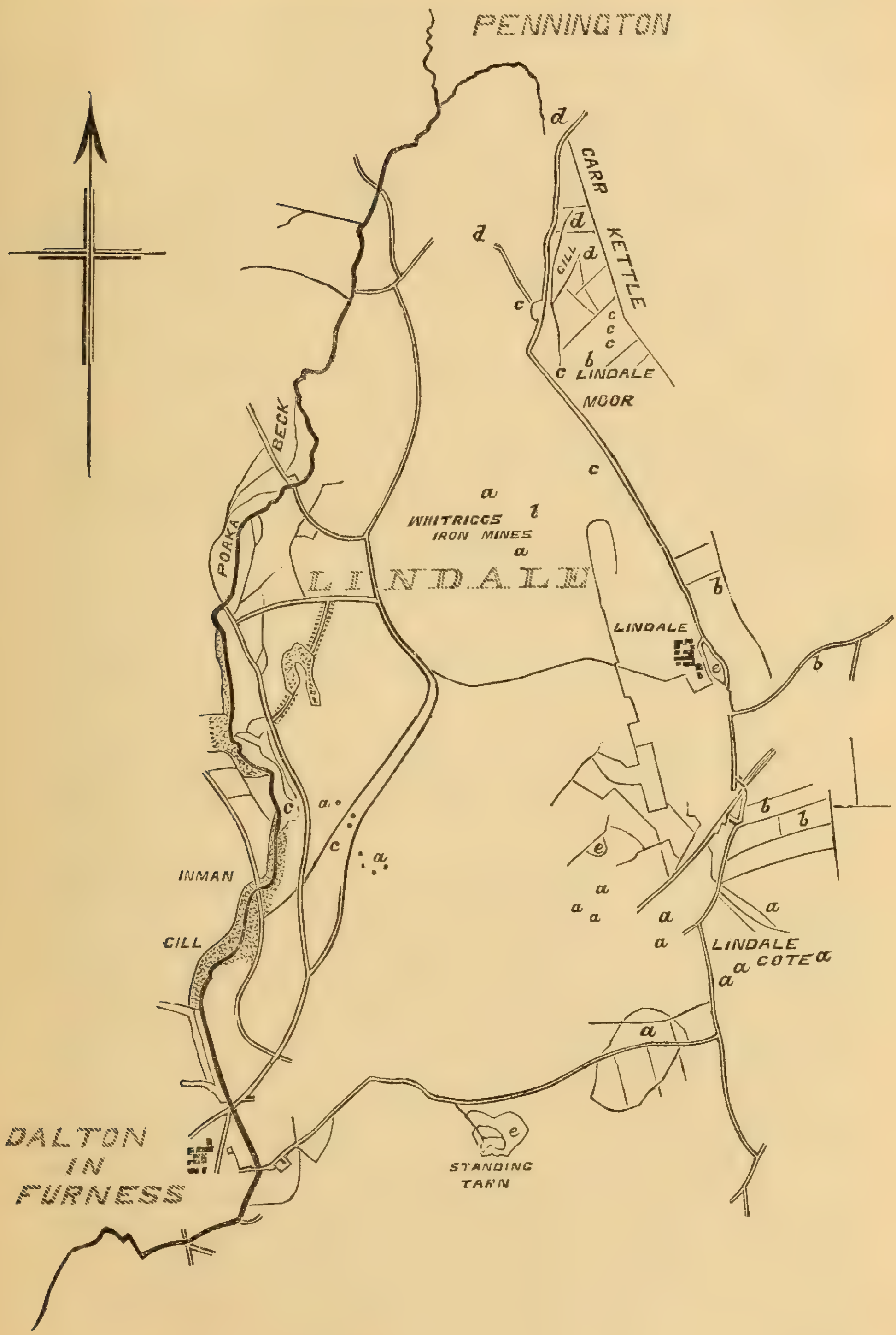
One marked about a quarter of a mile to the south-east of the Lindale Railway-station was disclosed by the surface giving way under the plough, and letting in the horses; this was about 12 feet deep.

Another smaller cavern is situated close behind the station. This one I have visited; like the last, it is close to the surface, and was met with in making a new occupation-road. It was, when discovered, two or three yards broad; it is now a good deal filled up, but close to a fence under which it seems to pass, an opening is left. I collected some of the material forming its roof and sides, specimens of which are in the Society's Museum.

* Some lately found and brought to me while yet moist could scarcely be distinguished from bog-peat, and it burned like peat-fuel.

† For calling my attention to these interesting caverns, and for the information connected with them, I am chiefly indebted to Mr. Lawn, of Ulverston, mining-agent of the Earl of Derby.

Fig. 1.—*Map of the Lindale District, near Ulverston.*



a. Shafts. *c.* Swallow-holes. *e.* Tarns.
b. Caverns. *d.* Springs.

Northwards, and a little to the east, is a cavern in the turnpike-road that leads to Ulverston.

At a short distance above Lindale Tarn, which is situated in the centre of the village, is a remarkable little cavern, in a field commanding a view of the vale. This was formed during one night in the spring of 1861,—an oval space 26 feet across and 58 feet long, sinking from 1 to 2 feet. At the south side of this is a cavern opening deep into the ground, apparently for a distance of three or four yards. I believe it is gradually changing in character, and I have no doubt the coming winter will alter it much. I send a specimen of the interior roof. This cavern is nearer to some of the works than those before mentioned; but it is not considered to be owing to any workings whatever.

Still further north, upon Lindale Moor, a cavern about 10 yards in diameter was disclosed, a few years since, by the falling-in of the surface.

At the distance of a little less than half a mile towards the south-west, cavernous ground is again met with on Whittriggs. In these mines, in the year 1843, a very large cavern was discovered, 60 feet below the surface. In sinking the vertical shaft which led to this discovery, a cavern of small dimensions was opened on one side of the shaft; but lower down the miners discovered an immense, dismal vault, 24 feet in depth. In this gloomy chamber a great mass of rock could be seen resting, as it seemed, on a very slender pedestal, and threatening every instant to fall down. This cavern, like the rest, was not in rock, but in the same material as the one behind the station.

Thus we have a line of cavernous ground proceeding up the eastern side of the vale, and occurring again on the north-western; and there is reason to believe that the miners are acquainted with many more.

That both kinds of caverns have been long known may be seen by referring to one of our oldest local writers on the antiquities of Furness*, from whose statements it appears that the earth-caverns were supposed to be caused by the sinking in of water. This idea seems to prevail still amongst the miners, who call them "*Water-washes.*"

The numerous depressions and inequalities of the surface on the moor called Carr Kettle, and other localities, would lead one to suspect some such mining work of nature there. The supposed rock-chasm, after having been slowly filled or choked by the falling matter, might at length have formed in it a compact floor, which, receiving constant additions from the falling roof, would gradually rise; and thus the cavern of 60 feet depth below the surface might become in time the cavern of 50 feet, then of 40, and ultimately merely a surface-depression or deep basin like the cavern on Lindale Moor.

I have very recently received information, from one of the gentlemen of the Dalton Mining Company, of another "water-wash" or cavern, occurring in their mines near Standing Tarn. It is situated

* Antiquities of Furness, by Thomas West. New edition, by W. Close, 1805, Supplement, p. 593.

rather more than a quarter of a mile south-west from that water, at a depth of about 84 feet from the surface, in strong "Pinel," but close to rock; the pinel of the roof is mixed with large stones. The cavern is about 9 feet in height, circular, and about 15 feet in diameter. Iron-ore, apparently of some depth, is found upon the floor. There is a small quantity of top-water in this cavern, which drains off into the adjacent mine at the rate of about half-a-bucket a day, and the pinel of the roof is loosening and falling. A fissure in the limestone, 16 inches wide, occurs about forty yards south of the Tarn, at a depth of 8 feet below the surface, dipping to the east.

It may also be mentioned here, as corroborative of the opinion given by Mr. Close, that, in a shaft sunk by my brother near to Stainton, the miners, at the depth of 90 feet, met with a narrow cavity in the pinel, about 18 inches wide; and, on following it down, they found, as the cause, a rock-fissure directly under it, and corresponding to it in width; clearly showing that the pinel had fallen down the chasm, while the roof remained firm.

Referring back to the cavernous field above Lindale Tarn (at p. 22), further indications of fissured rock have lately been noticed there. Another depression, in a line with that of the cavern, may be seen when viewed from the road below; and, again, the cutting of a tramway in a parallel line behind this has disclosed what seems to be a narrow rock-fissure, about 18 inches or 2 feet wide.

Swallow-holes.—I will now refer to what are locally called Water-sinks or Swallow-holes. In a later work on Furness, by the Rev. Francis Evans, 'Sinks,' in which the water disappears, are noticed as occurring here, "as in all limestone districts that abound with iron-ore*." I was led to understand these more fully by reading some remarks on the subject by Sir Charles Lyell in his 'Principles of Geology'†.

Their position in the Lindale district was first shown to me by Mr. Bolton, who pointed them out on the Ordnance-map, a short time previous to the writing of his paper. I at once attached great importance to these Swallow-holes, and, concluding that they might be found to have connexion with the deposit, I have since endeavoured to ascertain their accurate situation, antiquity, and nature.

a. *Lindale Moor.*—I will first notice those on Lindale Moor. They are situated about a quarter of a mile from the Lindale-moor Cavern, and a little more to the north.

By the help of an aged miner I have succeeded in noting down the true natural Swallow-holes,—not as they might appear in 1850, the date of the Ordnance-map, but as they existed fifty years ago. A copy of this has been transferred to fig. 1. Some which appear on the Ordnance-map are omitted, on account of their being only "open-top workings," as they are called, not natural Swallow-holes.

* Furness and Furness Abbey: or, A Companion through the Lancashire part of the Lake District. By Francis Evans, 1842, p. 19.

† Principles of Geology, vol. iii. fifth edition, ch. xiv. p. 204.

The Swallow-holes on Lindale Moor seem to be fissures in the limestone, which probably comes nearer to the surface here. These fissures continue open, it is believed, to a considerable depth.

There are numerous springs above the locality of the Swallow-holes; in dry weather some of them fail, and none remain but those noted on the sheet; but in January a field on the side of Carr Kettle was crossed by a line of numerous small springs. These unite, and join the larger streams, and the whole are then precipitated down the large Swallow-hole, which may be called "Swallow-hole No. 1, Lindale Moor." Some years since, the earth around this fell inwards, carrying with it parts of a hedge-row (which it will be seen on the Ordnance-map is made to cross it), leaving a large, deep depression, all the material disappearing through the chasm. The chasm remained open after this for about a year, when it was gradually choked up, so as to form a deep clear pool in the centre of the depression. There is little doubt that this remarkable Swallow-hole has been receiving the united waters of the several springs for more than a hundred years.

About 220 yards to the north-west of this there is another Swallow-hole, and, according to the miner, one equally old. This also receives a small stream, which is never cut off by dry seasons; and it is supposed the two engulfed streams unite, as a continuation of this chasm, much enlarged, was met with a little further to the east, proceeding, as it seemed, in the direction of Swallow-hole No. 1, Lindale Moor.

The other Swallow-holes in this vicinity are simply dry, funnel-shaped depressions.

Further west, in the "Cross-gates" Iron-mines, which are situated on the banks of the Poaka Beck, "water-sinks" or fissures, down which water rushes, are frequent. They are known also at Elliscales, a place still further west, and again at Stainton, to the south of Lindale. Much open ground, it is believed, of the foregoing description also lies between Lindale and Ulverston.

b. *Poaka Beck.*—I now come to a "Swallow-hole" which I deem to have the most connexion with the deposit. This is situated in the high end of Inman Gill, and until the year 1842 had been receiving, for an unknown period of time, the whole of the water of the Poaka Beck*. In very wet seasons, or in thunder-storms, when the chasm, large as it was, proved too small, the overflowing water would pass down the Gill on the surface; otherwise the Beck-course from this spot was usually almost dry. There was said to be an efflux of part of it about three-quarters of a mile further south, which, recovering the course from the Gill, flowed onwards along the south of Dalton. I believe, however, there is no question but that much of it was lost; and, as it was supposed to find its way into the neighbouring mines, the course of the stream was altered a little in the above year, with a view of keeping it on the surface. I have lately visited this locality. The gulf, for such it appeared

* It has been ascertained that the water entered the ground at this spot in the year 1802, sixty years ago.

to be*, is close to the steep side of the Gill, and is now strongly fenced off. The Gill here may be from 14 to 16 feet deep; it is thickly wooded.

A division of the stream has lately found another entrance about a quarter of a mile higher up. Here it *filters* through, *leaving its sediment on the surface, and forming mud-banks*†, through which the water noiselessly escapes in numerous little eddies. As in the former instance, the engulfed stream is believed to take an easterly direction. The Poaka Beck rises by several deep springs on Mean Moor, about two miles to the north of Lindale Moor, at an elevation of nearly 1000 feet. Taking rather a south-westerly course, it runs nearly parallel with the vale of Lindale, separated from it by a line of hills, but at no point of divergence exceeding the distance of one mile.

The superior claim of this stream, in regard to the deposit, over the waters before noticed is, I think, obvious. Its longer course, of nearly four miles from the rise to the fall, through a tract of varied country, its thickly wooded banks and gills, its far greater body of water (which in heavy rains is said to be almost white with mud and clay from the higher grounds), and especially the remarkable coincidence of its having been stopped from entering the ground for the last twenty years, thus leaving time for the deposit to become drained, are facts which seem to point to the Poaka Beck as the direct cause of the deposit.

Wherever water is precipitated into the earth through a chasm, it must take along with it an amount of deposit proportionate to its volume; and, supposing that such engulfed water may afterwards escape from the fractured rocks into the adjacent strata, thither it will carry its mud, &c., especially if in the adjacent strata it find a vacuity to receive it.

Sir Charles Lyell, in treating of the phenomena of springs‡, gives some extracts from M. Héricart de Thury, and the 'Bulletin de la Société Géologique de France,' which bear upon this subject.

Although the rocks in Inman Gill are now near the surface, and the Swallow-hole has been an open rock-chasm for the last sixty years, the bed of the stream at one time would be higher, and the gill not so deep. Therefore, however open or cavernous the subterranean region between the Beck and the present seat of the deposit might be, it is probable that the first influx was by infiltration, as at present. One is led to this conclusion by the nature of the bluish clay found underneath the vegetable deposit; this clay, from the scarceness of any vegetable forms, even in portions lying in close proximity to the vegetable deposit, may be supposed to have been collected by filtrated waters on their passage through the various materials of that region, and so left on the floors of the cavities, indi-

* From the point where I stood; the stream passing between prevented my getting close to it.

† See Specimen, in the collection of the Society, with probably an alder-leaf imbedded.

‡ Principles of Geology, fifth edition, vol. i. p. 306.

cated by the present position of the deposit, any disintegrated heavy substances lying lowest.

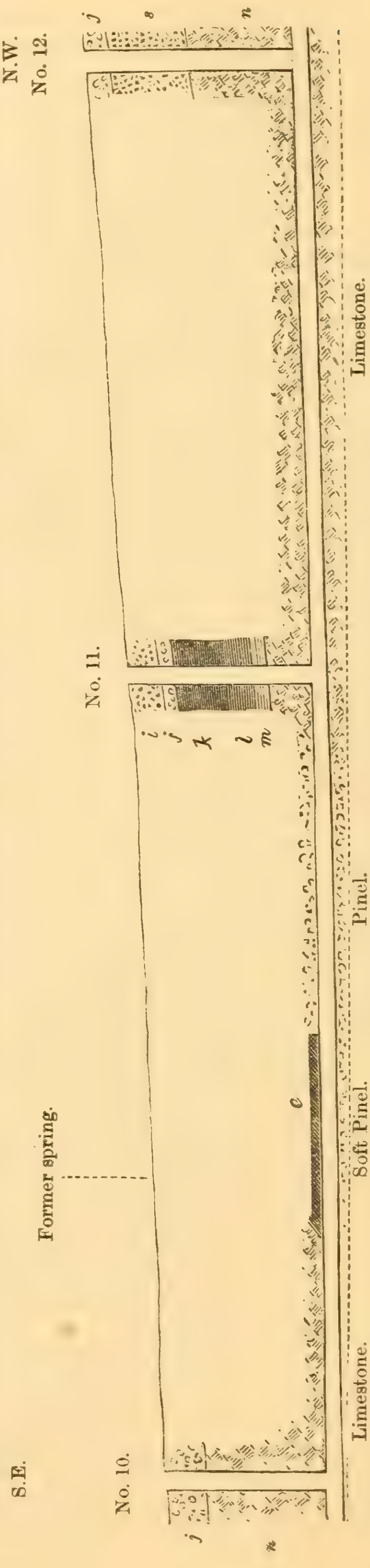
In process of time, the obstruction at the entrance being removed, the water would enter in greater volume, and, carrying in mud and vegetable matter, would then, no doubt, pass through filtrating media to several points of efflux—namely, springs, which in former years were numerous in the lower part of the vale, and which are now all cut off.

Sections.—As the position of the materials in Mr. Bolton's Section, fig. 1, would negative the possibility of a cavern there, inasmuch as there can be no caverns or cavities in gravel, I am compelled to question its accuracy.

Besides the information, in his own hand-writing, obtained from the principal man engaged in sinking the shaft, the one particular, that gravel and sand are at *the top*, has been corroborated by three other miners. The first attempt to sink in this gravel and sand was, at the depth of 5 feet, obliged to be abandoned, it was so full of water; and the disappointment attending that loss of time and labour is well remembered.

In fig. 1 of Mr. Bolton's paper, two beds of "Black Muck," with a thin vegetable clay-bed betwixt them, are made to lie next upon the limestone in the drift; whereas I have it on the authority of four of the

Fig. 2.—*Section of a part of the Water-way from Lindale Cote Mines to Urswick Tarn.* (Length about 100 fathoms.)



i. Gravel or sand. *j.* Pinel. *k.* Peaty deposit. *l.* Peaty clay. *m.* Bluish clay. *n.* Limestone. *s.* Iron-ore and limestone.
c. Peaty clay, not reaching the floor of the drift.

miners, one of them being the principal person engaged, that "Pinel" came next to the limestone in the drift.

It would seem from fig. 2 that the deposit in the vertical shaft (or rather the *cavity* in it) and that in the drift are not connected, unless it be by a mere channel of communication, and even that must remain only a matter of conjecture. The material called "Pinel," I am told, does not form regular beds.

The absence of bluish clay in the drift (see fig. 2) would lead to the belief that the first waters had not penetrated this cavity.

So far as I can learn, the material termed "Black Muck" was not present either in the shaft or drift *.

The accompanying section (fig. 2) of the last three shafts of the Water-way will, I hope, throw much light upon the ground in question. It has been drawn from information obtained, in writing, from two of the chief men employed in the work, neither of whom have been informed of my views on the subject.

It seems to me that there is a steep precipice (or escarpment) indicated by the abrupt termination of the rock in the Water-way south of the No. 11 shaft, and that, from this point to below No. 10, there may have been disturbance and continued change.

Referring to the section of the shaft, fig. 2 of Mr. Bolton's paper

* The following description of the material called "Black Muck" has been obligingly given to me by Mr. Cameron, F.C.S. :—

"'Black Muck' is a dark-brown substance found in the vicinity of hæmatite-deposits, and is a very good indication of the neighbourhood of the oxides of iron and manganese. It is never found of a uniform composition, but consists of varying proportions of siliceous and aluminous materials, and of the oxide of iron (hæmatite) and peroxide of manganese. The hæmatite iron-ores contain generally a certain proportion of the peroxide of manganese, sometimes titanic acid, and various other substances. When the hæmatite-ores are found in irregular pockets, the 'Black Muck' is very often found surrounding the ore entirely, like an outward shell, which peels off from the surface of the iron-ore, leaving it perfectly clean and glossy. When the ores are found in regular strata, the 'Black Muck' seems to assume a regular form also; for it is then almost always found overlying the vein of ore, running in the same direction, and taking the same dip with varying thickness. Sometimes it is found under the ore-deposit; and is always a certain indication, when found, of the proximity of the ores of iron and manganese. This substance, 'Black Muck,' is only found in connexion with the hæmatite-ores of iron; and its general constituents may be inferred from the composition of the following examples:—

'Black Muck.'

No. 1.

Oxide of iron (with a little alumina)	67·00
Peroxide of manganese	5·00
Siliceous matter	27·50
	99·50

No. 2.

Oxide of iron and alumina	28·00
Peroxide of manganese	17·86
Siliceous matter	53·75
	99·61

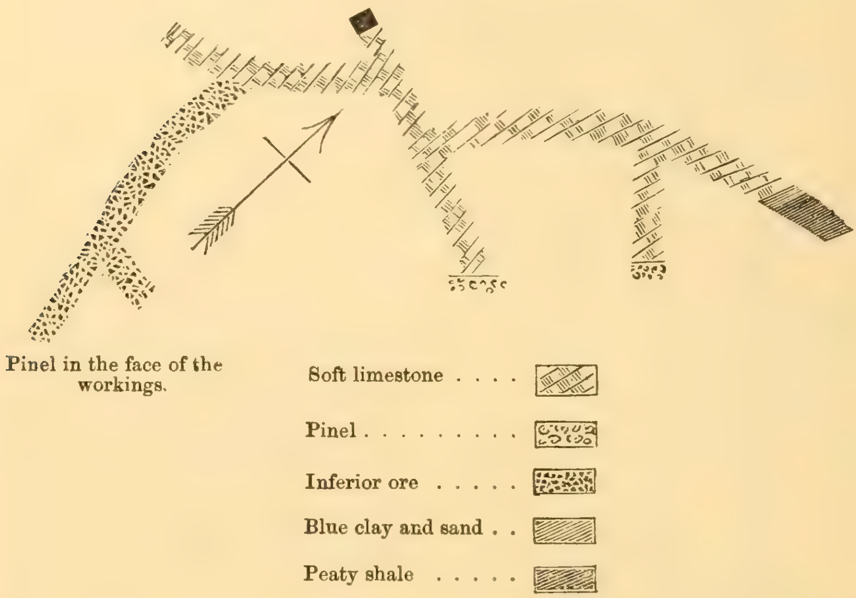
"Other samples differ a little in the percentage of their constituents, but the above may be considered a type of the general composition of 'Black Muck.'"

(p. 276), specimens of the "yellowish sandy material," marked *d*, lying next upon the vegetable deposit obtained from that shaft, accompany this paper. (See specimen marked "Next upon the deposit, Dalton Road Pit, No. 1.") It seems sufficiently compact to form a cavity. (See also other specimens from neighbouring pits.)

In the end of this drift, it appears that this yellowish sandy material was never reached. The last man in did not cut through the vegetable deposit. He informs me that, before abandoning the drift, they worked directly upwards a short distance, in the hope of finding ore, until the lights became extinguished by bad air, and a great accumulation of *wood* was the last material found *.

In the ground-plan of this pit (fig. 3), kindly furnished by Edward Wadham, Esq., the position of the iron-ore alluded to in Mr. Bolton's paper (p. 277) likewise indicates a cavern in the pinel, filled in at some time by the mineral.

Fig. 3.—*Plan of Dalton Road Pit* (1862).



The adit containing the peaty or "woody" deposit lies in a *north-easterly* direction—not exactly north, as represented in Mr. Bolton's section. Mr. Wadham remarks, "The plan now sent is chiefly from my own recollection, the proper plan having been neglected when it should have been made; it is, however, correct so far as the different substances are concerned, for I have a very vivid recollection of the whole working when it was in progress. Your view of the case, as to its being a cavernous deposit, is, in my opinion, perfectly correct; in fact I have not a doubt upon the subject. The iron-ore, too, as shown upon the plan (fig. 3), was deposited in the same way,

* On a piece of the deposit-wood in my possession, after removing the blue pigment, Dr. Walker-Arnott discovered what he considered to be the mark of a hatchet.

as I can prove; for in workings which have been abandoned, the small particles of ore, which exist throughout the whole of the district, have, by the action of the water, been washed through the cavities in the limestone, and been deposited in quantities sufficiently large to be worked."

Diatomaceæ and Plants.—At the risk of some recapitulation, I must not omit acknowledging that the idea of the clay having been very lately deposited did not entirely originate with myself. The opinion of one or two eminent microscopists, that the species of *Diatomaceæ* might confidently be expected to occur in its neighbourhood in a living state, served to suggest the possibility of its having been in some way conveyed below ground; whilst the remarks of equally eminent botanists, who detected for me the presence of rushes and other familiar water-side plants, further tended to strengthen the idea, and to impose the necessity of discovering its impracticability, before yielding to the deposit that antiquity which its position would appear to claim for it.

After ascertaining with accuracy the species of *Diatomaceæ* contained in the deposit, and noting to what conditions of growth they might be referred, it was found that not only did they belong to a peaty and subalpine district, but also to *running streams* (the peculiar habitat, if I do not mistake, of the species of freshwater sponge found in the deposit); all clearly indicating the hills and moors north of Lindale, and the streams and peat-bogs which occur there, as their source; and thus, without any previous knowledge of the district, its interesting features, as I have detailed them, became successively disclosed, and seemed to invite close and persevering investigation.

All the waters on Lindale Moor that could find access to the Swallow-holes were examined, and also the dry soils in the vicinity. All yielded Diatoms, including a few of the deposit-species, just sufficient perhaps to prove the correctness of altitude, but failing in some, from the absence of peaty or boggy ground; a result at once acting as an unerring guide to the district further west, towards the channel of the Poaka Beck, where the interesting facts connected with that stream soon after developed themselves, and tended indubitably to confirm, in all points, the preconceived idea.

Much of the arable and pasture land on the sides of the Beck, near Stewnor Park, was, thirty or forty years back, nothing but peat-bog.

With a view of obtaining the *Diatomaceæ* which might have lived upon the surface at that time, samples of bog were taken up by means of an iron rod from the depths of 2, 4, and 5 feet, on different parts near the Beck-course.

The following tabular list of the Diatoms found in the deposit will at one view show its character, and also with what success the representatives of the Diatoms have been searched for in the Poaka Beck. Allowing for the lapse of years, and the great changes that have been effected in what may be called the principal Diatom-ground on the course, the few species yet undiscovered ought not to negative the belief that the deposit has been supplied from thence; for there can be little doubt that the banks of the stream about Stewnor at one time presented most favourable conditions for the growth of the *Diatomaceæ*.

At the same time the *Diatomaceæ* are not abundant in the deposit. There is a great preponderance of vegetable and earthy matter, which renders it troublesome and difficult to prepare for the microscope. It is very likely that many of the Diatoms were lost on the passage. Their scarcity and broken state would indicate their having been carried a great distance by a current.

Diatomaceæ of Lindale Cote Deposit.

List of Species.	Localities where they are found living.	Other deposits in which they occur.
Epithemia Hyndmannii ...	Pond at Shooting-lodge, Glen Tilt, Loch Leven.	Lough Mourne. Cantyre peat.
—— turgida	Poaka Beck. Subalpine streams, Kirby, Furness, Lancashire.	Lough Mourne. Cantyre peat.
—— granulata	Poaka Beck	Lough Mourne.
—— Zebra, vars.	Poaka Beck. Near Ulverston.	
—— Argus	Poaka Beck.	
—— ocellata	Poaka Beck........	Cantyre peat.
—— longicornis.		
—— Sorex	....	Lough Mourne. Cantyre peat.
—— gibba	Poaka Beck. Near Ulverston ...	Lough Mourne. Peterhead.
—— ventricosa	Poaka Beck.	Peterhead.
—— proboscidea	....	Raasay earth.
Cymbella Ehrenbergii	Poaka Beck. Tarn near Ulverston	Lough Mourne. Premnay peat.
—— maculata	Poaka Beck. River Frome, Dorset	Cantyre peat. Peterhead.
—— Helvetica	Poaka Beck. Subalpine bogs, Ulverston.	Peterhead.
Cocconeis Placentula	Poaka Beck. Frequent in streams about Ulverston.	Lough Mourne. Peterhead.
Cyclotella minutula, *Kütz.*	Peat-trenches. Ulverston. Carr Kettle Moor.	
—— operculata	Poaka Beck. Subalpine bogs, Ulverston.	Cantyre peat.
Campylodiscus costatus ...	Poaka Beck. Rivers and springs	Lough Mourne. Peterhead, &c.
Cymatopleura elliptica......	Rivers, frequent. Near Ulverston.	
Nitzschia amphioxys	Poaka Beck. Rivers, common.	
Navicula elliptica, *Kütz.* ...	Poaka Beck. Subalpine bogs, Ulverston.	Lough Mourne. Peterhead.
—— lævissima........	Poaka Beck. Peat-trenches, Ulverston.	
—— gibberula	Poaka Beck. Subalpine bogs, Ulverston.	Lough Mourne. Dolgelly earth.
—— scita........	Poaka Beck.	
—— varians (Pinn.?), *Greg.*		
Pinnularia major	Poaka Beck. Subalpine bogs, Ulverston.	Cantyre peat. Dolgelly earth, &c.
—— viridis	Poaka Beck. Subalpine bogs, Ulverston.	Cantyre peat. Dolgelly earth, &c.
—— oblonga	Poaka Beck. Subalpine bogs, Ulverston.	Peterhead.
Stauroneis Phœnicenteron	Poaka Beck. Subalpine bogs, Ulverston.	Cantyre peat. Lough Mourne, Peterhead.
Pleurosigma attenuatum ...	Common in streams	Lough Mourne. Peterhead.

List of Species.	Localities where they are found living.	Other deposits in which they occur.
Synedra radians	Poaka Beck. Near Ulverston, in springs.	Lough Mourne. Peterhead.
Cocconema lanceolatum ...	Poaka Beck. Common in streams, Ulverston.	Lough Mourne. Cantyre peat. Peterhead.
—— cymbiforme	Poaka Beck............................	Lough Mourne. Peterhead.
Gomphonema acuminatum	Poaka Beck. Subalpine bogs, Ulverston.	Lough Mourne. Peterhead.
—— Vibrio	Poaka Beck............................	Lough Mourne. Peterhead.
—— dichotomum	Poaka Beck. Levers Water, "Old Man" Mountain, Coniston.	Premnay peat.
—— intricatum	Poaka Beck.	
Himantidium bidens	Poaka Beck. Hills, Ulverston. Levers Water, "Old Man" Mountain.	Dolgelly earth. Mull.
—— pectinale	Poaka Beck. Levers Water, "Old Man" Mountain.	Dolgelly earth. Mull.
Odontidium Harrisonii β...	River Thames.	
—— mutabile	Near Ulverston	Lough Mourne. Peterhead.
Denticula sinuata.		
Tetracyclus lacustris	River Spey	Dolgelly earth.
—— emarginatus............	Rivers, "mountain-streams, and cascades."	
Tabellaria flocculosa.........	Poaka Beck. Road-sides north of Lindale Moor.	
Mastogloia Grevillii.........	Mossy springs, Ulverston.	

Taking for a moment Mr. Bolton's view of the deposit, a question would arise respecting the "Leaves of Beech" said to have been discovered in it.

Now there is no record, I believe, of the *Fagus sylvatica* occurring truly wild so far north. Therefore, if correctly identified, the specimens would seem to have belonged to a *cultivated* tree; otherwise, we have yet to learn why the beech has, since that period, become extinct as a native.

Returning to my own views, I cannot say that there are no beech-trees all along the banks of the Poaka Beck; none were observed; the alder, oak, ash, maple, hazel, thorn, &c. occur—the first, perhaps, predominating.

Great quantities of very fine mosses grow in and about all the springs; we find their débris in all the diatomaceous gatherings. I also found, by careful washing, fragments of moss still adhering to a pebble from the deposit.

Rushes grow in great abundance; also ferns, especially the Hard Fern (*Blechnum boreale*) and the Common Bracken (*Pteris aquilina*). Spores of the latter have been detected in the deposit, with a fragment of a frond of the same.

3. *On the* Geology *of a part of the* Masulipatam District. By Captain F. Applegath, Madras Army.

[Communicated by the President.]

(Abridged.)

The country west of the Palair River, and north of the Kistnah River, is covered with a thinly stratified limestone (E) of a dark blue or black colour, which is about 150 feet thick, and alternates sometimes with dark purple slates (A), sometimes with a lighter-coloured speckled slate, and occasionally with some cubical pieces of clay ironstone. The extent of this district is 24 square miles*. The limestone here has a strike due north, and a dip about 19° east: this description mainly applies to all the limestone west of the Palair River. The slates are considered old, and have attracted much attention at Madras. No quarries have been opened in these limestone-fields; but the stone is burnt for lime by the natives, who use the slates extensively for the floors of their houses and verandahs. The slabs are usually about 6 feet long, $3\frac{1}{2}$ feet wide, and from 2 to 8 inches thick.

The dark-coloured limestone contains casts of shells, and rings when struck by a hammer. A similar limestone in appearance at Kurnool, Province of Ballaghaut, on the Toombuddra River, 250 miles N.W. of Madras, contains large quantities of lead; and in every ton of lead there are 400 oz. of pure silver; at least, a specimen analysed showed this per-centage.

The limestones on the east side of the Palair differ much in colour, appearance, and position from those on the west side, indicating great disturbance of strata; they are principally of a pale yellow, salmon, or red colour, sometimes brown, and occasionally black or blue; they are very thinly stratified, and feather out. The general strike of the yellow limestone is 70° N.E.; the dip varies from 11° to 30° S. The strike of the dark blue or black limestone here is E., and the dip N.

The black limestone alternates with red schist, which is found on undulating hills, which are frequently covered by rounded, quartzose pebbles, and occasionally by small masses of clay-ironstone. Each red-schist hill seems an independent basin, as the strata on the top are vertical, and those on the lower portions of the hill dip from 20° to 40° towards the centre. There is an evident intrusion of the same igneous rock as that which extends from the banks of the Kistnah for almost two and a half miles in a north-easterly direction. This intrusion appears to divide the red-schist area into two parts; and the red schist is finally overlain by a long ridge of variegated schist, which extends from the Kistnah banks, in a due northerly direction, for five miles. This schist attains an elevation of 400 feet above the river-bed, being most probably the last deposit; it has a uniform N.E. strike, and the dip varies from 15° to 50°.

* A sketch-map and several sections illustrating this paper are deposited in the Society's library.

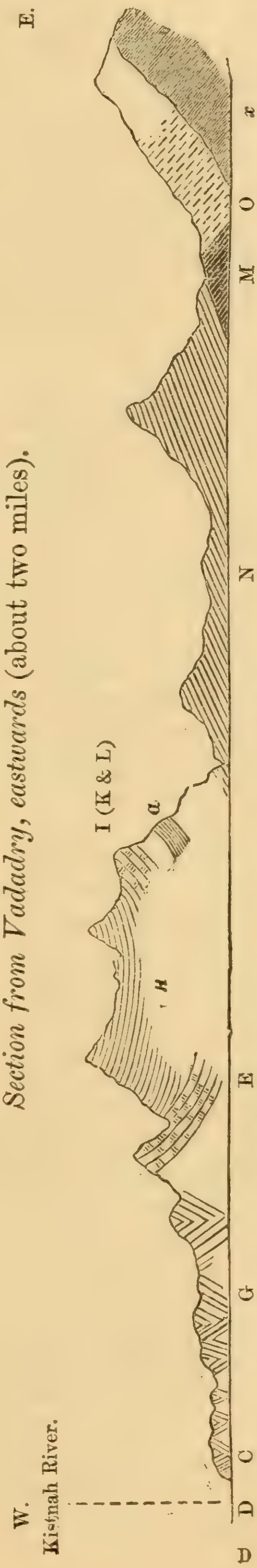
There is another remarkable feature in this locality,--several olive-coloured slate hills, with nearly horizontal strata. The variegated schist and olive slates appear to lie unconformably upon a kind of flag-stone; the latter rests on a hard, quartzose sandstone (O); and the base-rock is massive gneiss. The last-named rock is joined at the Fort of Juggiah Pettah by the limestone already described, the variegated schist extending as a ridge down the centre, and attaining an elevation of 400 feet in a conical hill called Noonacondah, or Oily Hill, which has been scarped by the river, and where a few traces of fossils have been found.

I must not omit to mention that in the bed of the Kistnah, accompanying the schist C, is a large mass of rounded, water-worn pebbles (a specimen of a reddish one is sent, D). They vary in size from 1 inch to 1 foot in diameter. They are principally of a pale-grey colour, weathering to brownish grey, and are composed of a very fine sandstone; their internal structure is perfectly crystalline, corresponding to that of the rock due north, at the Fort of Juggiah Pettah, where the sandstone assumes a tessellated form, and dips 9° S., strike 70° N.E.

On the eastern side of these fields the same description of sandstone is met with, but more massive and coarser, more like a grit, and dipping to the W., strike 65° N.E. It has a uniform strike along the ridge for about four miles, and an olive shale or slate is always found close adjoining.

An attempt was made some years ago to sink No. 1 shaft for coal through the red schist in the southern part of these fields. The red colour appears to be superficial; for at a depth of 10 or 15

Section from Vadadry, eastwards (about two miles).



C. Dark-coloured schist. G. Red schist. N. Olive-brown schist.
D. Quartzose pebble. H. Pink and variegated schist. O. Coarse sandstone.
E. Black limestone. I. Arenaceous limestone. x. Gneiss.
K. Ochre. L. Ironstone. M (?). Flagstone. a. Grey micaceous shale.

(The capital letters correspond with those on the specimens.)

feet it changes from red to greenish grey, blue, and sometimes black. In the bed of a natural ravine I commenced a shaft in the blue schist, which, in descending, was found to be more thinly laminated and of a greyer colour.

I also commenced shaft No. 2 on the northern boundary of this red schist, and, at a depth of 80 feet, a pale-brown sandstone was met with. However, no blue or grey schist was seen in this shaft; but the variegated schist was found immediately beneath the red surface, and continued for about 80 feet. This shaft was evidently sunk on the outer edge of the red schist. The pale-coloured, brown sandstone resembled that which I found in the Wells, but, not being provided with a pump of any sort, the water overpowered my attempts to pierce it.

The red schist often assumes a hard, fissile, unevenly stratified character, and appears occasionally to be traversed by veins of quartz, and probably is quite of a different age from the pink schist (H), which is much softer, and has invariably a very thin foliation; with the latter is also associated a cream-coloured arenaceous schist.

The schists are situated on a ridge of hills varying from 100 to 400 feet in height. Excavations, which can scarcely be called shafts, both horizontal and vertical, have been commenced; and the notes taken on the spot are herewith recorded. In gallery No. 3 (horizontal), white and reddish-brown schists were found. In sinking No. 4 shaft, commenced at the bottom of a ravine, about 200 feet below the top of the hill, thinly laminated, pinkish-coloured schist, indurated clay, $2\frac{1}{2}$ feet thick, and, at the bottom, finely laminated schist were found.

No. 5 shaft was sunk at right angles to the dip, through fine-grained, white, thick schist.

In shaft No. 6 were seen speckled white, brown, and yellow schists, and, beneath them, hard brown schist.

It is perhaps essential that I should attempt to describe the difference of the immediately underlying rock occasionally found under these pink and cream-coloured schists. It is a hard, arenaceous limestone (I), which is accompanied with a soft, dark, purple-coloured substance (ochre) (K), and iron-sandstone (L), in rectangular pieces, very abundant; in fact, the whole ground in this locality for a considerable distance is coloured brown. The ironstones run in bands, varying from 1 to 3 inches in thickness, and have a geodic structure. In consequence of the great labour and expense required, I have not sunk any shaft in this rock, but, at the depth of 5 feet, layers of white sand and blackish powder were found intermixed with it.

There is also another point of interest (a true limestone-basin) in this locality. On the north, south, and west sides there is a dark-coloured limestone, dipping towards a common centre, at angles varying from 5° to 52°; and on the east side there is a thicker limestone, more of the dolomitic kind, which dips 14° west, and strikes north. It contains numerous large, circular holes, about 8 inches in diameter, apparently the casts of some fossil, as the rock is not in a position to have been acted upon by water. The pink and cream-coloured schists are situated within the limestone-basin, attaining an elevation of 250 feet, the limestone forming a thin belt at the foot of the hill, on the north, south, and west sides. That on the east side occupies a higher position, and at the north-east corner of the basin graduates in step-like terraces, till it joins, or nearly joins, the limestone at the foot on the south side. The area of this limestone-basin is not less than 40,000 square yards; but outside it three other rocks are seen, the highest being a silver-grey, micaceous schist; secondly, a sandy, brown-coloured schist; and, thirdly, a hard, massive, blue schist, with innumerable circular impressions.

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4. *On the* Association *of* Granite *with the* Tertiary Strata *near* Kingston, Jamaica. By J. G. Sawkins, Esq., F.G.S.

[In a letter to Sir R. I. Murchison, G.C. St.S., F.R.S., F.G.S., &c. Dated Kingston, July 29th, 1862.]

The object of my writing at present is to inform you that, during the last few months, I have been tracing out a very interesting granitic formation traversing this island from the S.E. to the N.W., the direction of our earthquake-shocks.

My interest in the investigation was enhanced because it was generally supposed that lower rocks of this intrusive class did not appear on this island, and also by frequently observing small crystals of the carbonate of copper associated with it, by which I was encouraged in the belief that I should find this metal accompanying the granitic formation.

This formation first appears in the parish of Port Royal, piercing through the carbonaceous series; then west of the Hope River, in the parish of St. Andrew, between the white limestone and conglomerates. It is consequently of Tertiary age. It sinks below the white limestone at Stony Hill, rises again through the same to the N.W., and trends off into the parish of Metcalfe, where I found the copper associated with the granitic series in the manner the specimens sent with this note will illustrate, which I consider an interesting fact to lay before you.

The character of the granitic rock differs materially in the quantity of each constituent, and it is more frequently accompanied with hornblende than mica, the amount of felspar being greater than the quartz. It has, in many instances, undergone decomposition to so great an extent that it is recognized with difficulty.

After I surveyed Anguilla, some of the Americans engaged at Tombrero examined and experimented on the bone-breccia I found there; they abandoned it in a few days, and found no phosphatic rocks on the island worthy their attention.

NOVEMBER 19, 1862.

James Brunlees, Esq., C.E., 5 Victoria Street, Westminster, and M. Auguste Laugel, Ex-Secrétaire de la Société Géologique de France, Orleans House, Twickenham, were elected Fellows.

The following communication was read:—

On the CAMBRIAN *and* HURONIAN FORMATIONS. By J. J. BIGSBY, M.D., F.G.S.

CONTENTS.

PART I.
1. Introduction.
II. Characters of the Cambrian Rocks.
  a. Typical Form and Distribution.
  b. Stages in the Cambrian Epoch.
  c. Stratigraphical Characters.
  d. Organic Elements.
  e. Paucity of Fossils.
III. Abundance of Life above the Cambrian.
  a. Tracks of Crustaceans.
  b. Phosphatic Coprolites with *Lingulæ*.
  c. Primordial Zone.
Table I. Synopsis of the Cambrian.
Table II. Fossils of the Primordial Zone.

PART II.
I. Introduction.
II. Characters of the Huronian Rocks.
  a. Geological Position.
  b. Geographical Distribution.
  c. Lithological Characters and Typical Form.
  d. Connexion with the Laurentian.
  e. Igneous Intrusions.
III. Huronian of various Districts.
  a. South Shore of Lake Superior.
  b. Norway.
IV. Relations of the Cambrian and the Huronian.
V. Conclusion.
Table III. Synopsis of the Huronian.

PART I.—REMARKS ON THE GEOGRAPHICAL CONDITIONS OF THE CAMBRIAN SYSTEM.

I. *Introduction.*—Some of the following statements, and the conclusions to which they have given rise, were originally intended to refer, in chief, to the presence or absence of organic remains in the Cambrian rocks; but, led on by points of interest that gradually presented themselves, the inquiry has been conducted further than was at first anticipated.

I may perhaps be allowed, for the present, to take for granted that the Cambrian of Western Europe passes conformably upwards into the Silurian series, with certain changes introduced by altered conditions. Usually these two sets of rocks are mutually conformable, and pass into each other, sometimes by insensible gradations *.

It is also true that their unconformity is very frequent, from the local operation of plutonic forces. I shall not stop now to bring forward proofs of these several assertions.

I have given as a Table a synoptical list of all the Cambrian deposits known to me, and also other Tables of some use. On these Tables is grounded much of what is advanced in this paper.

* I ought, however, *in limine*, to say that the published proofs of this connexion between Cambrian and Silurian beds (*some of them at least*) need revision.

II. *Characters of the Cambrian.*—The Cambrian formation is so varied in its particulars, and so familiar as a whole, that a definition of it need not be attempted.

We find in it, however, the following characters:—

§ 1. In Northern and Western Europe alone (or nearly alone) it consists principally of purple and black clay-slates, often chloritic and micaceous, together with conglomerates, grits, and sandstones, placed almost indifferently on any horizon.

§ 2. This schistose constitution is elsewhere absent, except in one or two localities; and usually if any rocks exist intermediate between the Silurian beds and a crystalline base, those rocks are derived from the latter, and have no mineral or palæontological connexion with the Silurian series.

§ 3. *Immediate* contact (transgressive) between the Silurian and the metamorphic rocks may be said to be more general and more extensive than between either the schistose or the simply conglomeratic rocks above mentioned, which are themselves, perhaps, about equal in extent.

§ 4. The Cambrian has a tendency to assume a local character, inclining perhaps to the mixed schistose character mentioned in § 1, the typical form as heretofore considered.

§ 5. The various beds, argillaceous, arenaceous, &c., are inconstant in their succession, *i. e.* they have different horizons; and some may be absent altogether.

§ 6. They vary also in their thickness, both as a whole and in the individual beds.

§ 7. Some of the mineral substances essential to organic structure, such as lime, phosphorus, fluor, azote (?), are absent, except a little of the first, and that rarely.

§ 8. With a large and varied assemblage of highly organized life in the lowest Silurian deposit, we find this older, but kindred set of rocks to be almost totally wanting in evidences of animal and vegetable existence. Such forms as do appear are of low organization, and do not indicate a fauna differing essentially from that of the Silurian scheme: life is not here another, and an original, conception.

§ 9. The Cambrian is not the Huronian.

a. *Typical Form and Distribution.*—The description given in § 1 may be taken as representing very briefly the typical form of the Cambrian as generally understood, and as first seen in Wales by Professor Sedgwick. It has since been traced, with modifications, into Ireland, Brittany, Dép. Loire Inférieure, &c., in France, as well as into Thuringia and Bohemia, and less distinctly in a few other districts.

Many of the leading facts in Cambrian geology may be learnt by consulting the large Table at the end of this part of the paper; and still more satisfactorily by recourse to the original authorities, as set down in the footnote*.

* The principal authorities on the Cambrian Formation are as follows:—
England and Wales.—Professor Sedgwick. Proc. Geol. Soc. and Quart. Journ.

In § 2 a very different state of things is revealed: there is not a shred of Cambrian schist, nor of its grits and peculiar conglomerates, throughout vast spaces in America, as far as is yet known, embracing many degrees of latitude and longitude, throughout the Arctic Seas, Hudson's Bay, North-east America, with Texas, Nebraska, and Wisconsin.

We see the same absence of Cambrian schist through vast breadths of Northern Europe, that is, in Scandinavia, the north-west end of Scotland, and in Sardinia. In fact, the larger part of the schistose rocks of examined countries, though apparently Cambrian, is really Huronian.

From all these countries, as I have said, schists are either altogether absent or extremely rare. Where there is an intermediate mass of rock, it is a conglomerate supporting the Silurian base, and resting transgressively on the crystalline rocks. To take the following cases: a gneissic conglomerate is seen at and about Whitehall, on Lake Champlain, New York, in this position; also on the River San Saba, in Texas; in Nebraska, among the Black Hills; on Granite Island, Black Bay, Lake Superior *; and in the north-west of Scotland and the neighbouring isles.

The mineral constitution of all these conglomerates is much the same, but wholly dependent on that of the rock below. Thus the red Scottish conglomerate is totally derived from the underlying Laurentian rock, and, though in contact, has no mineral connexion with the Silurian above. It is both coarse and fine, and small portions of it are triturated into fine red or purplish sandstone.

Geol. Soc., *passim*; Philosophical Magazine.—Professor Sedgwick and Professor M'Coy. British Palæozoic Rocks and Fossils, 1855.

GREAT BRITAIN, &c.—Sir R. I. Murchison. Siluria, 2nd edit.; Quart. Journ. Geol. Soc., vols. xvi., xvii., *et passim*.

WALES, &c.—Prof. A. C. Ramsay. Lectures at Government School of Mines; Lectures at Royal Institution; Quart. Journ. Geol. Soc. vol. ix. pp. 162, 172; Geologist, vol. i. p. 171.—W. T. Aveline, Esq. Geol. Survey Sections, sheets 36, 37.—J. W. Salter, Esq. Quart. Journ. Geol. Soc. vol. xii. p. 246, and vol. xiii. p. 200.

SCOTLAND.—G. Tate, Esq.; Geologist, 1860, p. 240.—D. Page, Esq. Brit. Assoc. Rep. 1858.—Professor Harkness. Quart. Journ. Geol. Soc. vol. viii. p. 393; vol. xii. p. 239.—Professor J. Nicol. Quart. Journ. Geol. Soc. vol. xiii. p. 17.

IRELAND.—J. B. Jukes, Esq., and Messrs. Wylie and Kinahan. Journ. Dublin Geol. Soc. vol. v. &c.

FRANCE.—MM. Elie de Beaumont et Dufrénoy. Explic. de la Carte Géol. de France, pp. 130, 158, 204, 251.—MM. Lorieux et de Fourcy. Carte Géologique de Morbihan.—MM. Dalimier. Bull. Soc. Géol. France, N. S., vol. xviii. p. 664; Comptes Rendus, vol. xlvi. p. 636 (Cotentin and Pyrenees).—MM. de Verneuil, d'Archiac, Rouault, Triger, &c.; also Siluria, 2nd edit. p. 444.—Rozet, Ardennes.

ALPS.—MM. von Hauer et Fœtterle. Annales des Mines, 5^{me} sér., vol. viii. p. 130.

GERMANY.—Barrande. Syst. Sil. de Bohème; Bull. Soc. Géol. Fr. vol. viii. &c. &c.—Sir R. I. Murchison and Professor J. Morris. Quart. Journ. Geol. Soc. vol. xi. pp. lvi, 412.

S. AMERICA.—D'Orbigny. Cours de Paléontologie, pp. 111, 169.

N. AMERICA.—Roemer. Bull. Soc. Géol. Fr., N. S., vol. xviii. p. 216.—B. F. Shumard. Bull. Soc. Géol. Fr., N. S., vol. xviii. p. 220.

* Sir W. E. Logan, Geol. of Canada, 1862, p. 78.

These conglomerates and sandstones, sometimes 1500–3000 feet thick, are local; and they are called Cambrian because they occupy the place of that formation in the geological series; but they have no affinity with the Cambrian of Wales, for, both in Europe and America, they are merely the re-cemented fragments of the crystalline rock on which they repose. The same is to be said of the bed near Kinnekulle, in Sweden, which lies between the granitic gneiss there and the Silurian strata; it consists in like manner of re-adhering fragments of the metamorphic rock below—the "arkose" of Brongniart. These are important facts, and they derogate not a little from the high rank at present held by the Cambrian as a system.

The schistose form of Cambrian and the local puddingstone variety do not form constant and widely diffused strata, like those of many kinds of rocks in the palæozoic and mesozoic series, the conglomerate being native, the other comparatively foreign.

According to our present information, the *direct* superposition of Silurian upon metamorphic rocks, mentioned in § 3, prevails over considerably more space than the schistose or conglomeratic intermediates. We find them in close adhesion for 2000 miles, from Labrador westward to Minnesota beyond the Mississippi River. At a multitude of points along this line they have been examined by Logan, Murray, Chapman, Richardson*, myself, and others,—on the shores of Labrador, Lake St. John (L. Canada), near Quebec, Montreal, Kingston, Lake Simcoe, on the Great Lakes, and so on.

Professor Haughton, in the Appendix to M'Clintock's 'Fate of Sir John Franklin,' broadly states that "the Silurian rocks of the Arctic Archipelago rest *everywhere directly* on the granitoid rocks, with a remarkable red sandstone, &c.;" and, I suppose, transgressively, seeing that the Professor finds the Upper Silurian beds there to be horizontal. The same immediate contact takes place in the Appalachians and on the Upper Mississippi†.

In the excellent account of the geology of Bolivia and Southern Peru, by David Forbes, Esq., F.R.S.‡, the word "Cambrian" never occurs. Silurian beds of enormous thickness, with *Cruziana Boliviana* and Annelid-tracks, are said to rest directly on granite. Nor does the Cambrian show itself in either of Mr. Forbes's two sections (335 and 328 miles long respectively) through these countries, abounding in palæozoic strata. In the neighbouring province of Chiquitos M. d'Orbigny observed the same facts; and also on the flanks of the lofty Illimani, a part of these Cordilleras §.

This direct contact obtains also in Scandinavia, as at Andrarum, &c., in Scania, and in the Silurian trough of Christiania, Norway ||. As regards Bohemia, M. Barrande expresses himself very satisfactorily on this point in 'Bulletin Soc. Géol. de France,' n. s. vol. x.

* Logan and Murray, Geol. Reports, *passim*; Chapman, Canadian Naturalist; Richardson, Geol. Reports, Canada, 1857, p. 78.

† Rogers and D. D. Owen, Reports on Pennsylvania and Minnesota.

‡ Quart. Journ. Geol. Soc. vol. xvii.

§ Travels in South America, vol. iii. pp. 146, 225.

|| Sir R. I. Murchison, Quart. Journ. Geol. Soc. vol. xi. p. 162.

General Portlock, also, states* that in Londonderry coarse arenaceous schists, containing *Orthis grandis*, &c., rest directly upon, and skirt granite and hornblende-rock (see section, p. 230). Mr. Jukes observed a similar fact among the Cambrians of Wicklow † (see section); and Professor Ramsay informs me that he has seen it in Scotland.

b. *Stages in the Cambrian Epoch.*—The Cambrian epoch then is marked by three distinct conditions, which perhaps represent stages caused by changes in the relative level of land and sea; and hence the want of constancy in its constituents.

These conditions are :—

1. The under rock, Laurentian or Huronian, having been exposed above water, no deposit whatever took place until the Primordial epoch of the Silurian period arrived; in some places with abundance of life.

2. The parent rock having been submerged in shallow and disturbed waters, native conglomerates were produced by well-known processes (Scotland, North America, &c.).

3. These parent rocks having subsided into great depths, arenaceous, argillaceous, and other deposits took place, sometimes to the thickness of 25,000 feet and more; such deposits becoming afterwards more or less metamorphosed.

c. *Stratigraphical characters.*—Passing by § 4, we find in reference to § 5, on examining the Synoptical Table, that the succession of beds in this group of strata (schists, grits, conglomerates, &c.) is quite irregular. This arises from local causes; and the want of stratigraphical agreement, it is remarkable to notice, is as strong in contiguous districts as in those more remote.

In considering § 6, which treats of the thickness of the Cambrian strata, I believe that unusually great accumulations have no great geological importance. I deduce from them that a change of level has occasioned heavy denudations somewhere, followed, of course, by loaded currents, which have been suddenly arrested at the place of accumulation. One effect is, that this thick deposit has few or no fossils, for more than one obvious reason. We see this exemplified by the ten or twelve thousand feet of Devonian Sandstone (without organic remains) in Kerry and Cork, Ireland ‡; and in the three thousand feet of the same rock, forming the Catskill Mountains, New York, containing few animal remains, but many plants. The thickening of the middle Carboniferous Limestone in Derbyshire and Yorkshire is another similar instance. We must not, therefore, exaggerate the importance of thickening in the Cambrian.

d. *Organic elements.*—As regards § 7, the absence from this set of beds of phosphorus and such elements is generally believed, but upon what authority I know not. Instead of numerous analyses in support of this opinion, I only recollect a very few by Mr. D. Forbes and by Dr. Lyon Playfair. But we must not forget Professor Daubeny's

* Survey of Londonderry, p. 303.

† Jukes and Wylie, Journ. Dublin Geol. Soc. vol. vi.

‡ Jukes, Student's Manual, p. 409.

curious experiments, which consisted of sowing barley in powdered rocks; he found that whatever might be the age of the rock, provided only that it belonged to a series in which organic remains were present, the amount of phosphoric acid present in the crop exceeded considerably that existing in the barley from which it was derived. In Cambrian rocks Dr. Daubeny found no trace of phosphorus.

We know that calcareous matter in Cambrian beds seldom occurs, and only in small infiltrations, as in Wales, or in a thin and solitary seam, as in Brittany. Where one or more large calcareous beds, unfossiliferous, are observed in a group which seems to belong to this epoch, the strong probability is that it belongs to the Huronian series.

e. *Paucity of Fossils.*—We also know that § 8, marking the impoverished life of the Cambrian, contains an important fact which we are authorized to state, after a most pertinacious and skilful examination of its beds, in Wales and Ireland especially. Nor need we expect any traces of life in the contemporary conglomerates of Scotland and America.

The frequent occurrence of conglomerates, grits, and sandstones in this series forbids our attributing the absence of life in it to any permanent abyssal depths, as was supposed by the late justly lamented Daniel Sharpe*.

The remains of organized beings in the Cambrian are few, both generically or specifically, and they are mostly related to certain low forms in the primordial zone of various countries; for instance, the *Arenicola didyma*, which corresponds to the *Scolithus* (Annelid-tubes); *Palæopyge Ramsayi*, corresponding to the Trilobite (a high form, however); the *Oldhamia* is a sea-weed (Goeppert); the plant *Chondrites* occurs also in the Silurian as a genus†.

I repeat, then, that in this period we are not introduced to any set of living creatures wholly unknown in later periods, as we are in some other parts of the great sedimentary succession.

Some of the reasons for the absence of organic remains from this group of beds may be stated as follows:—

1. The general absence of carbonate of lime, and the probable absence of phosphorus and other elements of organization.
2. The great, continued, and occasionally tumultuary deposition of sediment, in which few or no animals could have lived (James Hall).
3. The deposition of substances unfit to support life, whether directly poisonous or because consisting of any unmixed material, as clay, lime, silex, &c.
4. Plutonic action, which was frequent in the Cambrian, operated by modifying or destroying rocks and their contents; metamorphism, which need not have been caused by subterranean heat, has the same effect.
5. Shells in porous or permeable strata are often removed by the infiltration of solvent fluids‡.

* Quart. Journ. Geol. Soc. vol. ii. p. 208. † *Ibid.* vol. xii. p. 246.
‡ See Mr. Prestwich's remarks, *ibid.* vol. viii. p. 245.

However we may seek to account for the absence of a varied fauna in the Cambrian strata, the fact is rendered the more remarkable by the occasional abundance of the phosphates, sulphates, and fluates, as well as of graphite, in the Silurian basement-rocks, which immediately followed the Cambrian by tranquil deposition.

III. *Abundance of Life above the Cambrian.*—Not a few naturalists are inclined to believe that in the *molluscan* form of life, from the earliest times, instead of an ascendant movement in their order of development, a decadence even has affected them ; and that these organisms of distant date do not yield in specialization to the like forms of today. A tendency to concur in such opinions may well arise from a consideration of the following facts, which show at the same time how abrupt and great must have been the change from life in the subjacent strata, to life in the Silurian ; from a state, that is, of great comparative sterility, to one singularly prolific.

a. *Tracks of Crustaceans.*—First, the occurrence in the Potsdam Sandstone (the oldest Silurian) about the mouth of the Ottawa, that noble river, and about Lake Louis into which it flows, of footprints and tracks of several species of large Crustaceans. They have been faithfully described by Sir W. E. Logan and Professor Owen, besides having been most generously illustrated by the former. These appearances carry the existence of complex forms of life very far down.

b. *Phosphatic Coprolites with Lingulæ.*—Secondly, while James Hall, the great palæontologist of America, found in the Delthyris Shaly Limestone (Upper Silurian) coprolite-like, phosphatic nodules, full of crushed *Lingulæ*, the Geological Commission of Canada met with facts more remarkable still. They discovered that a large breadth of country on the Ottawa River, from Lake Allumettes to, at least, Grenville, a distance of 80 miles in the south-east direction, is more or less sown with coprolites in calciferous sandstone. This rock, at the Falls of the Allumettes, is a conglomerate, and rests directly on Laurentian gneiss.

These coprolites are sometimes $2\frac{1}{2}$ inches long by $\frac{1}{2}$ an inch broad, and are filled with a large species of *Lingula* ; in one case a fragment of this shell was found lying crosswise in the nodule. Besides the *Lingulæ*, a few *Pleurotomariæ* or *Holopææ* are met with in these reniform masses.

The Grenville coprolites are smaller and more compact than those of Lake Allumettes. They give off an animal odour when heated, and principally consist of phosphate of lime, as do those of the Township of Hawksbury, close by. These latter are yellowish brown, and smell like burnt horn when heated. Dr. Lyon Playfair proved that similar bodies from the Bala Limestone, in North Wales, were foreign bodies of animal origin*. All phosphatic nodules may not be coprolites ; but these from the Ottawa have every appearance of being so.

The coprolites of Lake Allumettes, &c., seem to be the excretions of

* Quart. Journ. Geol. Soc. vol. vii. p. 267.

large animals, and are probably those of the large Crustaceans whose footprints have just been alluded to. So that we may now-a-days have some small perception of the antique and mysterious interest which is attached to these relics, dragged out of the abysses of time by a young science.

D. D. Owen and others after him have mentioned, with great surprise, the countless myriads of phosphatic *Lingulæ* buried in the Potsdam Sandstone which forms the walls of the River St. Croix, in Minnesota, not far from its junction with the Mississippi. In the same way Trilobites in incalculable numbers occupy a bed of Trenton Limestone at Beaufort, Quebec; all in fragments, and lying flat upon each other.

c. *Primordial Zone.*—I have, finally, to request your attention to the great and unexpected abundance of life in the Primordial rocks, the immediate successors of the inhospitable Cambrian.

About ninety genera of Mollusca, and 250 species (allowing for regional duplicates) met with regionally, are found in this one set of beds (called indifferently Potsdam Sandstone, Lingula-flags, Primordial zone, or, as I believe, Taconic). The Molluscan orders and genera are well represented in this initiatory basement-bed, even up to the most highly organized—excepting the *Cephalopoda*, which are entirely absent.

In this Primordial zone alone, there are twenty-five genera of Trilobites, and 114 species; seventy-three species have been found in Scandinavia alone, partly because this region has been thoroughly examined (by Angelin).

It must be remembered that vast spaces of the earth's surface have received no attention, and that extensive Silurian districts, such as Russia, Germany (exclusive of Bohemia), Scotland, and Sardinia, have as yet furnished not one indisputable basement-fossil; while from others, Australia, France, Spain, we have received but one or two.

We cannot but feel and express great astonishment to see a rich and well-balanced fauna thus spring forth from a Cambrian barrenness which was nearly absolute, and with a quickness not yet fully explained. Indeed this barrenness is in all probability more apparent than real, for, according to Mr. Salter, we are dealing with shore-deposits only, which generally present few species. There may have been, and probably was, a deep-sea fauna*.

All that has now been stated may well prepare our minds to recognize a living nature in the Laurentian, or fundamental gneiss-rocks, equally diversified and plentiful. We may not have found, at this moment, the very forms themselves, but their residuary elements are there in vast abundance.

* With a group or commonwealth of living creatures in the Primordial zone, so well furnished and peopled in every department of Molluscan life, some requiring deep or shallow waters, some only flourishing in moist sands or tangled seaweed, and others on rocks above low water, is it not probable that the universal, shallow levels frequently attributed by continental authors to the earliest Silurian period have only existed in imagination?

Table II.—*General Summary of Primordial Fossils.*

Countries.	Authors.	Genera. Cephalopoda.	Genera. Gasteropoda.	Genera. Pteropoda.	Genera. Brachiopoda.	Genera. Crustacea.	Genera. Annelida.	Genera. Cystidea.	Genera. Bryozoa.	Genera. Zoophyta.	Genera. Incertæ sedis.	Genera. Fucoids.	Genera. Total.	Species. Cephalopoda.	Species. Gasteropoda.	Species. Pteropoda.	Species. Brachiopoda.	Species. Crustacea.	Species. Annelida.	Species. Cystidea.	Species. Bryozoa.	Species. Zoophyta.	Species. Incertæ sedis.	Species. Fucoids.	Species. Total.
Spain	Casiano de Prado	...	1	..	3	5	...	1	...	...	...	1	11	...	2	...	5	8	...	1	...	...	...	...	16
Sardinia	Della Marmora	Omitted, but existing.																							
France	De Verneuil	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	1
England and Wales	Murchison, &c.	...	...	...	2	7	1	...	...	...	...	1	11	...	...	...	3	8	2	...	...	...	1	...	14
Scotland	Murchison, &c.	None?																							
Ireland		None.																							
Germany		Not known.																							
Bohemia	Barrande	...	...	1	2	7	...	3	1	...	2	1	17	...	...	...	2	27	...	4	6	...	2	1	42
Russia	Murchison, &c.	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1
Scandinavia	Kjerulf, Angelin	...	...	...	5	12	...	...	1?	...	...	...	18	...	...	...	8	73	...	...	2	...	...	...	83
Australia	Selwyn	...	...	...	1	...	...	...	1	...	...	...	2	...	...	...	1	...	...	...	1	...	...	...	2
Quebec, N. A.	Billings	2	7	...	6	8	...	...	?	2	...	...	25	9	21	...	9	22	...	...	30	...	...	...	91
Straits of Belleisle, Newfoundland.	Billings	...	...	1	1	2	...	...	...	2	...	2	8	...	...	3?	5	3	...	...	...	...	...	2	13
Vermont, U. S.	Billings	...	...	...	2	1	...	...	...	...	...	1	4	...	...	...	2	4	...	...	...	...	...	1	7
New York	Hall, &c.	1	6	1	2	7	1	...	...	...	...	1	19	1	12	1	4	7	1	...	...	...	...	3	29
Pennsylvania	H. D. Rogers	...	...	...	2	...	1	...	...	...	...	1	4	...	...	...	2	...	1	...	...	...	...	1	4
Tennessee	Safford	...	...	...	...	1	1	...	...	...	...	...	2	...	...	...	...	1	1	...	...	...	...	...	2
Texas	Roemer, Shumard	...	...	...	5	5	...	...	...	...	...	...	10	...	...	...	5	6	...	...	...	...	...	...	11
Wisconsin	Hall, &c.	...	...	1	3	6	1	...	1	...	...	1	13	...	...	1	2	8	1	...	1	...	...	1	14
Nebraska	Hayden & Meek	...	...	...	3	2	...	...	...	...	...	...	5	...	...	...	3	2	...	...	...	...	...	...	5
Total		3	14	4	38	63	5	4	4	4	2	10	151	10	35	5	52	169	6	5	40		3	10	335

ies, pp. 37 & 38.

1. W[…]LAND.		5. IRELAND.
From Menai Strait[…] to the North of Sno[…]	[…]s, Quart. Journ. […]p. 360. Sir R. I. […]uart. Journ. Geol.	Wicklow, Wexford, and Dublin Counties.
Prof. Ramsay, Ho[…] Survey of Great Br[…]	[…]W. Coast, Quart. […]ol. xvi. p. 219. […] Ross-shire, Quart. […]ol. xvii. p. 175.	Messrs. J. B. Jukes & Wyley, Journ. Geol. Soc. Dublin, vol. vi. p. 28.
Grit ……… Slate ……… Grit ……… Slate ……… Slate and grit ……… Grit and conglomer[…] Conglomerate and g[…]	[…]*ghlands.* […]stone, } 2000–2500 feet. […]al, grey, with red. […]*rath.* […]red, hard. […]bjacent gneiss. […]l. *[…]Coast; also Isle of […]Ross-shire.* […]pebbles of the rock […]al.	Chiefly green and purple grits, shading off into quartz-rocks. Grits, bright red, green, grey, coarsely granular, hard. Sandstones, compact, close-grained, white mica-flakes occasionally. Slates, green, red, olive-brown, yellowish, often chloritic, or a fine roofing-slate or flagstone. (Stratification very confused.) These rocks are identical with those of Barmouth, Wales.

6. FRA[…]	[…]AMERICA.	10. AUSTRALIA (?).
Cotentin? (Norm[…] Dalimier, Bull. So[…] vol. xviii. p. 664. Granville, Cancale[…] Bull. Soc. Géol. Fr. […] Ardennes, Slate-[…] mogne. Rozet et Du[…] mont et Dufrénoy, E[…] Géol. de France.	[…] Saba. B. F. Shu- […]l. Fr. n.s. vol. xviii. […] […]. Hayden, Trans. […]. vol. xii. p. 23, &c.	Victoria, on Rivers Loddon and Campaspe? A. Selwyn, Quart. Journ. Geol. Soc. vol. x. p. 299.
Cotentin? (Nor[…] Sandstone, compact,[…] Sandstones, purple. Cong'omerate, fels[…] Limestones, thin. Clay-slates at St. Zo. Schists, micaceous ar[…] Schists, macliferous. *Granville, Ca[…]* Schists, macliferous, and conglomerates *Ardennes (R[…]* Quartzite, thick-bedd[…] Psammite, alternatin[…] Schists, pale. Schists, shining; thi[…] Schists, argillaceous a[…]	[…]*as.* […]se granitic, 150 ft. […]nounted by fossili- […]Sandstone.) […]*ska.* […]brian. […] rests extensively […]bly on Azoic (Hu-	Sandstones, ferruginous, micaceous. Grits, felspathic, red, grey, brown. Slates, clay, arenaceous, felspathic, Flagstones, fine arenaceous. Quartz-rock, Conglomerate } alternating. Direction N. and S., dip high. Gold in quartz-veins. No organic remains. Thickness 35,000 feet. (N.B. Probably Lower Silurian.)

Table I.—*Synopsis of the Cambrian Formation.*

The order of succession in this Table is *descending.—For further information see List of Authorities*, pp. 37 & 38.

1. Wales.	2. England.	3. England.	4. Scotland.	5. Ireland.
From Menai Straits over Glyder Fawr to the North of Snowdon.	Longmynd, Shropshire. Thickness probably not more than 14,000 ft., as it is exaggerated by folds, the curves being cut off by denudation.	Longmynd, Shropshire.	North Highlands, Quart. Journ. Geol. Soc. vol. xv. p. 360. Sir R. I. Murchison. Cape Wrath, Quart. Journ. Geol. Soc. vol. xvi. p. 216. Durness and N. W. Coast, Quart. Journ. Geol. Soc. vol. xvi. p. 219. Isle of Lewis and Ross-shire, Quart. Journ. Geol. Soc. vol. xvii. p. 175.	Wicklow, Wexford, and Dublin Counties.
Prof. Ramsay, Horiz. Sect. 31, Geol. Survey of Great Britain.	W. T. Aveline, Horiz. Sect. 36 & 37, Geol. Survey of Great Britain.	J. W. Salter, Quart. Journ. Geol. Soc. vol. xii. p. 247.		Messrs. J. B. Jukes & Wyley, Journ. Geol. Soc. Dublin, vol. vi. p. 28.
Feet. Grit .... 1300 Slate .... 180 Grit .... 20 Slate .... 400 Slate and grit .... 650 Grit and conglomerate .... 900 Conglomerate and grit, obscure 1650 —— 5100	Feet. Sandstone, coarse red .... 7,000 Shale, sandy, red, micaceous... 300 Sandstone and shale, hard, coarse, red .... } 4,500 Sandstone, hard, gritty, grey... 1,500 Shale, purple, sandy .... 100 Sandstone, coarse, reddish-brown .... } 2,000 Shale and sandstone, purple... 4,000 Grey rock, very hard .... 1,000 Conglomerate .... 200 Sandstone, hard .... 400 Shale, greyish-blue, slaty ...... 2,000 —— 23,000 No base seen. (No lime.)	1. Sandstones and conglomerates, red. 2. Slates and sandstones, grey, alternating. 3. Sandstones, hard, grey, greenish. 4. Slates and sandstones, grey and red, alternating. 5. Slates, red, and hard. 6. Sandstones, hard, greenish, very fine-grained, or micaceous, rippled. 7. Schists, harder, rippled, felspathic; thin shale, greenish, alternating. 8. Schists, dark olive, with few lines of crystalline limestone.	*North Highlands.* Conglomerate-sandstone, chocolate-brown. } 2000–2500 feet. Gneiss, fundamental, grey, with red granite-veins. *Cape Wrath.* Sandstones, purple-red, hard. Conglomerate of subjacent gneiss. Gneiss, fundamental. *Durness and N. W. Coast; also Isle of Lewis and Ross-shire.* Conglomerate, red, pebbles of the rock below. Gneiss, fundamental.	Chiefly green and purple grits, shading off into quartz-rocks. Grits, bright red, green, grey, coarsely granular, hard. Sandstones, compact, close-grained, white mica-flakes occasionally. Slates, green, red, olive-brown, yellowish, often chloritic, or a fine roofing-slate or flagstone. (Stratification very confused.) These rocks are identical with those of Barmouth, Wales.

6. France.	7. France.	8. Bohemia and Germany.	9. North America.	10. Australia (?).
Cotentin? (Norman Bocage). M. Dalimier, Bull. Soc. Géol. Fr. n. s. vol. xviii. p. 664. Granville, Cancale, &c. D'Archiac, Bull. Soc. Géol. Fr. n. s. xviii. p. 664. Ardennes, Slate-quarries of Rimogne. Rozet et Dumont. De Beaumont et Dufrénoy, Explic. de la Carte Géol. de France.	Départ. Loire. Brevenne, &c., in patches. Grüner, Ann. des Mines, 3^{me} sér. vol. xix. p. 89. Near Maletroit, Guers, &c. Lorieux and De Fourcy, Geol. Map of Morbihan. Upper Garonne. La Pique. Leymerie, Compt. Rend. vol. xlvi. p. 636.	Central Bohemia. Barrande, Sil. Syst. Bohême, p. 66. South Thuringia and Saxony. Murchison and Morris, Quart. Journ. Geol. Soc. vol. xi. p. 412.	Texas, River San Saba. B. F. Shumard, Bull. Soc. Géol. Fr. n.s. vol. xviii. p. 218. F. Roemer. Nebraska. F. V. Hayden, Trans. Amer. Phil. Soc. n.s. vol. xii. p. 23, &c.	Victoria, on Rivers Loddon and Campaspe? A. Selwyn, Quart. Journ. Geol. Soc. vol. x. p. 299.
Cotentin? (Norman Bocage). Sandstone, compact, intermixed with [schists. Sandstones, purple. Conglomerate, felspathic materials, [granitic. Limestones, thin. Clay-slates at St. Zo. Schists, micaceous and satiny. Schists, macliferous. *Granville, Cancale, &c.* Schists, macliferous, with quartzites and conglomerates. *Ardennes (Rimogne).* Quartzite, thick-bedded. Psammite, alternating, thin-bedded. Schists, pale. Schists, shining; thickness great. Schists, argillaceous and roofing.	*Département de la Loire.* Schist, argillaceous, with felspar-crystals. Gneiss, micaceous or talcose. Granite, slaty. Schist, green, satiny, argillaceous. Sandstone, green, quartzose, schistose. Lydian quartz, in small beds. Conglomerate of quartz-pebbles in siliceous cement. (Much disturbed by porphyry.) *Near Maletroit, Guers, &c.* Schist, extensive, talcose. Granite, porphyritic. *Upper Garonne. La Pique.* Schists, fine, satiny (extensive). Gneiss. Granite.	*Bohemia.* Schists, granular and conglomeratic, with quartzose boulders. Slates, argillaceous. Schist, talcose, chloritic, micaceous. Granite. Total 22,000 feet. (No lime.) *South Thuringia and Saxony.* Schist, chloritic, greenish, and with hornstone. Schist, dark-coloured argillaceous. Quartz-rock. All these beds are in great mass, and are overlain conformably by Silurian.	*Texas.* Sandstone, granitic. Conglomerate, coarse granitic, 150 ft. Granite. (All surmounted by fossiliferous Potsdam Sandstone.) *Nebraska.* [Generally no Cambrian. Potsdam Sandstone rests extensively and unconformably on Azoic (Huronian?) rocks.]	Sandstones, ferruginous, micaceous. Grits, felspathic, red, grey, brown. Slates, clay, arenaceous, felspathic, Flagstones, fine arenaceous. Quartz-rock } alternating. Conglomerate } Direction N. and S., dip high. Gold in quartz-veins. No organic remains. Thickness 35,000 feet. (N.B. Probably Lower Silurian.)

Part II.—The Huronian Formation of Canada not Cambrian; with Remarks on its Regional Affinities.

I. *Introduction.*—The Huronian formation, one of the several great discoveries of the Geological Commission of Canada, will probably be found to be an important member of the fixed rocks of the earth; for on the north side of the Great Lakes of Canada, where it was first detected, it occupies a district 710 miles long, and there is a considerable area of it on the south-east side of Lake Superior. It is largely and variously developed also in Norway, and probably in other parts of Europe.

This set of rocks is therefore of great importance, geologically as well as economically, and is fully entitled to be called a formation if we adopt Deshayes's definition of the term, that is, "a certain number of beds laid down under the influence of the same phenomena"*.

The general feeling of geologists† is that the Huronian of Canada is the same as the Cambrian of Western Europe; but careful examination into all the circumstances seems to provoke more than a doubt as to the correctness of this view.

No true Cambrian exists in North America according to Dana‡; and, as far as my experience goes, the Huronian constitutes a group of beds which may be said to be its substitute in place, if not in time. It has received a name from Sir W. E. Logan because it has a new and distinct character, and needed a designation; and by him and Mr. Murray, his able and enterprising coadjutor, it has been minutely described.

As I have paid three visits to the greater part of this formation, in Canada, I may be permitted to make the following brief comments upon it; my object being, first, a summary account of its place and relations, with some small additions of my own; secondly, to point out an all but perfect identity in the members of this formation in Europe and America; and thirdly, to show that it is not Cambrian.

II. *Characters of the Huronian.*—a. *Geological position.*—The Huronian of Canada occupies a stratigraphical horizon not far from that of the Cambrian of Wales, between the Laurentian gneiss and the Silurian; but it is older, for the Cambrian is continuous into, and conformable to the base of the Silurian, when the latter is in an undisturbed and normal state, while the Silurian is invariably transgressive as regards the Huronian formation in both hemispheres. I have seen this exemplified in numerous instances in Lake Huron and Lake Superior. That the traces of life are not found in this formation affords but moderate aid in fixing its date, for this happens

* Deshayes, Bull. Soc. Géol. de France, N. S., vol. ii. p. 89.

† Sir W. E. Logan, American Journ. Science, N. S., vol. xiv. p. 227. Sir R. I. Murchison, Siluria, 2nd edit. p. 19. Coquand, Traité des Roches, p. 299. D'Archiac (as I understand), Bull. Soc. Géol. de France, N. S., vol. xviii. p. 664. Morris, Geologist, vol. i. p. 139.

‡ Dana (Address, Rhode Island), Canad. Journ. 1855, p. 386.

§ At the Twin Falls, River Menomonee, south side of Lake Superior; see Foster and Whitney, Geol. of Land District, p. 24. Also between the Rivers Missassaga and St. Mary, Lake Huron; see Sir W. E. Logan, Geol. of Canada, 1862, p. 56.

in all the stages of the sedimentary series; and the not uncommon marks of ripples, cracks, and mud-flows§ in its quartzites and fine grits render it possible that signs of animal or vegetable existence may eventually be met with. Neither do we learn much from its extraordinarily agitated and metamorphosed condition in many places, for the same may occur at any epoch.

b. *Geographical distribution.*—The geographical position of the true Huronian beds may be broadly stated in the following words.

With a breadth often small (10–20 miles), but often concealed by jungle and morass, the northern mass extends 710 miles, as already stated, along the north-west watershed of Upper Canada, and principally along the borders of Lakes Huron and Superior. We trace it for 150 miles from near Lake Tematscaming (R. Ottawa), 80 miles north-west of Lake Nipissing, south-westwards, to Shebahahning, on Lake Huron; and from thence westward for 120 miles to Gros Cap, in Lake Superior. From this well-marked headland, northerly and westwardly, the whole edge or coast of the latter lake, with small and uncertain exceptions, consists of this formation as far as the Pigeon River, near Grand Portage, about 440 miles; and it is amply exposed by the bare and hilly nature of the country *.

Another aggregate of these beds occupies more than 3000 square miles of the region south-east of Lake Superior, on the River Menomonee (a tributary of Lake Michigan), and the districts north and west of that river. It is an area of very irregular shape, 80 miles wide in one place, and having its highest points 1800 feet above the sea-level †.

There is good reason to believe, according to my own recorded observations, that the only three contiguous lakes in South Hudson's Bay at all known geologically—the Lacroix, Lapluie, and the Lake of the Woods—each a few hundred miles round, consist largely of this formation. Besides being extensively developed in the Adondirock Mountains of the State of New York, and probably also in Missouri and Arkansas, the Huronian is seen to great advantage in Norway, and is not wanting in France; but of its occurrence in these countries more will be found in the sequel.

c. *Lithological characters and typical form.*—Table III. is a Synopsis exhibiting the leading features of the Huronian beds, wherever they are known with tolerable certainty. It enables us to keep facts separate and distinct from suppositions.

For the minuter details, the several authorities named in the foot-notes may be consulted ‡. Of these I am most indebted to the minute and truthful reports of the Geological Commission of Canada; but my obligations to the other investigations are neither few nor small.

By reference to the Synopsis (Table III.) at the end of this paper, it appears that, on the large scale, the characteristic beds of

* Sir W. E. Logan, Geol. of Canada, 1862; Murray, Canadian Reports.

† Foster and Whitney, Geol. of Land District of Lake Superior, p. 31.

‡ Sir W. E. Logan. Geology of Canada, 1862, p. 50, &c. Alexander Murray, Geological Reports of Canada, 1849, 1857, &c. Thomas McFarlane, Canadian Naturalist, &c., vol. vii. p. 1. Foster and Whitney, Geology of Land District, Lake Superior. Durocher, Mémoires de la Société Géol. de France, vol. vi.

the Huronian formation in America, whether in Canada, Wisconsin (U. S.), or elsewhere, consist of:—

1. Slate; chloritic, siliceous, and hornblendic.
2. Slate; conglomeratic, matrix impurely argillaceous; the pebbles and boulders being granitic, syenitic, and slaty.
3. Conglomerates; quartzose, with white quartzose and red jasper pebbles.
4. Trap and pale greenstone, both conformable and intrusive.
5. Granite; red, moderately porphyritic, intrusive.
6. Crystalline limestone; with some serpentine.

All these rocks are set down in the order of their abundance, the most prevalent first; Nos. 2 and 3 being very thick compared with the other beds individually, *i. e.* 7900 feet out of 16,700 feet (between the Rivers St. Mary and Missassaga, Lake Huron*), if we add up the separate beds.

d. *Connexion with the Laurentian.*—The connexion of the Huronian set of rocks with the Laurentian is not so fully made out in America as in Norway; but we are not without some good materials, and time will do the rest. Sir William Logan met with a conformable junction of these two formations on the River Kaministiquia, on the north side of Lake Superior, in the rear of Fort William. At the lower end of the Second Portage, above the Grand Falls, the Laurentian appears as a massive syenite or, rather, as a hornblendic gneiss. Resting on it conformably, there occurs a series of dark, greenish-blue or greenish-black slates (Huronian); the one rock almost running into the other. The section extends for a quarter of a mile along the river-bank. The Huronian has been observed to rest on granite in two places,—on Spanish River in Lake Huron, and again on the same granite 100 miles to the west, near Gros Cap, on Lake Superior†.

No particular succession of individual beds has been, as yet, made out, either in Europe or America; not but that there are, in parts, long lines of distinct stratification, but because there are scarcely any dips to be depended on. On Lake Huron, in the district just mentioned, this may well happen, through the occurrence of two enormous downthrows in a wild and marshy country; and then again from the inextricable confusion created by the violent intrusion of molten rocks at five distinct epochs‡, the last of which produced large deposits of copper-ores.

e. *Igneous intrusions.*—Any description by words of the mutual penetration, interweavings, and delicate inosculations of bright-green greenstone and red granite, over considerable spaces of the mainland, between the Rivers Missassaga and Thessalon, has been abandoned in despair by Mr. Murray§. And Messrs. Foster and Whitney have been equally foiled by similar blendings of granite and greenstone on the Menomonee, between Sandy Point and Sturgeon Point||.

* Murray, Canadian Geological Report, 1858, p. 76.
† Canad. Geol. Report, 1849, p. 8.
‡ Murray, Report on North Shore of Lake Huron, 1849, p. 14.
§ Canad. Geol. Report, 1858, p. 76.
|| Foster and Whitney, Geol. Surv. of Lake Superior Land District, 1851, p. 19.

Many years ago I published in the 'American Journal of Science' a coloured representation of these capricious mutual infoldings on the east of the mouth of the Thessalon River (Lake Huron). In the middle, too, of a naked islet in Lake Huron, opposite the river just mentioned, but three miles off, a boss of granite pushes its bare red mass from beneath a paste-like envelope of fine-grained greenstone, just as occurs in Carp River, on the south side of Lake Superior*, but the mode of contact is not stated.

III. *Huronian of various districts.*—a. *South shore of Lake Superior.*—With respect to the Azoic Series of the south shore of Lake Superior, already alluded to, I beg to refer the Society to columns 8, 9, and 10 of Table III., and here quote Foster and Whitney† as saying that this series "is in alternating beds, of great thickness, of gneiss, of chloritic, talcose, argillaceous, and siliceous slate, of quartz, of saccharoid and crystalline limestones, and serpentines—all much contorted, highly inclined—nowhere having a sedimentary aspect, and most metamorphic near the lines of igneous outburst," so powerful and numerous hereabouts.

I look upon the Huronian or Azoic Rocks, here spoken of, as belonging to the Huronian of the north of Lake Huron and Lake Superior, for the following stratigraphical and mineralogical reasons:

1. The transgressive relation of the Potsdam Sandstone to both.
2. The same strike East and West in both; dip high.
3. The great prevalence in both of chloritic, dioritic, and hornblendic slates.
4. The abundance of trappean and hornblendic rock, sometimes in brecciated masses composed of jasper, slate, felspar, and hornblende.
5. The extraordinary and extensive intermixture of the beds of greenstone and granite, which defy description and classification.
6. The same quartzites, occasionally becoming a conglomerate, with red jasper and other pebbles.
7. The occasional bands of white, grey, and red crystalline limestone.
8. The presence in both of greenstone-dykes.
9. The absence of organic remains in both.

The quartzite of the country south of Lake Superior, unlike that of Lake Huron, contains vast beds of magnetic iron-ore.

Besides the Huronian beds, as already treated of, Sir W. E. Logan has described with great care a new formation, which he calls "the copper-bearing rocks." They are of great interest, and their more prominent characters may be best seen in columns 10, 11, 12 of the Synoptical Table III. They repose on the Huronian, unconformably to the crystalline rock below and to the Potsdam Sandstone above. This subformation occupies about 250 miles of the north shore of Lake Superior—that is, from Michipicoton to Pigeon River. It is very naturally divided into a lower and an upper group; the lower group, consisting of bluish slates or shales, with sandstones and interstratified columnar trap, extends from Thunder Head to Pigeon

* *Op. cit.* p. 14. † *Op. cit.* p. 14.

River, a distance of 42 miles. The upper group consists of sandstones, limestones, indurated marls, and conglomerates, interstratified with columnar trap.

b. *Norway.*—Leaving without remark the deposits in Arkansas and Missouri mentioned in column 12, because, although probably Huronian, they require further study*, I now proceed to Europe, where, at present, it is more than probable that the Huronian formation exists in Norway† in great quantity, and very clearly shown, as well as in other parts of that quarter of the globe.

In Norway, to a consideration of which country I shall first apply myself, it has received from M. Durocher‡ the name of "*the semi-crystalline schists,*" or "*the second group of Azoic formations,*" the lowest or first being Fundamental or Laurentian Gneiss§.

M. Durocher has called the first-named formation semi-crystalline because in Norway, as in Canada, it consists of two associated portions, the amorphous (sedimentary) and the crystalline (metamorphic); but it is a name very easily misunderstood.

M. Durocher professes himself unable to fix upon the age of these rocks with precision, but believes them to form a transition between the Fundamental Gneiss and the fossiliferous palæozoic rocks (Mémoire, p. 61), and that it corresponds in part to the Cambrian of Sedgwick.

This set of rocks does not, as in Canada, spread out in one mass continuously to great distances, but is in distinct tracts and basins within and upon the Fundamental Gneiss, which is the general base of all the rocks of the north of Europe.

There are six of these basins according to M. Durocher: viz. (1) at Nummendal and Haut-Tellemark; (2) in Central Scandinavia; (3) on the South-west coast of Norway; (4) on the sea-coast between Drontheim and Sogne Fiord; (5) in Finmark; and (6) near Tornea, at the head of the Gulf of Bothnia.

There is no difficulty as to the relations of this Huronian, if we may so call it, to the Fundamental Gneiss. It is seen to rest on it conformably in many places||; on the gneiss of Schneehatten, in the Dovrefield; on the south side of the Sogne Fiord; in the Fiord of Urland, &c. And it is often unconformable, as in the valley of the Beine and Elv¶, in the Fillefield, and other places; but these

* Engelmann, Foster and Whitney's Geological Survey of Lake Superior Land District, p. 31.

† To Thomas Macfarlane, Esq., of Acton, Eastern Townships, L. C., belongs the credit of associating the Huronian of Canada with the semi-crystalline schists of Norway, in a most valuable memoir published, in February 1862, in the 'Canadian Naturalist.' I have laboured independently to the same end, upon materials gathered from other sources.

‡ The author of a survey of Norway, most elaborate as far as is within the power of an individual. His paper in the sixth volume of the 'Mémoires de la Société Géologique de France' is a model of geological description.

§ Von Buch, Sir R. I. Murchison, Keilhau, Kjerulf, Naumann, and Macfarlane have also done good work in this country.

|| Mémoires de la Soc. Géol. de France, sér. 2, vol. vi. pp. 61, 90.

¶ *Op. cit.* p. 92.

M. Durocher considers local phenomena. But, as we learn from this author, the contact of this formation with Silurian is only seen with perfect distinctness on Lake Miosen*, where the latter is *transgressive* in a moderate degree, because, in the course of its undulations, the Huronian at that spot has not a high dip. The meeting of the Silurian beds of Hedemark, on the south of Lösness, with the Huronian or semi-crystalline Azoic rocks is rendered not so clear on account of the undulations of the latter, which have only a moderate dip, and are but feebly crystalline. Nevertheless it is here that it truly takes place. As in Canada, no very clear order of succession has been made out in the individual beds of the Norwegian formation. How could there be, when in both countries plutonic action has been intense, prolonged, and minute in its effects?

While these deposits present in their composition notable variations, from place to place, they nevertheless possess in every part of Norway the following common characters.

This second Azoic, or Huronian, formation is for the most part essentially a schist, argillaceous, chloritic, and micaceous by turns; changing often also from the foliate and crystalline condition to the amorphous or sedimentary, and this either suddenly or insensibly.

These schists frequently become siliceous, and then they may be accompanied by granular, compact, and subcompact quartzites; the latter being translucent, and with a conchoidal fracture. The Goustafield quartzite† is remarkably like that of Lake Huron. It is in mountain-masses, as in Canada, where it forms hills, whose sides shine bright and white from amid the dark pines. It is translucent, glassy, and clear; grey, greenish or bluish grey; and brittle, granular, or compact. It is also schistose; a tendency to which structure is increased by interspersed laminæ of talc, chlorite, or mica. Certain varieties on the east side of Altenfiord and elsewhere are red, green, violet, and white. Others assume the form of ribboned jasper (near Hjardal Church) or of hornstone, and become conglomerates and breccias, with a dark-coloured paste, and containing boulders of red and white jasper (on the Mandæla River), of quartz, chlorite-slate, and hornblende. Porphyritic intrusions are common among the quartzites, and those of Nummendal and Tellemark yield much sulphuret of copper, specular iron, and magnetite.

Besides these schists and quartzites, we have, in Norway, grauwackes (grits and conglomerates, in fact), conformable to the schists, &c., with a dark-green base, and pebbles of gneiss, granite, quartz, and porphyry; being the nearest approach, as far as I am aware, to the peculiar greenstone-conglomerate of this age in Canada. We must not always expect identities.

The Huronian limestone here is not quite equal in quantity to that in Canada, with the exception of that in Finmark‡, where it is pretty well developed. It is not white, but dark grey or blackish,

* Mémoires de la Soc. Géol. de France, sér. 2, vol. vi. p. 62.
† *Op. cit.* p. 63. ‡ *Op. cit.* p. 98.

and both granular and compact. For details the Society is referred to the admirable descriptions of Durocher; for general information, necessarily limited, the column in the Synoptical Table III., under the head "Norway," may be consulted.

My reasons for believing the Norwegian *Second Azoic Group* to be *Huronian* are as follows; and it is believed that they are not without great force:—

1. Its place—lying on the Fundamental Gneiss, and covered by Silurian.

2. The discordance of the palæozoic rocks above in regard to it.

3. Its resolving, as in Canada, into several distinct and important parts, not altogether dissimilar to those of Canada.

4. The schistose rocks, the same in kind and proportion in both countries.

5. The immense prevalence in this formation of diorite or greenstone, and of hornstone, both in Norway and Canada.

6. The peculiar, greenish-grey, talcose quartzite, and quartzite-conglomerates, with aphanite and red jasper pebbles, in these countries.

7. The dark-coloured slaty conglomerates, with boulders of gneiss, granite, and greenstone, in both.

8. The limestones in the two regions, similar in kind, and much so in quantity, but few in comparison with the other members, though large in comparison with the Cambrian limestones. Here they are dark, perhaps from graphite.

9. The total absence of life in both regions.

10. The presence in both countries of certain ores of copper and iron. I shall content myself, for the sake of brevity, with referring to Table III. for information regarding the probable Huronian of France.

IV. *Relations of the Cambrian and the Huronian.*—Having now sketched the leading features of the Huronian series, while those of the Cambrian have been treated of in Part I. of this paper, I am at length enabled to exhibit such of their geological differences as point to a difference of epoch, and they are as follows:—

1. The Huronian is unconformable to the Silurian both in America and Europe:—not so the Cambrian.

2. The Huronian in Norway is conformable to the Fundamental Gneiss formation; and confidently believed to be so in America:—not so the Cambrian.

3. Its mass is principally conglomeratic, such conglomerate being of a special and typical kind:—not so the Cambrian.

4. It contains large and prolonged beds of marble:—not so the Cambrian, which is nearly destitute of limestone.

5. Its plutonic invasions and disturbances are quite different in quantity and intensity from those of the Cambrian period, being of five distinct epochs *.

6. The Huronian is more highly metamorphosed than the Cambrian (containing gneiss, &c., Foster and Whitney); notwithstanding that in Anglesea the latter formation has been completely changed into gneiss.

* A. Murray, Canada Geol. Report for 1849, p. 14.

7. It contains large deposits of copper, native and in a state of combination:—not so the Cambrian*.

8. The Upper Huronian of Logan (his copper-bearing rock) has no resemblance to, or affinity with, the Cambrian (see Synopses, Tables I. and III.).

9. It is destitute of the traces of life:—not quite so the Cambrian.

V. *Conclusion.*—It is now time to conclude by observing that the 1st, 2nd, 4th, and 9th of these points appear to be fatal to any idea of the Huronian and Cambrian being the same formation, while the rest are not without weight.

Three circumstances create in my mind a strong feeling that the Huronian is *greatly* the older deposit. These are:—

1. Its marked similarity, lithologically, to the Fundamental Gneiss formation.

2. The conformity of these two sets of beds.

3. The great interval of time which must have elapsed between the periods of laying down the Fundamental formation and the Silurian, if we are to judge from the occasionally vast thickness of the Cambrian.

Beyond all comparison, the Huronian is more wide-spread and extensive, as well as more uniform in its mineral constitution, than the Cambrian group. It is, perhaps, also more important economically.

December 3, 1862.

Edward Hesketh Birkenhead, Esq., Master of the Wigan School of Mines; Antonio Brady, Esq., Maryland Point, Stratford, Essex; Samuel Higgs, Jun., Esq., Assistant-Secretary of the Royal Geological Society of Cornwall, Penzance; and Alan Lambert, Esq., 2 Portugal Street, Grosvenor Square, London, were elected Fellows.

The following communications were read:—

1. Description *of the* Remains *of a new* Enaliosaurian (Eosaurus Acadianus), *from the* Coal-formation *of* Nova Scotia. By O. C. Marsh, Esq., M.A.

(Communicated by Sir Charles Lyell, V.P.G.S.)

[The Regulations of the Society do not admit of this important communication being printed in full in the 'Quarterly Journal,' because, owing to an unfortunate misunderstanding, it was not received until after it had been published in the 'American Journal of Science and Arts' for July 1862, New Series, vol. xxxiv. p. 1, to which palæontologists are referred for a more detailed description of the fossil bones alluded to.]

[Abstract.]

Introduction.—The Reptilian remains from the Coal-measures, hitherto described, were stated to be few in number, and mostly of

* There is some copper in the Longmynd.

This series of beds is unconformable to those enumerated in the next column, and is copper-bearing. According to Engelmann (Foster and Whitney, Geol. Lake Superior, Land District) and Dr. Emmons, the series may be considered to exist in Arkansas and New York.			
	NORWAY.	FRANCE.	
	In Tellenmarken, South Norway, West Finmark, &c.	Upper Loire. (See Grüner, Annales des Mines, sér. 3. vol. xix. p. 151.)	
	True succession of the beds unknown. Quartzite or quartz-slate, grey, splintery, talcose, &c., in thick beds. Mica-schist, quartzose. Gneiss, fine-grained. Hornstone. Hornstone - porphyry passing into jasper. Slates, chloritic, talcose, &c. Limestone, granular, alternating with Gneiss, quartzose. Diorite, 1000–2500 feet thick. Conglomerate, with quartzose pebbles of red jasper, quartz, and slate. Strike various. Dip about 45°. Plutonic invasions numerous.	Schists, chloritic, with small beds of Lydian stone. Conglomerate, quartzose, with pebbles of Lydian stone and white quartz. Sandstone. Schist, micaceous, argillaceo-talcose. Gneiss. Granite, schistose. The 2nd, 3rd, and 4th beds alternate with one another, and are traversed by quartzose porphyry.	

TABLE III.—*Synopsis of the Huronian Formation.*

The order of succession in this Table is *descending* or unknown.

LAKE HURON.		
1. From Lake Tematscaming S.W. to Lake Huron, 150 miles.	2. North shore of Georgian Bay; from Collins Inlet, westward, 70 miles?	3. North shore, between the Rivers Missassaga and St. Mary, near Lake Superior.
{ Conglomerate of quartz, with jasper and quartz pebbles. { Quartzite, white and pale sea-green. { Quartzite, alternating with { Slates, chloritic and siliceous. Conglomerate, like the one below. Limestone, pebbly. Conglomerate, slaty, with boulders of syenite and jasper. Slates, siliceous, chloritic. No regular succession detected; the total thickness is 10,000 feet.	Feet. Greenstone .... 700 Quartzite-conglomerate with red jasper pebbles... } Quartzite, whitish-grey ... } 1000 Quartzite, alternating with } Slates, blue or black ...... } 500 Conglomerate-slate .... 800 Limestone (very long) ...... 250 Conglomerate-slate .... 1000 Quartzite, pale green ...... } Slates, green argillaceous ... } 1200 Greenstone .... 400 Slates, chloritic .... 1000 6850 Plutonic intrusions very frequent.	Feet. Quartzite, white .... 400 Limestone, like that below ... 200 Quartzite, white, mottled ... 150 Limestone, green, grey, and cherty; red sandstone at the bottom..................... 400 Quartzite, white, massive ... 2,970 Conglomerate of white quartz; red jasper and other pebbles 2,150 Diorite, alternating with ... } Quartzite, iron-stained, ripple-marks, &c. .... } 2,300 Conglomerate, like the one above .... 3,000 Limestone, grey and green; greatly disturbed .... 300 Diorite, alternating with ... } Conglomerate-slate, argillaceous, with boulders of gneiss, syenite, jasper, quartz .... } 1,280 Diorite .... } Quartzite-conglomerate...... } alternating. } Quartzite, white, vitreous ... } 1,000 Trap, interstratified .... } Slates, epidotic, chloritic ... } 2,000 ~~Quartzite, grey~~ .. .. 500 Gneiss. 16,650 Extreme confusion; two great faults. Plutonic invasions very frequent.

LAKE SUPERIOR.		
1. North and North-east shores; from River St. Mary to Pigeon River, 440 miles.	2. North and North-east shores; from River St. Mary to Pigeon River, 440 miles.	3. South shore; between Lakes Superior and Michigan. (See Foster and Whitney, *op. cit.* p. 19.)
UPPER HURONIAN of Logan. **Upper Group.** Sandstones, red and white, with calcareous shales: trap interstratified. Limestone, reddish-white, 120 feet. Sandstones, conglomeratic, with red jasper pebbles and limestones intermixed. Grit, white, with jasper pebbles. Veins numerous, containing ores of copper. Dykes of diorite, syenite, and porphyry, abundant. Trap, amygdaloidal and columnar. **Lower Group.** Slates, alternating with sandstone and limestone. Chert and Dolomite, with specks of Anthracite. Conglomerate, green, with jasper and quartz pebbles. Trap, in conformable bands, on several horizons. This series of beds is unconformable to those enumerated in the next column, and is copper-bearing. According to Engelmann (Foster and Whitney, Geol. Lake Superior, Land District) and Dr. Emmons, the series may be considered to exist in Arkansas and New York.	Quartzite, slaty and conglomeratic, containing pebbles of jasper and quartz. Slate-conglomerate. Slates, like No. 7. Quartzite. Mica-slate. Diorite, alternating with Slate, dark grey, and green. Dip, N. and S. 70°. Laurentian gneiss.	Potsdam Sandstone, transgressive. Conglomerate, quartzose, with quartz-pebbles. Slate, siliceous; *Novaculite.* Slate, chloritic. Trap, hornblendic and felspathic, bearing Potsdam Sandstone in denuded spots. Trap-dykes, frequent. 4. Same region nearer Lake Superior. Limestone, crystalline; on several horizons, with clay-slate. Magnetic and specular iron-ore, with white quartz. Hornblende-rock, compact. Slates, chloritic, talcose. Quartzite, felspathic. Granite, intrusive. The same section is seen on Chocolate River and Carp River.

NORWAY.	FRANCE.
In Tellenmarken, South Norway, West Finmark, &c.	Upper Loire. (See Grüner, Annales des Mines, sér. 3. vol. xix. p. 151.)
True succession of the beds unknown. Quartzite or quartz-slate, grey, splintery, talcose, &c., in thick beds. Mica-schist, quartzose. Gneiss, fine-grained. Hornstone. Hornstone-porphyry passing into jasper. Slates, chloritic, talcose, &c. Limestone, granular, alternating with Gneiss, quartzose. Diorite, 1000–2500 feet thick. Conglomerate, with quartzose pebbles of red jasper, quartz, and slate. Strike various. Dip about 45°. Plutonic invasions numerous.	Schists, chloritic, with small beds of Lydian stone. Conglomerate, quartzose, with pebbles of Lydian stone and white quartz. Sandstone. Schist, micaceous, argillaceo-talcose. Gneiss. Granite, schistose. The 2nd, 3rd, and 4th beds alternate with one another, and are traversed by quartzose porphyry.

Batrachian or Amphibian affinities; and it was observed that, previous to the year 1844, the evidence of even this low form of reptilian life during the Carboniferous period was unsuspected by most geologists, and its first appearance upon the earth confidently referred to the Permian epoch. The author gave a short *résumé* of the reptilian remains discovered since that date in rocks of the more ancient period, especially alluding to the joint discoveries of Dr. Dawson and Sir Charles Lyell* and the more recent researches of the former geologist†.

The remains which form the subject of the present communication consist of two centra, or bodies of vertebræ, which were discovered by the author in August 1855. Their resemblance in form and appearance to the vertebræ of *Ichthyosaurus* was considered by him to be so marked that, at the time of the discovery, he referred them to that genus. A subsequent and more careful examination and comparison, though it confirmed his idea of their Enaliosaurian character, showed some important differences; consequently, as every endeavour to procure further remains met with no success, he proposed for the fossil the name of *Eosaurus Acadianus* in a short notice which appeared in the 'American Journal of Science' for March 1862, N. S., vol. xxxiii. p. 278. In a subsequent number of the same journal a full description was given, illustrated with figures and microscopic sections of the vertebræ.

Locality whence the fossil was obtained.—The fossil was found at the South Joggins, in Nova Scotia, on the southern shore of the Chiegnecto Channel, a branch of the Bay of Fundy, in a bed of argillaceous, chocolate-coloured shale, which forms part of group xxvi. in the elaborate section of this formation made in 1852 by Sir Charles Lyell and Dr. J. W. Dawson.

Mr. Marsh then gave some stratigraphical details respecting the coal-measures of this locality, noting the more fossiliferous beds and the principal organic remains found in them.

Osteological description.—The vertebræ, as already stated, are two in number, and when discovered were attached to each other‡. Their uniformity in size and appearance, as well as their collocation when found, would indicate that they belonged to the same animal, and were contiguous in the vertebral column. They are remarkably well preserved, a result of their complete ossification in their natural state, and of their being imbedded in the peculiar matrix which has since contained them, and furnished the material for their mineralization. The posterior vertebra, in fact, with the exception of a small fracture, seems to be nearly as perfect as in its original condition; and from it the description and measurements given§ were mainly taken.

A detailed account of the osteological characters of the fossil was then given, and the points in which it agrees with, or differs from,

* Quart. Journ. Geol. Soc. vol. ix. p. 58.

† *Op. cit.* vol. xvi. p. 273.

‡ See Am. Journ. Science, pl. 1. figs. 1 & 2, n. s., vol. xxxiv.

§ *Op. cit.* p. 4, &c.

Ichthyosaurus were particularly described, and contrasted in a table of the measurements of the vertebræ in the two Enaliosaurians.

In the margin of one of the vertebræ there is an angular notch, about a line in depth, which Prof. Agassiz, after a casual examination, considered to be organic rather than accidental, and to indicate an inferiority of structure, as a similar character is common in Fishes. Prof. Jeffries Wyman, on the other hand, regarded the notch as purely accidental, and the result of a fracture, which has also displaced the articular pits of the superior arch. He is also of opinion that the notch would not be sufficiently important, if it were organic, to affect at all the Enaliosaurian character of the remains.

Microscopic structure.—A microscopic examination of the osseous structure of these vertebræ revealed well-marked reptilian characters, which were fully described and compared with the characters exhibited by microscopic sections of the vertebræ of *Ichthyosaurus* and *Plesiosaurus*.

Comparison with other vertebræ.—The author then stated that the vertebræ of *Eosaurus*, in their biconcave centres, exhibit a structure which prevails in the class of Fishes, in the Labyrinthodonts, as well as in a few genera of extinct Saurians, and which is seen in existing reptiles only in the Geckos and the Perennibranchiate division of Batrachians.

Amongst Fishes, the *Plagiostomi* were stated to possess vertebræ having more in common with those of *Eosaurus* than others of the class, but that the latter show a much higher degree of ossification in all their parts than the former; also that the osseous structure differs in the two cases, and that these vertebræ do not possess, on their articular faces, any traces of those concentric rings which so generally exist on the vertebræ of fossil and recent Sharks.

Mr. Marsh also alluded to the persistence of the notochord in the Palæozoic Fishes, and the incomplete ossification of the vertebræ in Mesozoic species; also to the general difference in the osseous structure of these vertebræ and those of Fishes. He therefore rejects that class, and places the *Eosaurus* among the Reptiles.

The differences between the fossil in question and reptilian biconcave vertebræ, other than those of the *Ichthyopterygia*, were then pointed out, the author remarking that in the orders *Ganocephala* and *Labyrinthodontia* of Owen, either the notochord was persistent or the neurapophyses were anchylosed to the centrum, neither of which characters is to be observed in *Eosaurus*. The *Crocodilia* of the Secondary formations differ from it in having the superior arch united to the centrum by suture; and in the only genus of *Sauropterygia* whose vertebræ resemble it in their proportions (cervical vertebræ of *Pliosaurus*), the articular faces were flat, or but very slightly concave.

The characters of the vertebræ of *Eosaurus* were contrasted at length with those of *Ichthyosaurus*, and a very close resemblance was found to exist between them, especially in their flattened and subhexagonal form, in their deep and regular terminal cavities, and in the separate state of the neural arch. The most marked differences are seen in the absence of costal articular surfaces from the sides of the centrum, in the deeper concavities at the vertebral extremities, and in the form and dimensions of the superior arch in this fossil. It was therefore concluded that the points of similarity between it and the *Ichthyosauri*, which it most resembles, clearly indicate that they belong to the same natural group of marine reptiles, and to the same order; while the differences which exist between them seem to be sufficiently numerous and important to authorize the conclusion that they are generically distinct, as might naturally be expected from the vast periods of time that separated their existence.

Habits of the Eosaurus.—These vertebræ of the *Eosaurus*, although the only remains of the genus at present known, are so characteristic and well preserved that Mr. Marsh considers them sufficient to indicate that the animal, like the later Enaliosaurians, was of great size, air-breathing, cold-blooded, and carnivorous; that it was aquatic, and probably marine, inhabiting the sea or estuaries, or, possibly, as might be inferred from the place of its entombment, the mouths of rivers flowing into the sea. The flattened form of the vertebræ, the great depth of their terminal concavities, the separate condition of the neural arch, and its short longitudinal extent at the base, were stated to be all consistent with the conclusion that the *Eosaurus* was capable of rapid progress through the water in pursuit of its prey, which was probably fishes; and since it had then, according to our present knowledge, no superior in point of size, it probably reigned supreme in the waters of the Carboniferous era.

Chemical examination.—Mr. Marsh observed that a comparison of the composition of recent and fossil bone is interesting, both in a chemical and a physiological point of view, and has already attracted some attention. As he considered it desirable to add to the limited data on this subject hitherto collected, he analysed a portion of a vertebra of the *Eosaurus*, and the results were given in full.

A preliminary qualitative examination showed the presence of iron, manganese, copper, alumina, lime, magnesia, potash, soda, organic matter, and water, as well as fluorine, chlorine, and sulphur, with silicic, carbonic, phosphoric, and sulphuric acids. The complete separation of these various constituents was necessarily attended with some difficulty, and the methods resorted to were therefore fully described, and a table showing the percentage of each constituent substance was given.

A nitrogen-determination was made with a portion of the fossil of a rather different character, which gave ·776 per cent. for the amount of that substance in it. This corresponds essentially with the results obtained by M. Delesse, who has made some extensive researches on this point, and who considers that the quantity of nitrogen in fossil bones is, within certain limits, a reliable indication of their age. The above-mentioned percentage of nitrogen is much greater than that indicated by the analysis, and was probably due in part to the substance used in the two cases being somewhat different; but part of the nitrogen in the determination may have been derived from ammonia, which is sometimes introduced into fossils by infiltration. A want of sufficient material prevented fuller investigations of the organic elements in these remains.

The fossil bones hitherto analysed appear to have been all from the more recent formations; but it was remarked that the results of this analysis of a Palæozoic fossil did not differ materially, in most respects, from those previously obtained by analysing fossil bones from much newer deposits.

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2. Description *of* Anthracosaurus Russelli, *a new* Labyrinthodont *from the* Lanarkshire Coal-field. By T. H. Huxley, Esq., F.R.S., F.G.S., Professor of Natural History in the Royal School of Mines.

In September last, Mr. James Russell, Mineral Surveyor, of Chapelhall, near Airdrie, called at the Museum of Practical Geology to make some inquiries respecting the probable nature of a fossil (supposed to be a fish) lately brought to light by the workmen engaged upon the Monkland Iron and Steel Company's estate, about a mile from Airdrie and twelve miles east of Glasgow, and found in what is known as the Airdrie or Mushet's black-band Ironstone*. I was at that time absent from London; but Mr. Etheridge, to whom Mr. Russell described the fossil, strongly advised that a careful drawing should be made and sent up to London, for my examination. This was eventually done, and the sketch, faithfully executed in its general characters, which reached me on the 6th of November, appeared so conclusively to indicate the Labyrinthodont nature of the fossil, that I at once requested Mr. Russell to permit me to have it sent up to the Museum for closer examination. Mr. Russell very obligingly consented to this proposition, and the specimen reached me in perfect safety on the 27th of November, my interest in it having in the meanwhile been greatly heightened by the reports respecting its characters which had reached me from Professor Rogers, Mr. David Page, and Mr. Armstrong of Glasgow.

A glance at the fossil was sufficient to satisfy me that these reports had not unduly exaggerated its merits. It exhibited, in fact, the greater part of the contour of a skull, 15 inches long by 12 inches wide at the widest part. That the under or palatine surface of the skull was turned towards the eye was obvious from the numerous stumps of broken teeth which followed the anterior moiety of its contour;

* The President has kindly furnished me with the following note respecting the stratigraphical position of the Airdrie black-band Ironstone:—

"The fossils described in this memoir were found in, or else close to the 'Airdrie or Mushet's black-band' Ironstone, which at this point changes into Coal. According to Mr. Ralph Moore's published section, this stratum lies about 564 feet below the topmost Coal-measures, and about 666 feet above the 'Moorstone rock,' which I believe to be the general equivalent of the English Millstone grit. The bones were therefore found in the true Coal-measures, far above the Gilmerton Limestone series (the equivalent of part of the English Carboniferous limestone, in which *Loxomma* was discovered), and probably 2000 feet or more above the horizon of the Burdie House limestone."

but almost the whole of this surface was obscured by a thick coat of the matrix, in which were partially imbedded many of the long and pointed crowns of the teeth. These had been broken off, and lay not very distant from their stumps, with their points all directed inwards, towards the middle line of the palate. Their arrangement was just such as might have been expected if the axes of the teeth had naturally been turned somewhat inwards, and the vertical crush of the superincumbent strata, after the fossilization of the skull, had consequently caused them all to fall inwards as they broke. The same pressure has produced a slight asymmetry of the whole skull.

From the proportional size and structural features of the teeth, and from the general contour of the skull, I concluded this to be a new genus of Labyrinthodonts; but in order to make sure of the point, I proceeded to develope the fossil, from the hard matrix in which it was imbedded, with much care; removing some of the teeth and, on one side, even a portion of the bony palate, in order to obtain a view of those parts, such as the orbits and posterior nares, which would enable me to decide the question.

The skull, as it now appears (fig. 1), presents almost the whole of its palatine or inferior surface to view, with the exception of the right temporal region. Its greatest length, measured along a median line drawn from the middle of the premaxillary region to a level with the posterior and external points of its prolonged and broad temporal prolongations, is 15 inches. Its greatest width, obtained by doubling the distance from the left posterior and outer margin to the middle line, is 12 inches. Opposite the great vomerine tusks (*d*), the skull measures 5·3 inches in width. It diminishes slightly from this point to the rounded snout, and gradually increases in breadth posteriorly to the level of the supratemporal foramina (*c*), where it measures about 10 inches in width. Beyond this point it widens suddenly by about half an inch on each side, and the lateral contours continue to diverge from hence to a point about 2½ inches distant from the hinder extremity of the temporal prolongations of the skull. The external contour of the temporal prolongation now becomes rounded off, and sweeps evenly inwards, until it meets the internal contour, which appears to be nearly straight. The epiotic processes are not visible.

In the middle line of the base of the skull, extending as far backward as the level of the posterior part of the supratemporal foramen, is the well-ossified basisphenoid, 1·7 inch broad, and slightly excavated posteriorly. The basisphenoid narrows anteriorly, so that, at 1·4 inch from its posterior extremity, it is not more than 0·9 inch wide; beyond this point it suddenly widens to form the lateral processes, like those commonly exhibited by the basisphenoid of fishes, and then rapidly tapers forward, having, at 2·8 inches from its hinder extremity, a diameter of not more than 0·25 inch, and continuing straight and style-like as far as it can be traced, which is to a distance of about 6 inches from its hinder extremity.

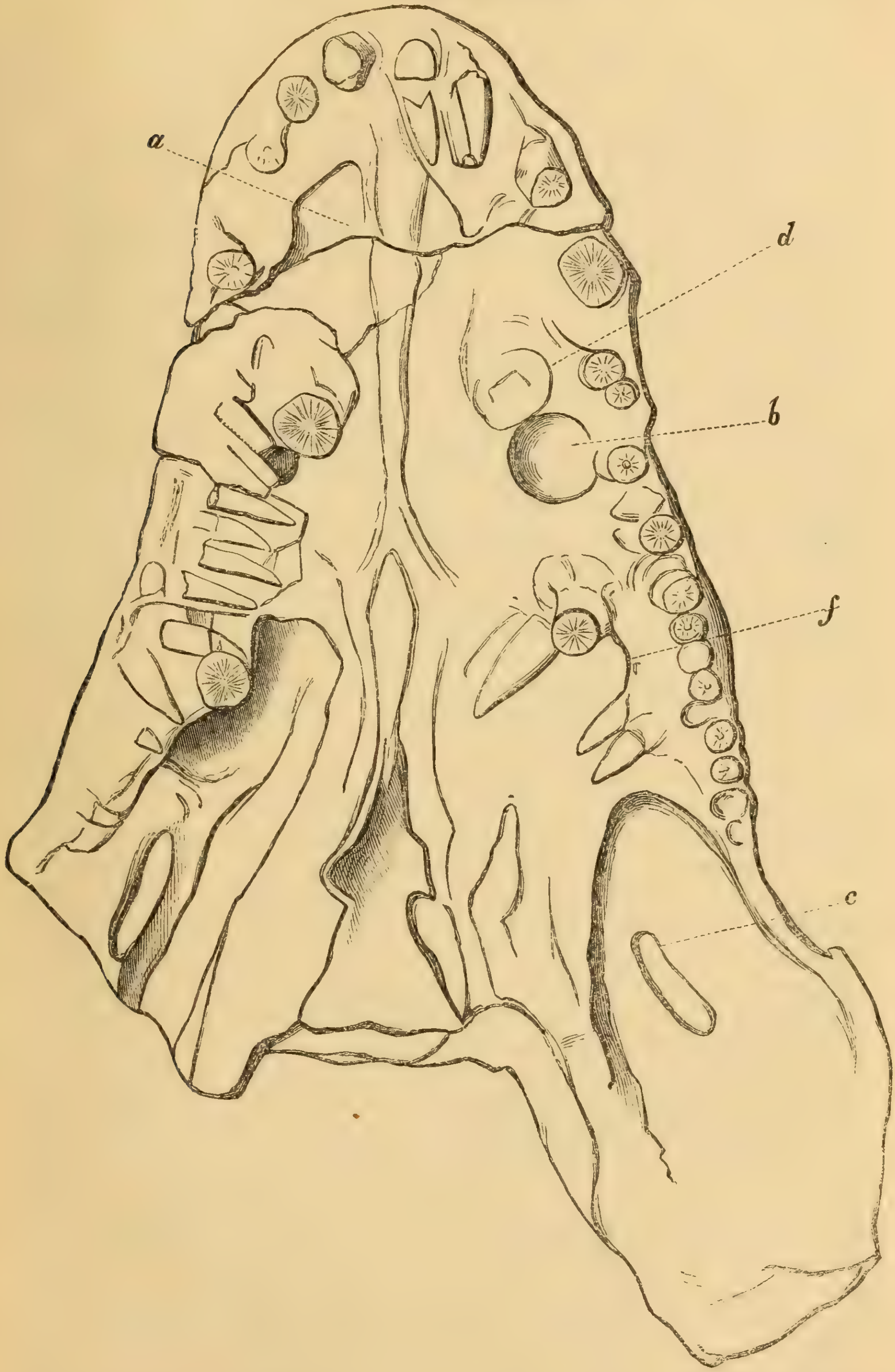
The limits of the vomers cannot be accurately defined; but they are very broad plates, separating the large anterior palatine foramina (*a*) from the comparatively small posterior nares (*b*), which are round apertures, 1 inch in diameter, and 5 inches from the anterior end of the snout, situated between the vomer, the maxilla, and the palatine bones on each side. The vomers unite in the middle line with one another and with the prolonged anterior extremity of the basisphenoid. Posteriorly they are connected with the palato-pterygoid arcade, the separate components of which cannot be accurately defined. The palatine portion, however, is a broad, flat plate, measuring 3·5 inches between the posterior nares and the palato-temporal foramen. It is united externally with the maxilla. Internally it is separated by a narrow interval from the basisphenoid. Posteriorly it passes into the pterygoid portion, which is narrow and curves outward, beneath the inner contour of the temporal prolongation of the skull, to be lost about the posterior and internal angle of that region. Externally the margin of the pterygoid portion is arcuated, to form the boundary of the palato-temporal foramen. Through this foramen the under surface of the upper wall of the skull in the temporal region becomes visible. The sutures separating the component bones of this region are not visible; but on the level of the posterior end of the basisphenoid it presents an elongated aperture, or supratemporal foramen (*c*), 1·3 inch long by 0·4 inch wide. The long axis of this foramen is directed obliquely forwards and inwards, and it is nearer the pterygoid than the external boundary of the palato-temporal foramen.

Although I worked out this region of the skull with extreme care, I was in doubt whether the aperture in question was really a natural one, until I cleared away the matrix from the opposite side, and there found a foramen of quite a similar character, though distorted by the crushing of this part of the skull.

The premaxillary bones, strong and arched, send back two processes from their apposed ends, which run upwards and backwards in the middle line (in the manner common in Amphibia) towards the junction of the vomers. As the anterior portion of the vomerine plate is inclined upwards and forwards, it follows that the most anterior region of the palate has a somewhat arched roof, as in the Frog. The anterior palatine foramina (*a*), included between the recurrent processes of the premaxillaries, their dentigerous processes, and the vomers, appear to be about $1\frac{1}{2}$ inch long by 1 inch wide; but it is difficult, from the condition of the fossil, to define their limits with exactitude.

Thirty-seven teeth, or remains of teeth, are visible. Of these, on the left side, thirteen are situated in the premaxilla and maxilla, and three on the palatine bone; while, on the right side, nineteen are attached to the premaxilla and maxilla, one to the vomer, and one to the palatine bone. On the whole, the maxillary teeth decrease in size from before backwards, but not very regularly. The first tooth on the left side was 1·7 inch long when entire, by about half an inch thick at the base. The second immediately follows it, and is somewhat larger. The third, of about the same size as the second,

Fig. 1.—*Palatine aspect of the skull of* Anthracosaurus Russelli.
(One-third of the natural size.)



a. Anterior palatine foramen.
b. Posterior nares.
c. Supratemporal foramen.
d. Place of attachment of left vomerine tusk.
e. Vomerine tooth.
f. Palatine teeth and alveolar plate.

is separated from the latter and from the fourth, by spaces about three-quarters of an inch wide. The fourth tooth, broken short off, must have been a very large one, being not less than three-fourths of an inch in diameter at the base. It is separated by a deepish fossa, 0·7 inch wide, from the succeeding tooth. This, the fifth, is close to the sixth, and both are small, the base of neither attaining more than 0·3 inch in diameter. The seventh and eighth teeth, rather large, are situated at tolerably equal intervals from one another, and from their predecessors and successors, in the interspace of about 2 inches which separates the sixth from the ninth tooth. There are marked fossæ, as if for the reception of the points of mandibular teeth, between them. The bases of the ninth and tenth teeth, close together, occupy 0·7 inch. They are separated by a space of about half an inch from the eleventh tooth, and this by a somewhat smaller interval from the twelfth, which is close to the thirteenth. The bases of these last-mentioned teeth do not exceed 0·4 inch in diameter. The last tooth is nearly on a level with the anterior margin of the palato-temporal foramen. There is a fossa of nearly the same size as its base behind it, but no trace of the attachment of any other tooth.

The premaxillary and maxillary teeth on the right side by no means exactly correspond, either in position or in size, with those on the left.

The tooth nearest the middle line in the right premaxilla is six-tenths of an inch in diameter, and its base and its several fragments, when put together, show that it had a length of at least an inch and three-quarters. The two succeeding teeth are about half an inch in diameter at the base, and are not more than a quarter of an inch apart. Then follows an interspace of 0·9 inch, in which I think I can trace the remains of the attachment of a great tusk. Then comes a large tooth, 0·7 inch in diameter at the base; and then four small ones, none of which exceed 0·3 inch. The crowns of the succeeding teeth are all broken off, and lie with their points inwards upon the matrix, which covers this region and obscures their broken roots. None of them, however, have a basal diameter of more than 0·35 inch, and the last measures hardly more than 0·2 inch at the base. The anterior of these teeth are about 1·3 inch in length, while the hinder ones become shorter, until the last was probably not more than half an inch long when entire. The right vomer gives attachment to an immense tusk, 0·8 inch in diameter at the base. It could hardly have been much less than 3 inches long, but it is unfortunately broken short off. The left vomer presents the surface for the attachment of a similar tusk, but the tooth itself is entirely detached. There is not the least trace of the existence of any other vomerine teeth besides these.

On the left side, the palatine bone, eight-tenths of an inch behind the posterior nasal aperture, supports a tusk 0·6 inch wide at the base, which, when entire, was very nearly 2 inches long. The palatine bone is raised up into a ridge, so as to form a sort of alveolar wall on the outer side of this tusk, and the wall is continued backwards as a thin plate of bone directed almost horizontally inwards (*f*). At a distance of three-quarters of an inch from the great anterior tusk, the alveolar plate, the margin of which is excavated in the interval, affords support to a tooth 0·35 inch in diameter at its base, and this is immediately followed by another of the same dimensions. These teeth are about 0·9 inch long.

On the right side, the base of a similar palatine tusk and part of an alveolar plate are visible; but there are no small teeth, and the tusk is situated nearly an inch further back than on the left side. But the alveolar plate extends forward in front of this tusk, and presents a deep sinus, in which I suppose a tusk corresponding to that on the opposite side may have been developed. If the sinus upon the palatine alveolar plate of the opposite side has the same signification, it would appear as if there were normally two great palatine tusks on each side, but that the anterior and posterior of opposite sides are shed simultaneously.

The fossil was broken into two pieces when it reached me; the fracture passing obliquely between the third and fourth teeth on the left side, and through the fourth on the right. The fractured surface shows the roof of the skull, or rather the snout, and proves that it was raised into a broad longitudinal ridge, so convex as to be almost semicircular, about 1·5 inch broad and 0·6 inch above the general level of the facial bones. From the sides of this convexity, the sides of the face slope with a gradual curve towards the alveolar margin. The depth of the skull, immediately over the centre of the maxillary alveoli, is rather less than one inch. From the centre of a line joining the margins of the alveoli to the top of the central ridge is a distance of about 1·9 inch; and in the occipital region the skull is not deeper: considering its breadth and length, therefore, the skull is extremely flat.

The teeth are round, or slightly oval in section at their bases, and throughout the greater part of their length. They taper gradually to sharp points and become slightly incurved towards their apices. Their bases are not grooved, but, on the contrary, are marked by numerous delicate and sharp longitudinal ridges, so that transverse sections appear to be very slightly polygonal. Towards the apex of the tooth, two of these ridges, an anterior and a posterior, become more distinctly marked, and, combined with a very slight flattening of the tooth, give it a double edge.

In one of the anterior teeth, the front face towards the point is much worn, as if by attrition against one of the mandibular teeth.

Transparent transverse sections of the teeth exhibit a singularly beautiful and complex structure. The relatively small pulp-cavity sends off primary radiating prolongations, which pass straight to the circumference of the tooth, and at a small distance from it terminate by dividing, usually, into two short branches, each of which gives off from its extremity a wedge-shaped pencil of coarse dentinal tubuli. These spread out from one another, and terminate in a structureless or granular layer, which forms the peripheral portion of the dentine, and, from the small irregular cavities scattered here and there through its substance, reminds one of the 'globular dentine' of the human tooth. An extension of this peripheral layer is continued towards the centre of the tooth, between every pair of primary prolongations of the pulp-cavity. The short secondary processes which are sent out from opposite sides of the primary prolongations of the pulp-cavity, give off in the same way, from their ends, pencils of conspicuous dentinal tubuli, the ends of which terminate in the inward extensions of the peripheral layer. The secondary processes of adjacent primary prolongations alternate and, as it were, interlock with one another, so that the inward extension of the peripheral layer takes a sinuous course between them. A thin layer of dense and glassy enamel invests the tooth continuously, but sends no processes into its interior; and, of course, under these circumstances there can be no cement in the interior of the tooth, nor can its surface be said to be plaited or folded. It will be understood that this description gives merely the principle of arrangement of the parts of the tooth: its details could only be made intelligible by elaborate figures.

In *Rhizodus* and in *Ichthyosaurus* the principle of construction of the complex tooth is totally different, the surface of the tooth being really folded, and prolongations of the cement being continued into the folds.

Addendum, January 14, 1863.

The Referee, to whom the preceding description of the skull of *Anthracosaurus* was sent, has suggested that it is desirable I should express some opinion respecting the systematic relations and affinities of the fossil. I am glad that I am in a far better position to comply with this suggestion now, than I was when the description of the cranium was sent to the Society; for at that time I was not in possession of the valuable evidence regarding the characters of the vertebral column, which has come into my hands within the last few days through the exertions of my indefatigable correspondent, Mr. Russell.

For some years past, I have been acquainted with well-ossified vertebræ and ribs from the Carboniferous formation; but the vertebræ have always been devoid of their arches and processes; and though the ribs presented characters suggestive of their belonging to a higher division of the Vertebrata than Fishes, I thought it better to wait for further evidence as to their real nature before giving any account of them.

More than a year ago, I brought away with me from the collection of the Earl of Enniskillen, at Florence Court, a remarkable rib and vertebral centrum. I have seen similar remains in the admirable collection of Dr. Rankin, of Carluke; and, more recently, Mr. Russell has sent me up a number of vertebral bodies of different kinds from the Airdrie workings. I had every reason to believe some of these vertebræ to belong to *Anthracosaurus*, and it was with that conviction in my mind that I ventured to caution the members of the Geological Society, on the occasion of the reading of Mr. Marsh's paper on "*Eosaurus Acadianus*,"* against too hastily concluding that the vertebral centra, which he had found in the Nova-Scotian coal-

* See *antè*, p. 52.

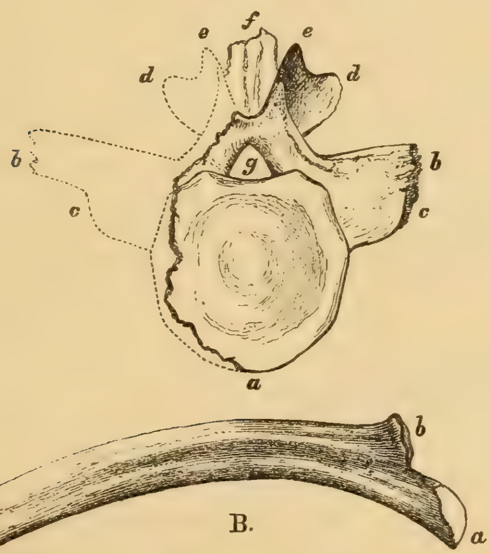
field and then described, were necessarily Ichthyosaurian,—seeing that I had much reason to suspect that they might belong either to Labyrinthodonts, or to some genus of intermediate characters, between Labyrinthodonts and Ichthyosaurians.

Within the last few days Mr. Russell has sent me the vertebra of which an outline-view is given in fig. 2 (one-half the natural size). It was found in the same bed as that which yielded the skull of *Anthracosaurus*, and corresponds very well in size with what one might expect would be the dimensions of a dorsal vertebra of that animal. Associated with it on the same slab are several other less complete vertebræ and the remains of two ribs.

Fig. 2.

A. *Dorsal vertebra of* Anthracosaurus, *viewed from behind.*
B. *Rib of the same Amphibian.*

A.



A.—*a.* Body of the vertebra.
b. The longer division of the transverse process, and
c. The shorter division.
d. Anterior zygapophysis.
e. Posterior zygapophysis.
f. Spinous process.
g. Neural canal.
B.—*a.* Capitulum. *b.* Tuberculum.

The body of the vertebra is greatly flattened from before backwards, as the subjoined measurements will show. The exposed articular surface is concave, and a section which I have had made of a similar vertebral body shows that it was equally concave upon both sides. The concavity, however, is not conical in section like that of a fish's vertebra, but its sides are a little convex, rising slightly, within the margin. Hence the section of this vertebra has very much the same appearance as that of Mr. Marsh's problematical vertebra represented in the figure which accompanies his paper*.

The contour of the vertebral body is not circular, but is slightly angulated, so that it would tend to be octagonal were not the place of

* Am. Journ. Science, n. s., vol. xxxiv. pl. 2. fig. 2.

the uppermost angle of the octagon occupied by the excavated floor of the neural canal. The short sides of the vertebral body are concave from before backwards, and in other specimens exhibit a slightly rugose marking.

The neural arch is very small in proportion to the size of the body of the vertebra, and its contour is nearly that of an equilateral triangle with a curved base.

The very stout sides of the neural arch are continued upwards into a strong spinous process, which is broken off a short distance above its origin and nearly on a level with the upper parts of the zygapophyses. Of the latter the posterior pair are turned towards the eye, and are much broken. The hinder face of the right anterior zygapophysis is visible (at *d*), and its curved contour is nearly entire.

The transverse process of the right side (the only one preserved) springs by a long line of origin from the lower part of the neural arch and from the upper half of the circumference of the vertebral body. It is greatly flattened from before backwards, and its lower half (*c*) ends, at a distance nearly equal to half the diameter of the body of the vertebra, in a rounded edge, which appears to be complete and unbroken. The upper half, on the other hand, terminates in an obviously rough and fractured extremity. I conclude from this circumstance, and from the characters exhibited by the proximal ends of the ribs, which I shall immediately describe, that the upper division of the transverse process extended much further outward than the lower, and I have indicated this in the dotted restoration of the left side of the vertebra.

	inch.
Height of body of vertebra	1·6
Transverse diameter	1·6
Length	0·47
Height of neural arch	0·3
Depth of transverse process	0·8
Thickness of transverse process	0·2

The best-preserved rib is $6\frac{1}{2}$ inches long* and half an inch broad, measured in a direction perpendicular to its length. It is, however, much flattened from before backwards, so that its thickness does not amount to more than one-sixth of an inch. The face of the rib is not flat, but it is somewhat excavated, so that the bone is thinner in the middle than at the edges. At its proximal end the rib exhibits a very distinct *tuberculum* and *capitulum*. The former projects, so as to disturb the sweep of the curve of the convex side of the rib and to convert it for a short distance into a concavity, and it is abruptly truncated posteriorly. The capitulum of the rib continues the line of its general curvature for half an inch beyond the tuberculum, and ends in a rounded extremity. I presume that the capitulum articulated with the lower half of the transverse process (*c*), and that the tuberculum articu-

* The sternal end of the rib is broken off. It was certainly much longer when perfect, as the rib from Lord Enniskillen's collection, though more slender, measures $8\frac{1}{4}$ inches along its curve, and still presents a fractured extremity.

lated with its upper half, in which case the distance (*a*, *b*) on the rib would be practically equal to the excess of length of the upper division of the transverse process over that of the lower.

The skull, a dorsal vertebra, and a rib of *Anthracosaurus* being known, I now return to the question, what are the affinities of that Labyrinthodont?

The large size of the teeth, the comparative solidity of their bases, and the complex character of the labyrinthic ramifications of the pulp-cavity are all characters in which *Anthracosaurus* resembles the *Mastodonsaurus* of von Meyer and Plieninger and its allies, and differs from *Archegosaurus*. Whether *Anthracosaurus* had well-ossified occipital condyles like *Mastodonsaurus*, or cartilaginous ones such as were probably possessed by *Archegosaurus*, does not appear, the fossil being defective in this region. In the large size of the anterior palatine foramina, the extent to which the palate-bones are united with the maxillaries, in the form of the pterygoidean arch and that of the basisphenoid, *Anthracosaurus* is nearer to *Archegosaurus* and *Dasyceps* than to *Mastodonsaurus*.

But the vertebræ are altogether Mastodonsaurian. The vertebræ of *Mastodonsaurus* were described and figured in 1844 in the well-known work of von Meyer and Plieninger, 'Beiträge zur Paläontologie Würtembergs.' No fewer than seventeen vertebræ were discovered in one slab, together with the skull of this remarkable Labyrinthodont; another block contained eight vertebræ, belonging to the same animal, but not immediately succeeding the former; and a third slab of stone contained five more trunk-vertebræ, besides three others which were caudal. Dr. Plieninger seems inclined to think that all these cervico-dorsal vertebræ belonged to one animal: but even the fact that seventeen vertebræ were found together in one block, and the existence of caudal vertebræ, must be amply sufficient to satisfy every anatomist of the untenability of the hypothesis that the Labyrinthodonts were frog-like or toad-like in form.

The trunk-vertebræ of *Mastodonsaurus* are biconcave, and much flattened from before backwards. The neural arch ends above in a strong spinous process; there are well-developed zygapophyses, and the stout transverse processes exhibit a division into an upper longer and a lower shorter portion. So far they are very similar to those of *Anthracosaurus*. The ribs again are strikingly similar to those of *Anthracosaurus*, as may be seen by comparing plate 5. figs. 1 & 2 of the work cited with fig. 2, B.

On the other hand, the vertebræ of *Mastodonsaurus*, according to Plieninger, presented characters which I do not meet with in *Anthracosaurus*. Thus, the articular surfaces of the bodies of the vertebræ of the Triassic Amphibian are inclined towards one another superiorly, while those of *Anthracosaurus* are parallel; and the upper and lower portions of the transverse process, which are said by Plieninger to be separated by a suture, so that the neural arch, with the upper longer transverse processes, readily separates itself from the body with the lower and shorter transverse processes, are, so far as I can observe, perfectly continuous in the Carboniferous Amphibian.

Double transverse processes, the upper more particularly connected with the neural arch, and the lower with the body of the vertebra, are to be found, though the circumstance does not seem to have received much notice from palæontologists, in several genera of *Saurobatrachia*, or Salamandroid Amphibians.

In *Salamandra maculosa*, for example, each cervico-dorsal vertebra, except the atlas, has, on each rib, a prominent transverse process inclined backwards; and all these processes, except perhaps the very last, are deeply bifid, so as to be divided down nearly to their origin into two more or less divergent processes. The upper division comes off distinctly from the neural arch, while the lower arises for the most part below the level of the upper margin of the articular face of the body of the vertebra. The transverse processes of the three or four anterior caudal vertebræ are also bifurcated at their ends, and at the eighth or ninth caudal the transverse processes cease to be distinguishable.

The proximal ends of the four anterior pairs of ribs are divided into capitular and tubercular processes of nearly equal length, and possess a distinct 'angle,' whence a process is given off upwards and outwards *. In the hinder ribs the tuberculum becomes a little shorter and more slender than the capitulum. In *Pleurodeles Waltlii*, the vertebral column and the proximal ends of the ribs resemble those of *Salamandra maculosa*, though the division of the transverse processes is less marked, and the capitulum and the tuberculum of the ribs are not so deeply separated; indeed, posteriorly, the separating cleft becomes almost obsolete. In *Euproctes* the division of the transverse processes is hardly discernible; nevertheless there is a rudiment of the angular processes in the anterior ribs. In other *Saurobatrachia*, a groove on each side, indicating an incipient division of the proximal end of the rib, is not uncommon. In all these cases, I am not aware that the single or bifid character of the transverse processes is correlated with any notable differences in other parts of the organization.

It appears to me, then, that the characters of the certainly Labyrinthodont vertebræ† made known by von Meyer and Plieninger, and in the present paper, are in perfect accordance with the view originally put forward by Professor Owen, that these animals are more closely allied to the *Batrachia* than to any of the *Reptilia* proper. But I conceive that the affinities of the Labyrinthodonts are clearly with the *Saurobatrachia* (and, in some cranial characters, with the *Cœciliæ*), and not with the *Anura* as was at first suggested; and, with every deference to the opinion of so great an authority on all that relates to the Labyrinthodonts as von Meyer, I must venture to doubt whether, in any characters, these *Amphibia* exhibit a real approximation to the *Reptilia*.

* Plieninger notes what appears to be a process of a similar character to this in the ribs of *Mastodonsaurus*.

† It does not appear that there is any evidence to show that the vertebræ ascribed to *Labyrinthodon* by Professor Owen in his paper on the Warwickshire Labyrinthodonts (Geol. Trans. 1841) are such, while there is much reason to believe they are not.

At present we are acquainted with two apparently very distinct types among the Labyrinthodonts—that of the ARCHEGOSAURIA (*Archegosaurus*), at present known to occur only in the Carboniferous rocks, and that of the MASTODONSAURIA (*Mastodonsaurus, Labyrinthodon, Capitosaurus, Trematosaurus*), which seem to have flourished in remarkable abundance during the Triassic epoch. Both groups exhibit the sculptured and polished* surface of the crania, the vomerine and palatine teeth, the forwardly situated posterior nares, the permanently distinct epiotic bones, the divided supra-occipital, the three sculptured pectoral plates, the elongated, caudate, salamandroid body, and the comparatively short limbs and weak feet which are distinctive features of the Labyrinthodont *Amphibia*, as well as the more or less complex ramifications of the pulp-cavities of the teeth, which they share with Fishes and *Ichthyosauria*.

But the *Archegosauria* have imperfectly ossified vertebral bodies†, while the *Mastodonsauria* have them thoroughly well ossified, though still biconcave; and the *Mastodonsauria* have double ossified occipital condyles, which have not been found in *Archegosauria*.

Of the other distinctions, if such there were, of the two groups, we know very little. It is true that the *Archegosauria* had, as von Meyer has proved, in his splendid monograph 'Die Reptilien des Steinkohls,' a persistent branchial apparatus and a very remarkable scaly ventral armature. But what do we know with certainty about the presence or absence of corresponding structures in the Triassic *Mastodonsauria*? Whatever may be the nature of the doubtful *Anisopus* or *Rhombopholis*, it is certain that the African, probably Triassic, *Micropholis* was protected by ventral scutes; and until Mastodonsaurian Labyrinthodonts are found preserved as favourably as the *Archegosauria* have been, I think it will be hazardous to take it for granted that they had neither ventral scutes nor even persistent branchial arches.

If we adopt these two divisions and endeavour to range the known Carboniferous Labyrinthodonts under one or the other,—*Archegosaurus*, of course, takes its place among the *Archegosauria*; and *Pholidogaster*‡, I suspect, must go with it, though its vertebræ are far better ossified, and the condition of the cranial condyles is not known. *Baphetes* and *Parabatrachus* are too little known to justify us in arriving at any conclusion respecting them; and the like is true of *Loxomma*. As regards the *Raniceps* of Wyman (Am. Journ. of Sci. and Arts, 1858), the *Dendrerpeton* and *Hylonomus* recently discovered by Dr. Dawson in the Nova-Scotian coal-field, and the new genus *Hylerpeton* instituted by Professor Owen, from the same locality, I do not think we are even in a position to say that they are Labyrinthodont, much less whether they have Archegosaurian or Masto-

* Whence the term 'Ganocephala' as a distinctive appellation of the *Archegosauria* is inadmissible.

† It seems to me probable that the vertebral centra of *Archegosaurus* may really have been osseous rings, such as are found in embryo frogs and salamanders, and as persisted in *Megalichthys* and probably in *Rhizodus*, and that they have broken into the separate pieces described by von Meyer in the process of fossilization.

‡ Quart. Journ. Geol. Soc. 1862.

donsaurian affinities. Among the many remains discovered by the zealous research of Dr. Dawson, I do not know that a single specimen of one of the pectoral plates, so characteristic of all Labyrinthodonts, has made its appearance. They may possibly have been *Amphibia*; but their skulls, their cycloid scales, and their deeply biconcave, fish-like, vertebral centra appear to me to indicate a closer affinity with the *Ophiomorpha* (*Cœcilia, Ichthyophis,* &c.) than with the *Labyrinthodontia*.

Of the unquestionable Labyrinthodonts which occur in the Carboniferous rocks, then, *Anthracosaurus* is the only genus regarding the vertebral column and ribs of which there is any information; and the description and comparisons which I have given seem to me to necessitate the conclusion that, side by side with the Archegosaurian type, the Mastodonsaurian type of vertebral organization, hitherto known to occur only in the Trias*, was well developed in the *Anthracosaurus* of the Scotch coal-field. At the same time, the anchylosed condition of the neural arches, the supratemporal foramina (which may, however, be parts of the 'mucous grooves' common upon Labyrinthodont skulls, the floor of which was very thin, or merely membranous in the temporal region of *Anthracosaurus*), and the strong median convexity of the snout, separate *Anthracosaurus* from any known Triassic Labyrinthodont. And though, in the general form of the cranium and in some other respects, *Anthracosaurus* has a certain resemblance to the Permian *Dasyceps*, it differs as widely as possible from it in its dentition.

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3. *On the* Thickness *of the* Pampean Formation, *near* Buenos Ayres. By Charles Darwin, Esq., M.A., F.R.S., F.G.S., &c.

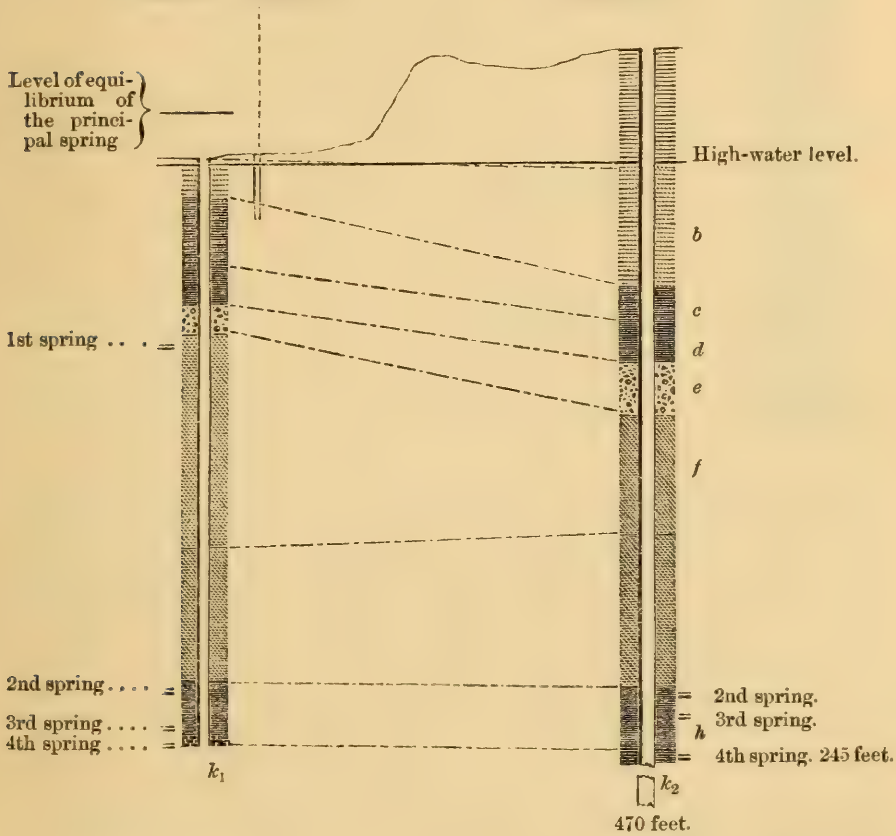
M. Sourdeaux and J. Coghlan, Esq., C.E., have had the kindness to send me, through E. B. Webb, Esq., C.E., some excellent sections of, and specimens from, two artesian wells lately made at Buenos Ayres. I beg permission to present these specimens to the Geological Society, as they would be of considerable service to any one investigating the geology of that country. The Pampean formation is in several respects so interesting, from containing an extraordinary number of the remains of various extinct Mammifers, such as *Megatherium, Mylodon, Mastodon, Toxodon,* &c., and from its great extent, stretching in a north and south line for at least 750 geographical miles, and covering an area fully equal to that of France, that, as it appears to me, a record ought to be preserved of these borings. Southward, at the Rio Colorado, the Pampean formation meets the great Tertiary formation of Patagonia; and northward, at Sta. Fé Bajada, it overlies this same formation with its several extinct shells.

In the central region near Buenos Ayres no natural section shows its thickness; but, by the borings there made in two artesian wells (figs. 1 & 2), the Pampean mud, with Tosca-rock, is seen to extend

* Nothing is at present known of the vertebræ of *Dasyceps Bucklandi*, from the Bunter sandstein of this country. See Memoirs of the Geological Survey of Great Britain:—The Geology of the Warwickshire Coal-field; by H. H. Howell, F.G.S. 1859.

downwards from the level of the Rio Plata to a depth of 61 feet, and to this must be added 55 feet above the level of the river. These argillaceous beds overlie coarse sand, containing the *Azara labiata* (a shell characteristic of the Pampean formation), and attaining a thickness of about 93 feet*. So that the entire thickness

Fig. 1.—*Comparative Sections of the Artesian Wells of Barracas and Buenos Ayres.* (Distance $3\frac{3}{4}$ miles.)

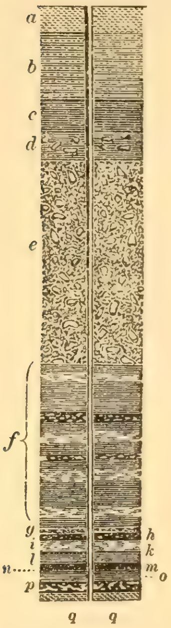


	Thickness at Barracas. Feet.	Thickness at Buenos Ayres. Feet.
a. Clays and Tosca	...	57
b. Sand	13	51
c. Very sandy clay; *d.* Dark-blue plastic clay; *e.* Tosca with calcareous nodules	47	52
f. Yellow sands, very fine and fluid	94	45
g. Green sands	66	62
h. Tertiary clay and sandstone (for details see fig. 2)	34	33
k_1. Hard sandstone at the bottom of the Barracas Well	$4\frac{1}{2}$	
k_2. Very calcareous red clay, becoming more marly beneath; bored through to a depth of	...	225

* The following extract from the Report of the borers relates to this bed:— "The bed of yellow, fluid sands between 18m·60 and 47m·20 below the ground

of the great estuarine or Pampean formation near Buenos Ayres is nearly 210 feet.

Fig. 2.—*Detailed Section of the Artesian Well at Barracas.*



	Thickness in metres.
a. Sand	4·33
b. Very arenaceous clay	8·02
c. { Fine clay	1·05
c. { Blue plastic clay	2·90
d. Tosca with calcareous nodules	2·30
e. Yellow sand, very fine and fluid, with quartz-pebbles and fluviatile shells	28·60
f. Green clay, more or less plastic and calcareous, with iron-pyrites, marine shells, and nodules of lithographic stone	20·30
g. Green sand, with shells and quartz-pebbles	·80
h. Shelly limestone	·45
i. Calcareous clay	2·00
k. Shelly sandstone	·25
l. Green arenaceous clay	2·00
m. Shelly sandstone	·30
n. Speckled sand	·70
o. Very compact arenaceous clay	2·25
p. Coarse sandstone	1·40
q. Green sand, very fine and fluid, with quartz-pebbles and shells	2·35

This formation rests on various marine beds of indurated green clay, sand with corals, sandstone, and limestone, altogether 107 feet in thickness. These beds contain fragments of the great *Ostrea Patagonica*, *O. Alvarezii* (?), *Pecten Paranensis*, and other shells, apparently the same (but they have not been rigorously compared) with those enumerated by M. A. d'Orbigny and by myself as found at Sta. Fé Bajada, as well as at various points on the coast of Patagonia. The already enormous continuous extension of the Patagonian Tertiary formation is thus largely increased. Beneath these beds a mass of red calcareous clay, becoming in the lower part more and more marly, containing layers of sand, and of the thickness of 213 feet, was bored through to a depth of 470 feet from the level of

contains a subterranean ascending current, the level of which has not varied by a centimètre for three years. The level is $0^{m}·60$ (2 feet over the level of the wells at Barracas). This bed ('napa') is powerfully absorbent. At $68^{m}·30$ a second subterranean current ('overflowing') was met, which rose one foot over the surface of the ground at Barracas. The discharge was about 50 pipes daily, but the water was salt and undrinkable. At $73^{m}·30$ was found a third subterranean current ('overflowing'), which reached with difficulty the level of the ground. The discharge might be calculated at 100 pipes daily. The water was very salt, and absorbed that of the first overflowing current. The great spring was met with at $77^{m}·65$."

As regards the quality and abundance of the water, Mr. Coghlan remarks that "The quantity of water discharged per hour through a tube of about 4¼ inches in diameter, at a level of 6 feet above high-water mark, was 2658 gallons. Its temperature was 21° Cent., and it had a slightly disagreeable taste, from its being impregnated with salts of lime and magnesia and a small quantity of sulphuretted hydrogen."

the Rio Plata. This lower mass contained no fossils, and its age is of course unknown*; but, I may add, that I saw at two points in Western Banda Oriental, beneath the marine tertiary strata, beds of red clay with marly concretions, which, from their mineralogical resemblance to the overlying Pampean formation, seemed to indicate that at an ancient period the Rio Plata had deposited an estuarine formation, subsequently covered by the marine tertiary beds, and these by the more modern estuarine formation, with its remains of numerous gigantic mammalia; and that, finally, the whole had been elevated into the present plains of the Pampas.

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4. Geological Notes *on the Locality in* Siberia *where* Fossil Fish *and* Estheriæ *have been found.* By C. E. Austin, Esq., Mem. I.C.E., F.G.S. *With a Note on* Estheria Middendorfii; by Professor T. Rupert Jones, F.G.S.

(Abridged.)

In 1858 I had the pleasure of presenting to the Society some slabs of fossiliferous shale, containing specimens of the fossil fish mentioned by Dr. von Middendorf† as having been obtained by him at Nertchinsk, during his last journey in Siberia, and named *Lycoptera Middendorfii* by J. Müller‡.

The slabs also contain the remains of a number of *Estheriæ*, referred to by Müller as *Limnadiæ*§, as well as portions of reeds and stems of plants, some lignite, and two imperfectly preserved shells which probably belong to a species of *Limnæus*, but may possibly be *Paludinæ*. They were taken by me from the bed, *in situ*, in the year 1848.

The bed lies about 160 versts south by east of Nertchinsk, at the base of a cliff from 6 to 10 feet high, extending north and south, and forming the west or right bank of a small clear stream, called the Toorga, which flows southward into the River Onon. The bed dips westward about 25°.

The east bank of this stream, where it flows by the fossiliferous strata, rises gradually, and extends, above the level of the water, into a plain, on which conspicuous masses of igneous rocks are distributed.

At a point eight versts to the south of that where the fossils were found, an abrupt hill of augite-porphyry rises from the plain to an elevation of more than 100 feet. Its southern face is composed of rhomboids cemented together by quartz into one solid mass, and thus a rock is formed which is not uncommon in the mountainous districts of Siberia.

* It was supposed by Dr. Burmeister to be Silurian.

† A. Th. von Middendorf's 'Siberische Reise,' Band i. Theil. 1. Einleitung; Klimatologie; Geognosie. Fossile Fische, bearbeitet von Johnnes Müller: 4to. St. Petersburg, 1847. See also Quart. Journ. Geol. Soc. vol. vi. part ii. Miscell. pp. 45–48.

‡ *Op. cit.* p. 262, pl. 11. § *Op. cit.* p. 261.

The strata forming the cliff were found, where they were cut through by a shaft sunk, by the direction of the author, for the purpose of examining their relations and position, to lie in the following order:—

	Ft.	in.
1. A small quantity of alluvium between the cliff and the steep part of the hill.		
2. Gravel composed of the detritus of trap-rocks, containing soft clay and laminæ of indurated shale	2	6
3. Gravel of indurated shale in an argillaceous matrix	1	6
4. White porcelain-clay	2	0
5. Clay containing pieces of the indurated fossiliferous shale	1	6

About 300 yards to the north of the excavation, where the course of the stream has a direction from N.W. to S.E., the cliff is higher. At its base occurs a dome of basalt, which has bent the beds upwards into the form of a parabolic arch. Immediately above lies a gravel formed of the rounded detritus of trap-rocks, resembling that found in the shaft, 6 feet in thickness; and above this gravel, beds of indurated shale, in thin leaves, alternate with clay, forming a bed 1 foot 6 inches thick. Above this lies a gravel composed of disintegrated trap-rocks.

The laminæ of shale in the thin beds of clay just mentioned resemble in substance and colour the fossiliferous strata below, but they are too disintegrated to contain perceptible traces of fossils. They are very distinctly seen in the cliff for a considerable distance to the north, but eventually disappear beneath the bed of the stream, about one verst to the north of the excavation made to examine the position of the strata.

The surface of the plain where the igneous rocks are seen seems to be composed of a detritus formed by their disintegration. It is bounded eastward by a high ridge of hills rising gradually from the plain, and extending northward and southward. This ridge is composed of fine-grained granite, and is covered in places with fragments of lava and scoriæ. Remnants of metamorphic rocks occur to the east of this ridge amongst fragments of basalt, and further eastward ridges of clay-slate crop out with a westerly escarpment.

At the foot of the ridge of fine-grained granite, and about 20 versts south of its southernmost extremity, lies Odon Tchalon, the "Variegated Mountain." The summit of this mountain is formed of three cone-shaped hills, composed of a very crystalline garnet-bearing granite, containing abundant nests of yellow topaz and aquamarine. Beryl and amethyst are also found in it, some of the latter being very valuable.

The inference it seems most natural to draw, on consideration of the general position of the strata which appear on the surface of the surrounding country, and from the dip of their beds, is, that the garnet-bearing granite of Odon Tchalon represents the nucleus or centre of this eruption; and that the ridge of fine-grained granite, commencing immediately to the north of it, and running nearly north and south, is the line of the eruptive force that formed the Nertchinsk ridges, which together compose a branch or spur, or what may be termed a parallel wave, of the great Daourian chain.

With regard to the age of the fossiliferous strata, some Ammonites and Ceratites were given to me in Siberia, which were said to have come from the neighbourhood of Yakootsk and the banks of the Lena. Mr. Etheridge has had the kindness to examine them, and he assigns the Ammonites to the "middle division of the Oolites"*, and the Ceratites to the Trias. Another Ammonite appears to be the *A. virgatus* of von Buch, and is therefore undoubtedly from the Lower Oolite. The cliffs forming the right bank of the Angara, about 30 versts below Yakootsk, are formed of sandstone containing beds of coal several inches in thickness. A specimen of Fern taken from these beds renders it probable that they are of Oolitic age.

Several specimens of *Rhynchonella cynocephala*, found in what appeared to be a bed of alluvium near Verchne-oudinsk, and which are nearly perfect, having still a soft coat of shelly matter, appear to show the occurrence of the Inferior Oolite there.

The connexion, however, between the shale containing the Fish and *Estheriæ* and the other fossiliferous deposits is not apparent. Dr. von Middendorf must therefore have pronounced the former to be Lias through the evidence which he derived from these fossils. It is possible that the striped schist found in the neighbourhood of Nertchinsk may be a continuation of the same strata in an altered form, as it very much resembles them in many respects.

It may be presumed, from the presence of the fossil fish associated with *Estheriæ*, and two shells which appear to be a species of *Limnæus*, or possibly *Paludina*, as well as from the relation of the fish (as determined by Sir Philip Egerton) to *Aspius*, that the shale is of lacustrine origin.

Note on ESTHERIA MIDDENDORFII.
By Professor T. RUPERT JONES, F.G.S.

THIS is a well-marked species of that interesting genus of Phyllopodous Crustaceans which appears to have its representatives in the freshwater or brackish deposits of nearly all the great geological groups of strata, from the Devonian to the existing period.

Estheria Middendorfii† occurs in great numbers in grey shale found on the River Toorga in Siberia, and was first regarded by Middendorf as a shell, and then noticed and figured by J. Müller as a *Limnadia* (see references in Mr. C. Austin's paper, above). The carapace agrees well in its characters with that of *Estheria*, both in contour, concentric ridges, and sculptured interspaces. It is relatively large among its congeners, recent and fossil, being $\frac{3}{4}$ths of an inch long; few of the known forms attaining the length of half an inch (excepting the somewhat Limnadioid *Estheria Birchii* of Australia, which

* The species appear to be *Ammonites cordatus* and *A. planula*?; but the former resembles in some respects *A. Chamusetti*.

† Described and figured in my "Monograph of Fossil *Estheriæ*," Palæontographical Society.

is an inch long, and *Estheria striata* of the Coal, which is as large). The valves are frequently (if not mostly) in pairs, closely adpressed, as if the animals had been suddenly imbedded; and this is apparently the case on the several planes of bedding which their abundant presence makes so readily apparent in the fissile shale. Rarely, however, are the valves perfect; their tenuity and a slight lateral shift, which oblique pressure has given them, have led to their being crushed and wrinkled, and the two separated faces of a bed-plane divide unequally between them concentric portions of the light-brown, glossy, thin, corneous valves. The umbones are usually wanting.

Putting aside the wrinkles (mechanically formed) that affect the carapaces, we see, with a low power of the microscope, a delicate, raised reticulation between the concentric ridges, the meshes often passing into irregular, anastomosing riblets, perpendicular to the ridges. The usual ornamentation of *Estheria* is some reticulate sculpturing of the interspaces between the ridges; and this is not unfrequently modified by passing into vertical riblets: still, different patterns or modifications are recognizable in the several species of *Estheria*; and the bold freedom of the delicate reticulo-linear ornament in this case differs from all the other patterns that I know of. The carapace of *E. Middendorfii* approaches in general appearance that of *E. Dahalacensis* (Durckheim), from the freshwater marshes of Dahalac, off the coast of Abyssinia, and found also in stagnant water on the banks of the Tigris by the late W. Kennett Loftus; and the reticulation of the two species would be similar, did it not lose itself in riblets in the former. Though the carapaces seem to have been, at least in many instances, imbedded whole, yet they do not appear to contain any limbs or remains of the body, with the exception, in one or two individuals, of what may be ova; these are numerous little globular bodies, occasionally somewhat crushed, and about $\frac{1}{16}$th of an inch in diameter.

The slightly indurated condition of the shale gives it a modern appearance; but there is a want of collateral evidence as to its geological age, excepting in the case of the little Fish that occurs in considerable abundance in the deposit, both with and without the *Estheria*. This Fish is termed *Lycoptera Middendorfii* by J. Müller; but Sir P. Egerton informs me that he has no doubt of its being either an *Aspius* or some closely allied genus. *Aspius* (a Cyprinoid) is found in some Miocene freshwater strata in Europe.

Limnæus seems also to have been found with the *Estheria*, both by von Middendorf and Mr. C. Austin, as well as a few fragments of Insects and some remains of Plants; and hence there is here, as in most other fossil occurrences of *Estheria*, every reason to believe the deposit to be of freshwater formation.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

On some Fossil Crustacea *from the* Coal-measures *and* Devonian Rocks *of* British North America. By J. W. Salter, Esq., F.G.S., A.L.S., of the Geological Survey of Great Britain.

[Read May 21, 1862*.]

Dr. Dawson, so well known for his researches in the Coal-measures of Nova Scotia, has entrusted to me several fragments of *Crustacea* from the Coal-measures and Devonian rocks of that region for description. These form a most welcome supplement to the late discoveries in Scotland, recorded in the last volume of the Society's Journal†, which Dr. Dawson could not have seen when he kindly sent these specimens for examination.

Accompanying the *Crustacea*, there are eight specimens‡ of other fossils, of which three are shells (see further on, p. 80) agreeing closely in character with some from our own Coal-measures, and tending to confirm, if proof were needed, the age of the Crustacean fragments. They are numbered by Dr. Dawson from 1 to 5.

Of these, No. 1 is most probably the abdomen of an Isopodous Crustacean, and is from a rich plant-bed in the Coal-measures of the Joggins, Nova Scotia. No. 5 is part of a large species of *Eurypterus,* also from the Coal-measures. Nos. 3 and 4 belong to a small species of *Eurypterus,* a genus already well known in the Devonian. They are from St. John's, New Brunswick.

Of No. 2, from the Devonian slate of St. John's, I know no analogue, and can only guess that it has some relation to the Stomapods. It is well preserved, however, and there can be no doubt of its general structure. I have here called it *Amphipeltis.*

I am obliged to propose new generic terms for some of these Crustacea, even though the specimens are imperfect. I will describe the large Devonian species first.

Amphipeltis, gen. nov.

Carapace oblong-oval, rounded in front, and more truncate behind, with a thorax of (probably) nine segments, five of which project beyond the carapace, and four are concealed beneath it. Tail-piece

* For the other communications read at this Evening-meeting, see Quart. Journ. Geol. Soc. vol. xviii. p. 331.

† Vol. xviii. p. 528.

‡ All the specimens noticed are in the Colonial Collections of the Museum of Practical Geology, except Nos. 1 and 1*a*, which have been returned to Dr. Dawson's cabinet.

semicircular, as wide as the abdomen, and as long as the last three segments taken together.

AMPHIPELTIS PARADOXUS, spec. nov. Fig. 11.

The length of the carapace is fully $\frac{3}{4}$ of an inch; its breadth somewhat less. It is gently convex in the middle, and, if the appearance be not deceptive, it has the central area subtriangular and raised above the flattened sides. But I can see no trace of definite ornament on the surface, nor any eyes. The margin shows a minute serration. Beneath the carapace the thorax-rings, four in number, are very narrow at their origin, but they attained their full width before leaving the shield; and the hinder seven rings are all about $\frac{1}{2}$ an inch broad, smooth, or with scattered punctations, and regularly arched from side to side. The pleura are somewhat oblique, bent backwards, and a little rounded at the tips; they are not distinguished, except by the remote fulcral point, from the broad axis.

Looking for the analogues of this fossil among recent forms, one is obliged to neglect the whole of the Isopod order, on account of the great size of the carapace in the fossil before us. This becomes a point of agreement with the *Phyllopoda*, to some of the Apodoid forms of which there is a general resemblance; the few segments of the body do not prove otherwise, since in the Palæozoic forms of the group (*Ceratiocaris*, &c.) the number is much less than in the recent forms. But the expanded, broad shape of the segments is unlike that of any Phyllopod. Again, although the recent *Apus productus* has a large, spatulate, terminal joint (other species have a short notched one), yet the great caudal styles are much more important than the telson. These styles, however, in the Palæozoic forms are always elongate, sometimes greatly so; and hence, if *Amphipeltis* be a Phyllopod, it is of a group yet unknown, and should form the type of a new family. I should prefer comparing it (as Dr. Dawson did in his letter to me) with the *Stomapoda*; among these, *Squillerichthys* and *Erichthys* have a large caudal shield, but their carapace is both angular and spinose. I confess I am not at all satisfied with this analogy, but consider it at all events preferable to that of the *Phyllopoda*.

Locality. Devonian rocks near St. John's. Fragments of a Fern and of a *Cardiocarpum* occur here on the same slab of black glossy slate. These plants have been described by Dr. Dawson, Quart. Journn. Geol. Soc. vol. xviii. pp. 296, &c.

DIPLOSTYLUS, gen. nov.

Carapace unknown. Body-segments (in number —?) arched, and with minute pleura. Tail-segment large, triangular, spinose, with two pairs of simple, ovate appendages.

It was not till I had tried hard to find analogies with *Squilla* that I could persuade myself that this was not the abdomen and tail-flaps of a Crustacean allied to that genus. The shape, ornaments, and spines of the broad telson cannot fail to remind the observer of *Squilla* (fig. 8); and if I could have believed that the palettes (fig. 6*a*) were portions of a concealed, three-jointed appendage, this analogy must have been received. But the more the specimen is studied, the more clear it is that there are two pairs of appendages attached (one pair to the sides, another near the tip) to the terminal joint. *Squilla* and its allies, like all the higher *Crustacea*, have, of course, no appendages to the broad telson. And for the same reason, the affinity of *Diplostylus* with the *Macrura* is out of the question.

But when reference is made to the *Isopoda*, the resemblance is much greater; and none are better suited for comparison than *Sphæroma* (fig. 7), which has a large, tuberculo-spinose, terminal joint, and a two-jointed, palette-shaped style on each side. In *Sphæroma* the appendages are higher up on the sides; in *Serolis* they are nearer the apex.

But in no case that I have yet seen or heard of, among Isopod Crustaceans, are there two pairs of appendages to the last joint. The *Isopoda* have all a single pair only*.

Diplostylus Dawsoni, spec. nov. Fig. 6.

The portion preserved consists only of five rings and the broad telson; and these together are $\frac{3}{4}$ of an inch long, and less than $\frac{1}{2}$ an inch broad at the widest part. The telson is somewhat narrower than the body-rings, broad above, and pointed behind, where it is notched into three spines, the centre one very short, the two on each side of it broad, and on their outer sides covering the attachment of two small obovate palettes. These palettes are a little oblique, narrower than their length, rounded at their posterior margin, and striated distinctly. Outside these, and much higher up on the sides, are a pair of broader notches, which give origin to a pair of small palettes, ovate and not broader at their ends, and striated obliquely. And above the insertion of these are a pair of broad, flat spines on the surface of the tail-joint.

The body-segments are transverse, the axis not much distinguished from the short, pointed, recurved pleura; with a narrow, articular furrow, and strongly punctate on the exposed portions. The punctations (in the hinder segments only) are overhung by short plications: such punctations are observable in many Isopod Crustaceans.

Locality. Coal-measures of the Joggins, Nova Scotia, in a plant-bed in the middle of the series.

Having looked in vain for a similar pygidium among the large-tailed Isopods, and consulted Mr. Spence Bate with a like result, he referred me to a group of parasitic Amphipods (the *Hyperina*), among which there are a few forms† (such as fig. 12) with tail-segments coalesced and bearing appendages. These show a sufficient resemblance to warrant our referring *Diplostylus* provisionally to the

* Lest it should be thought I had overlooked their occurrence, I may mention that there is sometimes a pair of moveable spines at the extremity of the tail-joint in *Squilla*, which might represent the terminal palette-like styles. Still this would not account for the lateral appendages; and I do not think there is any real relation to *Squilla*.

† *Anchylomera, Typhis, Brachyscelus, &c.*

Amphipod order. I am very much obliged to Mr. Bate for this analogy (which would certainly have escaped me in Milne-Edwards's work). Mr. Bate's late papers on the Amphipods (Ann. Nat. Hist. 1861) admirably illustrate this peculiar group.

Eurypterus pulicaris, spec. nov. Figs. 9, 10.

This minute form (sent under the name of "*Stylonurus* or *Eurypterus*" by Dr. Dawson) can only be compared with such species as I have described and figured in the 15th volume of our Journal. The small *E. pygmæus* (*op. cit.* p. 232, pl. 10. figs. 5, 6) resembles our species in size; but the tail-joint, fig. 18 (*E. abbreviatus*), figured from the Downton Sandstone (Uppermost Ludlow Rock), is the nearest in point of shape.

The tail-joint is a characteristic portion, and is sufficiently preserved in the specimen from Nova Scotia to show that it is a distinct species from the British one. I hope that better material will soon occur to Dr. Dawson's search. The entire length of the more perfect specimen (including nine body-joints and the telson) is less than $\frac{1}{2}$ an inch. These nine body-joints taper rapidly backward, from $\frac{1}{8}$th of an inch to quite a narrow base in the penultimate joint above the telson. The telson is broader than the penultimate joint, swelling rather rapidly from its origin, and then suddenly contracting into the serrate tip.

Locality. Devonian rocks; St. John's, New Brunswick. Dr. Dawson desires me to add, that the rare Devonian forms from near St. John's were collected and given to him by Messrs. Matthew, Hartt, and Payne, of that city.

Eurypterus; a large species allied to *E. Scouleri*, Hibbert. Fig. 5.

A mere fragment of a large body-ring, which nevertheless indicates a species nearly as large as the great Scotch *Eurypterus* (*E. Scouleri*, Hibbert).

The large "teardrop-tubercles" along the hinder margin sufficiently show the nature of the ornament. These, in all probability, were replaced by spines on the carapace, as in our own Coal-measure species (to be described in a succeeding paper).

The carbonaceous film which remains in part on the surface, cracked (by shrinking) into minute areolæ, represents evidently a corneous substance, from which the animal matter has been dissolved away. The suggestion of Professor Huxley, that the large *Eurypteridæ* had a thick crust like that of *Limulus*, with but little calcareous matter, is most probably true.

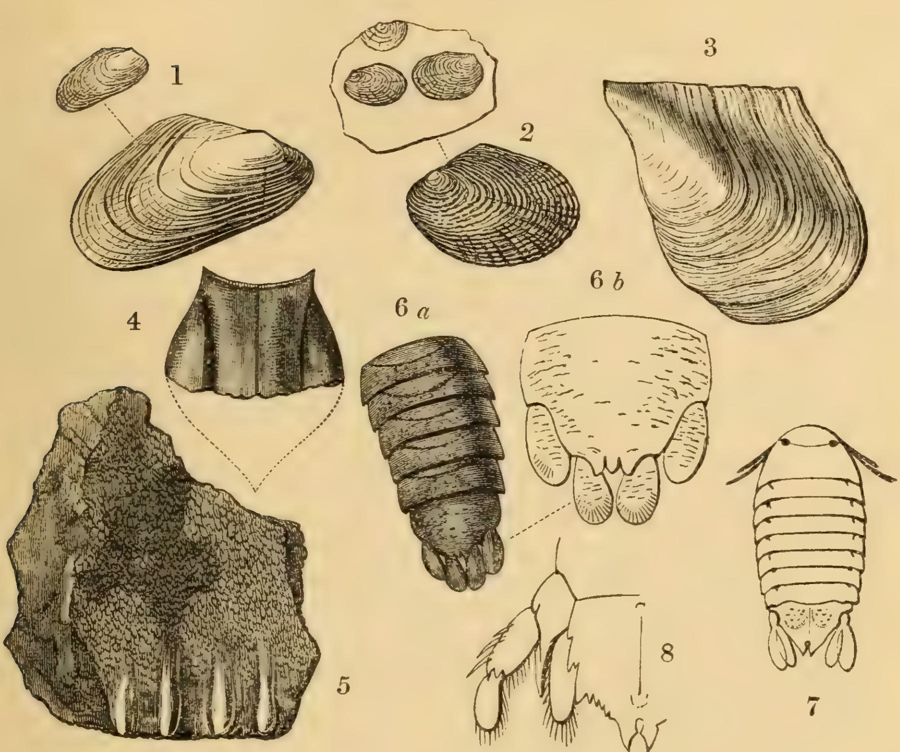
Locality. Coal-measures; Port Hood, Cape Breton.

Eurypterus (?), tail of. Fig. 4.

This small specimen, found with the *Diplostylus* in the Joggins plant-bed, has evidently nothing to do with that genus. It is imperfect, but can hardly be supposed to be other than the caudal joint (broken) of a *Eurypterus* or allied form. It is, as usual in that genus, contracted at its origin; but swells out afterwards, in the

Figs. 1–12.—*Fossils from British North America.*

COAL-MEASURES.



DEVONIAN.

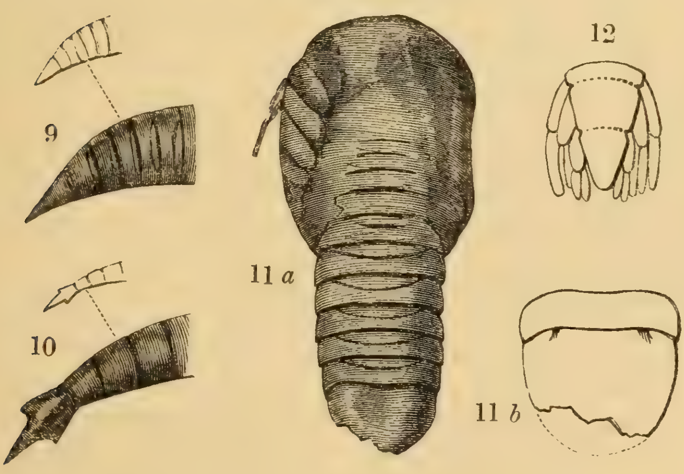


Fig. 1. *Anthracomya elongata.*
2. *Naiadites lævis.*
3. *Anthracoptera carbonaria.*
4. *Eurypterus*, tail of: nat. size.
5. *Eurypterus*, sp.
6. *Diplostylus Dawsoni.*

Fig. 7. *Sphæroma.* } Outlines.
8. *Squilla.* } Outlines.
9, 10. *Eurypterus pulicaris.*
11. *Amphipeltis paradoxus.*
12. Tail-piece of *Typhis* (recent).

manner of the tail-joint of *Slimonia* (*Pterygotus*) *acuminata*. (See Quart. Journ. Geol. Soc. vol. xii. p. 28.)

There are no surface-markings nor marginal serrations.

Locality. Coal-measures; Joggins, Nova Scotia (cabinet of Dr. Dawson).

While dealing with *Crustacea* of the Carboniferous rocks, I may be permitted to make a correction in reference to my last paper*, and to alter the term *Palæocrangon* to *Crangopsis*. I had overlooked the fact that the term "Palæocrangon" was applied to the small Isopod Crustacean in the Permian rocks described long ago by Schauroth (see Quart. Journ. Geol. Soc. vol. xiii. p. 214). It is true my correspondent, Mr. Kirkby, would replace that name by a more satisfactory term, as *Palæocrangon* suggests a wrong affinity. Most naturalists, however, are agreed that a generic name once given is entitled (like a specific one) to priority, unless utterly erroneous in meaning, or accompanied by a manifestly imperfect description.

Fossil Shells from the Coal-measures of Nova Scotia.

I have added figures of three species of shells sent to me by Dr. Dawson. They are from the Coal-measures, and are specially interesting as being the genera common in our own Coal-deposits, and which I cannot but regard as of marine origin. There are three species, which I find Dr. Dawson has named respectively *Naiadites elongatus*, *N. carbonarius*, and *N. lævis*, in the Supplementary Chapter to his 'Acadian Geology.'

The first and last are species of a genus which I have described and figured as *Anthracomya* in the Memoirs of the Geological Survey†. They are thin equivalve shells, wider behind, and with a (byssal?) sinus on the anterior ventral edge. A wrinkled epidermis shows that the animal probably had a closed mantle and respiratory siphons; and the ligament is external, as in *Panopæa*, which is essentially one of the *Myadæ*.

As Dr. Dawson had only proposed the name *Naiadites* without description, perhaps these shells may be allowed to retain the name I have given them. The *Anthracomya* (*Naiadites*) *lævis* (fig. 2) is, I believe, identical with a shell from the Upper Coal-measures of Manchester.

For the second species, however, *N. carbonarius* (fig. 3), no generic name has yet been proposed, though Professor King had long ago noticed the genus (Ann. and Mag. Nat. Hist. Jan. 1846, vol. viii.). It includes the so-called *Myalinæ*. Nor can they be described as species of *Dreissena*, as has been done by Herr Ludwig, in his recent descriptions of Coal-fossils in the 'Palæontographica,' vol. ix.

Meantime, until Professor King or myself describe some of the Coal-fossils of this group, I shall employ the name *Anthracoptera* for these triangular shells. They are abundant in our Coals.

* Quart. Journ. Geol. Soc. vol. xvii. p. 533.

† "Iron-ores," 1861, p. 229, pl. 2.

On some SPECIES *of* EURYPTERUS *and Allied Forms.* By J. W. SALTER, Esq., F.G.S., A.L.S., of the Geological Survey of Great Britain.

[Read May 21, 1862.]

SINCE the appearance in 1859 of the memoir by Prof. Huxley and myself on *Pterygotus* and its allies, the great work of Prof. Hall, of Albany, has appeared ('Palæontology of New York,' vol. iii.), containing the fullest material for the illustration of this genus; and following, as it did, upon the very full account given by Dr. Wieskowski, it has completed our knowledge of the structure of this remarkable genus. And there seems to be now no doubt whatever that the anomalous plates and processes about the position of which Prof. Huxley and myself were compelled to guess, and which for many obvious reasons were compared with the under portion of the head, really belong to the under part of the thorax.

All this was as satisfactorily made out by the Russian author as by Prof. Hall's independent researches. We had also arrived at the same conclusion before Wieskowski's admirable paper reached us. For previous to the Meeting of the British Association at Aberdeen in 1859, I was sent by the Director-General of the Geological Survey to examine the collections made by Mr. Slimon, of Lesmahago; and in that fine series (which was sent to the Meeting for exhibition) we found abundant proofs of the true position of the sternal plates, such as Wieskowski and Hall have figured, and of the place of the post-oral plate, previously assigned by Prof. Huxley to the hinder margin of the mouth. The position of the chelæ in these new specimens also confirmed the Professor's judgment in assigning them to the antennæ or antennules; and they supported my own view too as to the existence of three pairs of appendages to the head, exclusive of the chelæ and the large swimming-feet, which are also, as we learn from the new and more perfect specimens found both in America and Russia, included with the appendages of the mouth.

The chief new points, I take it, in Prof. Hall's beautiful series are, first, the larger number of joints in the great maxillary appendages than was supposed from analogy with *Pterygotus*, where there are certainly only seven; and secondly, the existence of ocelli on the dorsal surface of the shield, such as give it a wonderfully limuloid aspect. But some of the *Copepoda* have similar ocelli; and as to the affinities, it would be out of place in every way to give my opinions, when the naturalist is by who first truly studied these relations. Whatever corrections better specimens may have led to, the main credit is due to him who from fragmentary materials constructed a true hypothesis. The business of the palæontologist—half-naturalist, half-geologist—is to collect, arrange, and describe the material, giving to and receiving from both naturalist and geologist all the aid he can.

The kindness of some friends in Scotland has lately enabled me to examine, for the purpose of description, the rare *Crustacea*, from the Glasgow coal-field, published in the last volume of the Society's

Journal*. Immediately after, others exerted themselves to obtain for us the loan of the great Scotch *Eurypterus*, made so famous by Dr. Hibbert, and which was found, not in the Coal proper, but in the Carboniferous Limestone of Linlithgow.

No sooner had the Scotch *Eurypterus* been taken in hand, than I found a new one in our own Coal, almost as large. A friend in Staffordshire sent me a unique form from the coal-measures of that district, the remarkable spined *Eurypterus* described below. A new Shrimp turned up from the Millstone Grit of Yorkshire, under the hammer of the well-tried Collector of the Geological Survey, Richard Gibbs. A beautiful Crustacean, illustrating new points in the Palæozoic history of the class, came to light in Dumfriesshire; and, while considering what to do with all this material, Dr. Dawson of Montreal sent me his Carboniferous and Devonian novelties to describe for the Society.

Eurypterus Scouleri, Hibbert.

Eurypterus Scouleri, Hibbert, Trans. Roy. Soc. Edinb. vol. xiii. p. 179, pl. 12. figs. 1–5; *Eidothea*, Scouler, Cheek's Edinb. Journ. of Nat. and Geograph. Science, vol. iii. p. 352, pl. 10.

For an opportunity to examine this fine head, long ago described by Dr. Hibbert in the 'Transactions of the Royal Society of Edinburgh,' I am indebted to Mr. James Smith, of Jordan Hill, Glasgow, and Dr. Rankin of that place. It was kindly lent me by the Council of the Andersonian Institution for a fresh description and figure, that of Dr. Hibbert being incomplete. The large carapace is all but perfect (a portion of the right side only being absent), and in its natural condition uncompressed; so that the great convexity of the form is manifest. The carapace and the two front body-rings (preserved so as to show both their dorsal and ventral surfaces) are retained in this specimen, attached to one another; and, bent upward beneath it, is a large fragment of a swimming-foot, consisting of the first four joints, all imperfect.

The dimensions are as follows:—Carapace, forming more than a quarter of a sphere, $4\frac{1}{2}$ inches long by fully $6\frac{3}{4}$ broad, and the convexity such as to follow the shape of the body-rings, which are $4\frac{1}{2}$ inches broad and 3 inches deep from back to front. The greatest convexity is in the region behind the eyes, which are placed, not quite halfway up the head, near together, only an inch and a quarter apart. They are divided from each other by a pair of inflated triangular lobes, with a small central process lying in the deep hollow between them. This central prominence, the round approximate eyes, together with the rough, hirsute, spinous character of the convex region behind the eyes, give the whole head much the appearance of a deformed human countenance.

The outline of the carapace is about two-thirds of a circle, the short, broad, spinous ears being curved inwards, not outwards; and the posterior edge is only gently arched. A very distinct depression indents the front, but does not affect the actual anterior margin.

* I have, however, since seen another fragment in the Hope Collection at Oxford.

The round prominent eyes are also set in depressions, which run from them in a curved line to the inner margin of the broad posterior spines on each side, and thus enclose the convex, semicircular space which, lying behind the region of the eyes, is covered with thick-set spinous squamæ. Another deep triangular indentation lies between two thick lobes, diverging backward, which separate the eyes; and, as these lobes are much swollen, the depression is really greater than any of the others. In the midst of it lies a short, triangular, prominent mass, broken in our specimen. Above, in front of this depression, is a slight boss (which would very probably be the place of the minute stemmata, were they preserved); but there are no wrinkles nor elevations of any kind in front of the eyes. The whole surface is evenly convex, divided by the semicircular furrows from the rugose portion behind the eyes, as above mentioned. The margin is narrow, thickened, and raised all round. The ornament of the surface is minute in front, and consists of small prominent tubercles, with minute granules between them; further down the sides the tubercles become triangular squamæ, with others interspersed; and these squamæ become larger and larger towards the ears (with raised borders and generally a strong central tubercle), and attain their largest size on the posterior area, where they are also narrower and more pointed, as well as stronger, than elsewhere. On the extreme hinder border they become linear ridges; and in this form they also occur on the free edges of the body-segments. The crust is not thick; and the squamæ, except in the largest, appear to be more convex and prominent beneath the crust than above it, so as to indent the cast. This is particularly the case with the smaller squamæ, which are so concave above as to be truly convex below: the margin shows this conspicuously (fig. 5); and wherever the surface has been abraded or weathered, the hollows are much deepened and exaggerated.

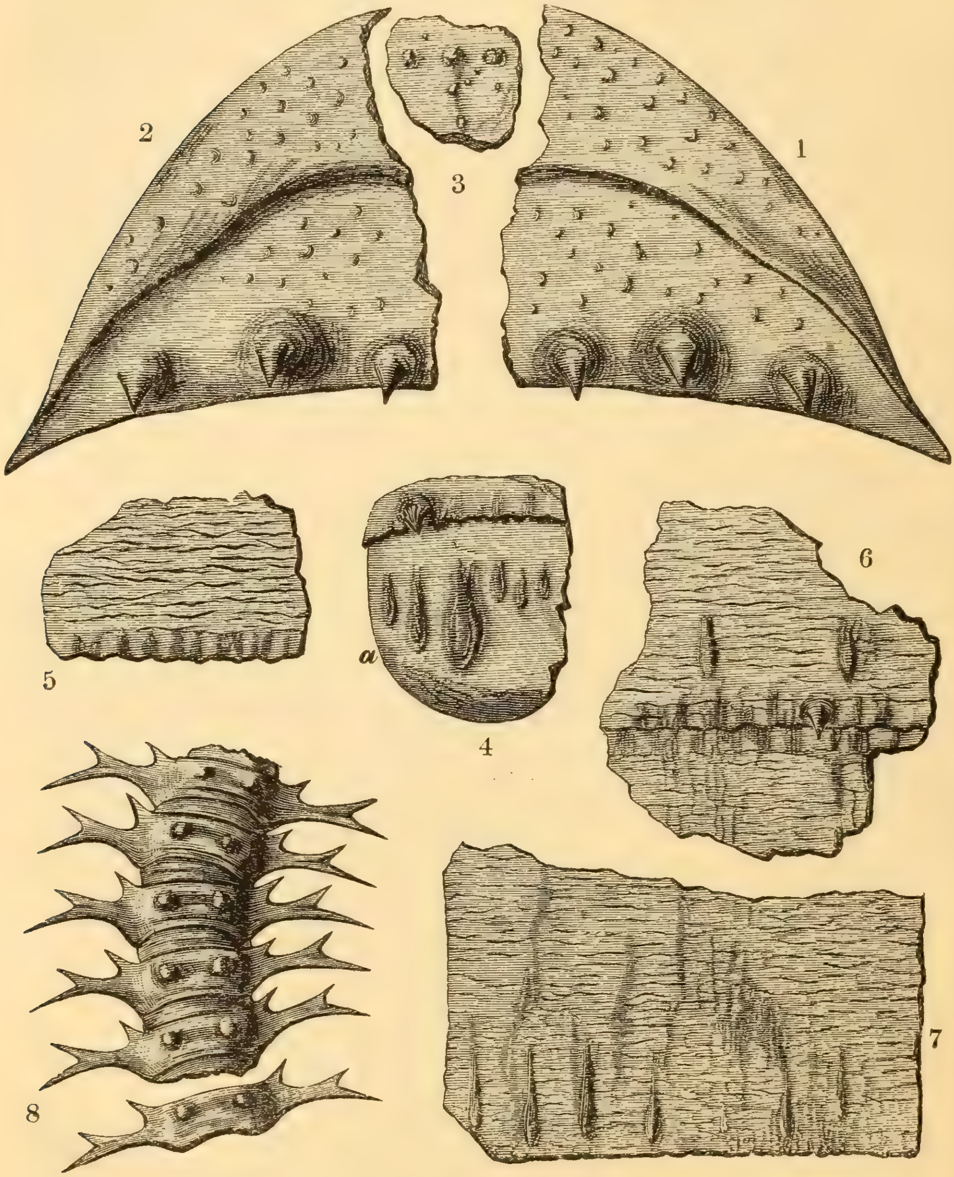
The body-rings have a great convexity, as above stated; the two anterior rings are very short, not more than half an inch long even in this large specimen. On the under side they expand into the broad sternal flaps so characteristic of this family of Crustacea. One of the swimming-feet is preserved. The basal joint is either very small, compared with that of *Pterygotus*, or is imperfect. The shape of the other three is not well defined; but they are evidently thick, carinate at the edges, and have the usual triangular or wedge-like shape alternately in the lower joints.

In Dr. Hibbert's description of *Eurypterus Scouleri*, he says (p. 281):—"The *Eurypterus Scouleri* is to be distinguished from other species by the prolonged eminences intervening between the eyes, which, at their apex, form an angle wherein appears a central tubercle; also by the small, acutely angular protuberances, like spines, which are diffused over the surface of the head beneath the eyes. The characters of the feet cannot be given, as no vestiges of them, except very slight ones, have turned up." In truth, there is no known species with which it can be confounded, nor any approaching it in size.

Hall's beautiful specimens have enabled him to show, what was not clear in any figures before, that *Eurypterus* had more than seven joints in the limbs.

I would gladly have given a natural-sized figure of this fine fossil,

Figs. 1–8.—*New Species of* Eurypterus.



Figs. 1–7. *Eurypterus mammatus,* natural size.
8. *E.* (*Arthropleura*) *ferox,* natural size.

had the arrangements of this Journal permitted it. I hope to figure it at some future opportunity.

Localities. Carboniferous Limestone of Kirkton, Bathgate; and also in Upper beds of Old Red Sandstone, at Kiltorkan Hill, Kilkenny. (See Quart. Journ. Geol. Soc. vol. xv. p. 232, pl. 10. fig. 3.)

On the general characters of the species here described, it is to be observed, first, that von Meyer evidently thinks *E. Scouleri* should be regarded as a new type, distinct from *Eurypterus*, and that Scouler's old name, *Eidothea*, should be restored. Its great size (fully 1½ foot long), round convex carapace, the processes between the eyes (to which might be added their approximate position), and the large sculpturing seem to him sufficient to distinguish it. These are certainly good characters; and, if we only knew more of the species of the genus, I should be disposed to unite in this opinion. But very few of the known species show enough to decide that ornamentation, or a slightly different position of the eyes, is accompanied by positive characters in the other parts, so as to warrant the distinction. I should say the same of his proposed genus *Adelophthalmus*; for scarcely enough is left of the carapace to prove that it had no eyes, on which character the genus is founded. *Arthropleura* is probably distinct; but as the known specimens have neither a whole carapace, nor eyes, nor appendages, it would be premature to separate it generically.

EURYPTERUS (ARTHROPLEURA?) MAMMATUS, sp. nov. Figs. 1–7.

I have fragments of the head, of the lateral portions of the body-segments, and parts nearer to the tail, but not of the central surface of the carapace, of the eyes, nor of the appendages of this species.

The first fragment occurred to the Collectors of the Geological Survey, when they were breaking the rubbish of the mine-tip from Pendleton Colliery, Manchester. Others were obtained afterwards by Messrs. Gibbs and Rhind; and the exact bed proves to be the "Ferny Metal," under the "Big Coal" or "Rams Mine."

In this bed many plants are found, viz.,

Lepidodendron obovatum.	Neuropteris gigantea.
—— Sternbergii.	Cyclopteris flabelliformis.
—— elegans.	Sphenopteris obtusiloba.
Neuropteris Loshii.	—— latifolia, &c.
—— heterophylla.	

The bed lies rather high in the "middle coal" series.

The lateral portions (fig. 1) of the head of this large Crustacean, which must have been at least 8 or 9 inches broad, show a strongly arched border, running out into a short, acuminate, broad spine, into which a strong, curved, sharpish ridge runs from about the upper central portion of the head (probably from the eye itself). The space outside and above this ridge is flat, and is covered with prominent squamæ; beneath it the surface is tolerably smooth and concave, until near the hinder border, at a short distance within which at least six (and probably more) large, mammillated, tubercular spines are ranged in a tolerably even line. They are directed backwards, and are full a third of an inch in length, and as much in diameter, at the swollen base. Another portion of the head (fig. 2) shows large and small tubercles instead of squamæ. Then we have a fragment (fig. 3) which I suppose to be the hinder margin of the head, with the first body-segment, showing one or two of the "tear-drop" ornaments characteristic of *Eurypterus*. Such have been figured in my monograph of the genus, Quart. Journ. Geol. Soc. 1859, vol. xv. p. 229, pl. 10. figs. 3, 11, 12.

The remaining pieces are evidently parts of a great Crustacean, and almost certainly belong to this one; for they have the same ornaments on the hinder edge; but they differ remarkably by having a curious set of short, wavy, interrupted ridges (or furrows,—it is impossible to say which), lying transversely to the length, and which are equally distributed over the whole segment. They are not all of the same size, small rounded ridges being mixed with those of a more linear shape. On some of these body-segments (figs. 4 & 5) large spines occur on the hinder edges; and these I suppose to have been the rings nearest the head. On others a large spine is rare, as fig. 6; and on fig. 7, which was probably nearer the middle of the body, only the linear "tear-drop" ornaments are present.

Locality. Pendleton Colliery, near Manchester. In the "Ferny Metal," beneath the "Seven-foot Coal" or "Rams Mine."

Although I have supposed figs. 1 and 2 to belong to the head, I have really little else to recommend this view than the great comparative size and breadth, and the general form, which is like that of the hinder angles of the head of the Scotch *Eurypterus*. If the original figure, given by M. Jordan ('Palæontographica,' vol. iv. pl. 2. figs. 4 & 5, p. 13), of the *Arthropleura armata* be consulted, a somewhat similar piece, having a similar arrangement of tubercles, will be seen to occur in contact (not joined) with a fragment, which would make the pointed portion more like the pleuron of a trilobed segment. I do not believe this is the case, but still it is worth while to call attention to the circumstance. M. Jordan evidently does not know to what part of the animal he is to refer this plate; and as it is not certain, according to his own showing, that the two portions of his fig. 5* belong to the same piece, while in his fig. 4 there is a large plate like a carapace connected with tubercular body-rings, I think we may interpret our own fragments without reference to the Saarbruck fossil, except to identify the genus. The authors von Meyer and Jordan have failed to give a generic character, and, in the absence of any proof that it is distinct from *Eurypterus*, I do not feel justified in referring the British fossil to any other genus.

The fragment next described carries still further the strange ornamentation with spines and tubercles, and may belong to a distinct genus.

Eurypterus? (Arthropleura) ferox, sp. nov. Fig. 8.

A fortunate blow of Mr. Charles Ketley's hammer has yielded one of the most curious Crustacean fragments on record. He found it in the Staffordshire Coal-measures, at Tipton, and states that it came from the shale over the "Thick Coal." Abundance of coal-plants were with it.

At first sight, it would strike an entomologist as a fossil caterpillar of the *Saturnia* genus, so strong is its resemblance in size, form, and ornament to the larvæ of that group. Unlike most Crustaceans* from the old rocks, it is extravagantly ornamented, with long forked spines. Were it not for the figure of von Meyer quoted above, which shows a considerable amount of ornament in a species of the *Eurypterus* group, it would have been impossible to have so assigned it. I believe it to be the central lobe of the abdomen of a trilobate *Eurypterus* or allied genus, and shall so describe it.

E. horridus, axi corporis (solum conservato) subcylindrico, annulis rugosis spinosis; tubercula in utroque segmento 4, quorum 2 centralia brevia, lateralia longispinosa, spinis bifurcatis et ad basin bispinulosis.

The length of the fragment, including five rings, is 1½ inch; and the breadth of the axis, without the long forked spines, is ⅖ths of an inch. The forked spines are ⅖ths of an inch each, and have at their base, front and back, two other smaller spines.

Locality. In ironstone, North Staffordshire (Museum of Practical Geology). Another specimen, as above noted, occurs in the Hope Cabinet, Oxford; its locality is uncertain.

On Peltocaris, *a new Genus of* Silurian Crustacea. By J. W. Salter, Esq., F.G.S., A.L.S., of the Geological Survey of Great Britain.

[Read May 21, 1861.]

In a paper on *Graptolites* from the Anthracite-shales (Llandeilo-flags?) of Scotland (Quart. Journ. Geol. Soc. vol. viii. p. 391), a figure (pl. 21. fig. 10) was introduced of a minute Crustacean, the affinities of which were doubtful, but which nevertheless had much resemblance to *Dithyrocaris*, a Carboniferous fossil. That specimen was imperfect; but one or two since collected in Dumfriesshire are more complete; and, lastly, a beautiful and perfect example has been given to the Museum of Practical Geology, through the kind offices of Mr. James Young, of Glasgow.

Fortunately, since I described the above-mentioned little Crustacean as *Dithyrocaris*? *aptychoides*, I have had occasion to study a large series of Silurian Crustacea, which have, in their turn, furnished the data whereby to connect this old Phyllopod with the modern *Nebalia* and *Apus*; and I propose in describing this genus to notice them, as chronological as well as zoological links, believing that such illustrations of the theory of Mr. Darwin may best serve to give the data whereby to confirm or refute his masterly hypothesis.

Peltocaris, gen. nov.

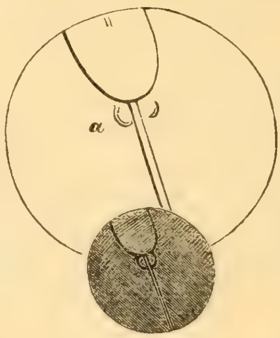
A small Phyllopod, with a round, shield-shaped carapace; bivalved, the valves open and imperfectly joined along the dorsal line; deeply emarginate in front, the excavation so formed being filled up completely by a parabolic plate, which is the analogue of the rostrum, and completes the broad oval shield.

* There are only a few living Crustaceans which show such an ornament; the *Lithodes* described by De Haan, in the 'Fauna Japonica,' is one of them.

Peltocaris aptychoides. Fig. 1.

Dithyrocaris aptychoides, Salter, Quart. Journ. Geol. Soc. vol. viii. p. 391, pl. 21. fig. 10.

Fig. 1.—*Peltocaris aptychoides*, natural size and enlarged.



The broad, rounded-oval shield measures only 5 lines in length, by about 4¼ lines in breadth; so that it is not a true circle, but appears nearly like one. The rostrum, as broad as long, and of a parabolic shape, is just one-third the whole length. The body and appendages have not yet been found.

The division along the dorsal line is continued as an open fissure for a part of the length, then as a narrow line; but the valves seem to have been so far connected (by membrane?) that they occupy their original place; and in one case only, I think, have I seen the valves dissevered, never bent down. Immediately behind the rostrum, in this specimen, what should be the apex of the valve is circumscribed (*a*) and apparently cut off by a deep furrow, or suture, from the rest. The two umbones, if they may be so called, are in this way *isolated*. It may not be so in all specimens; but this notched umbone existed also in the larger specimen, figured as above quoted, and which is also, by favour of Professor Harkness, in the collection of the Museum of Practical Geology.

Locality. Anthracite-shales (Llandeilo-flags), Dumfriesshire. Museum of Practical Geology.

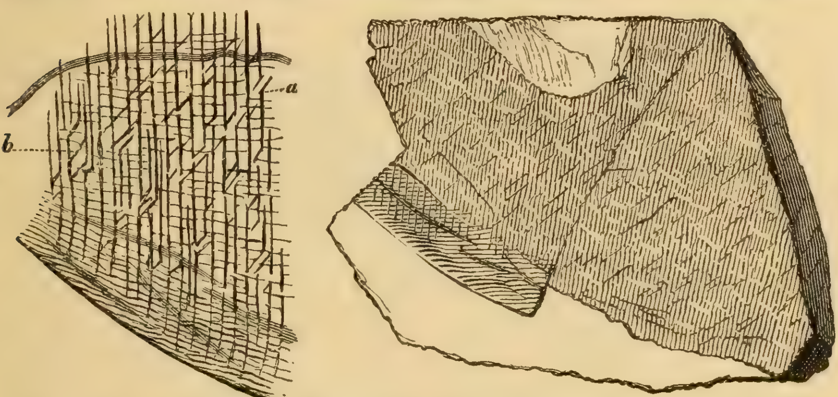
Peltocaris? Harknessi, sp. nov. Fig. 2.

A fragment, 2 inches long, in the same black Anthracite-shale which afforded the *Peltocaris aptychoides*, was sent me by my friend Professor Harkness many years back; and I then made the accompanying drawings (fig. 2) and description. I hope the specimen is still safe in his cabinet.

It is a fragment of a much larger carapace than that of *P. aptychoides*, probably 3½ inches at least in length. Only the ventral edge is shown, and that for a short distance, covered by oblique marginal lines, which run backwards, while these are crossed by ventral striæ, transverse to the general direction of the carapace. The latter are more remote than the marginal lines, and meet or cross these at an angle of about 85° or 90°; while in the region unoccupied by the marginal striæ, the cross lines are themselves interrupted and frequently decussated by short striæ in an opposite direction. These short striæ may possibly be structural. But they are all exhibited on the fossil; and I have introduced them accurately in the figure. Fig. 2, B, is a magnified portion. The marginal lines are closer than the vertical, and more wavy, and they occupy the undefined border to the exclusion of the others; but they are distinctly traceable for a short space across the vertical lines on the general surface (just as these are continued also faintly towards the margin). The vertical lines, though more distant than the marginal ones, are still very close together—eight or nine of them at least in the space of $\frac{1}{10}$th of an inch. They are not so regular as they appear to be at first sight. Most of them, after proceeding a short distance, turn obliquely and abruptly forwards, or else are crossed by short oblique striations, to join the next vertical line, which is generally, but not always, obliterated above the point of junction (as at *a*). Very rarely these oblique lines cross the space of two vertical lines (*b*); and, as they are all strictly in the same direction, they give the appearance of a third set of parallel striæ ruled across the other two.

Fig. 2.—*Peltocaris? Harknessi.* A, natural size. B, enlarged.

B.



A.

The faint transverse lines above mentioned are, I believe, due to mineralization only; but three sets of lines are certainly present, viz. the strong, vertical ones, the oblique, close, marginal striæ, and, lastly, the short, oblique lines in the opposite direction to those last mentioned. I do not remember such a complication of lines on the surface of any other carapace*. *Peltocaris aptychoides* is so small and smooth, that there is no opportunity of judging whether it may be the young state of this larger species. Its nearly uniform size in the half-dozen specimens I have seen would seem to be in favour of its being distinct.

Locality. Anthracite-beds (Llandeilo-flags), Dumfriesshire. Professor Harkness's collection.

And now a word or two regarding the affinities of this curious Crustacean.

Before the structure of *Ceratiocaris* was known, of which genus a reduced figure is here given (fig. 6), the rostral portion of *Peltocaris* could not have been understood. But a reference to the accompanying series of woodcuts will show that a tolerably broad rostrum, placed in the same relative position, occurs in *Ceratiocaris*†. In the recent *Nebalia* (fig. 12) it is fixed; and in *Dithyrocaris* (fig. 8) and

* The margin of *Argas testudineus* (fig. 9) is striated, but in the same direction as the transverse lines on the rest of the shield.

† More complete figures are given in the Ann. & Mag. Nat. Hist. for March 1860, p. 154.

other genera it is perhaps yet to be discovered. Again, *Ceratiocaris*, together with its moveable rostrum, has a bivalved shell, yet habitually keeps its valves half closed, as I learn from perfect specimens.

Figs. 3–12, *a* to *i*.—*Geological distribution of* Phyllopoda.

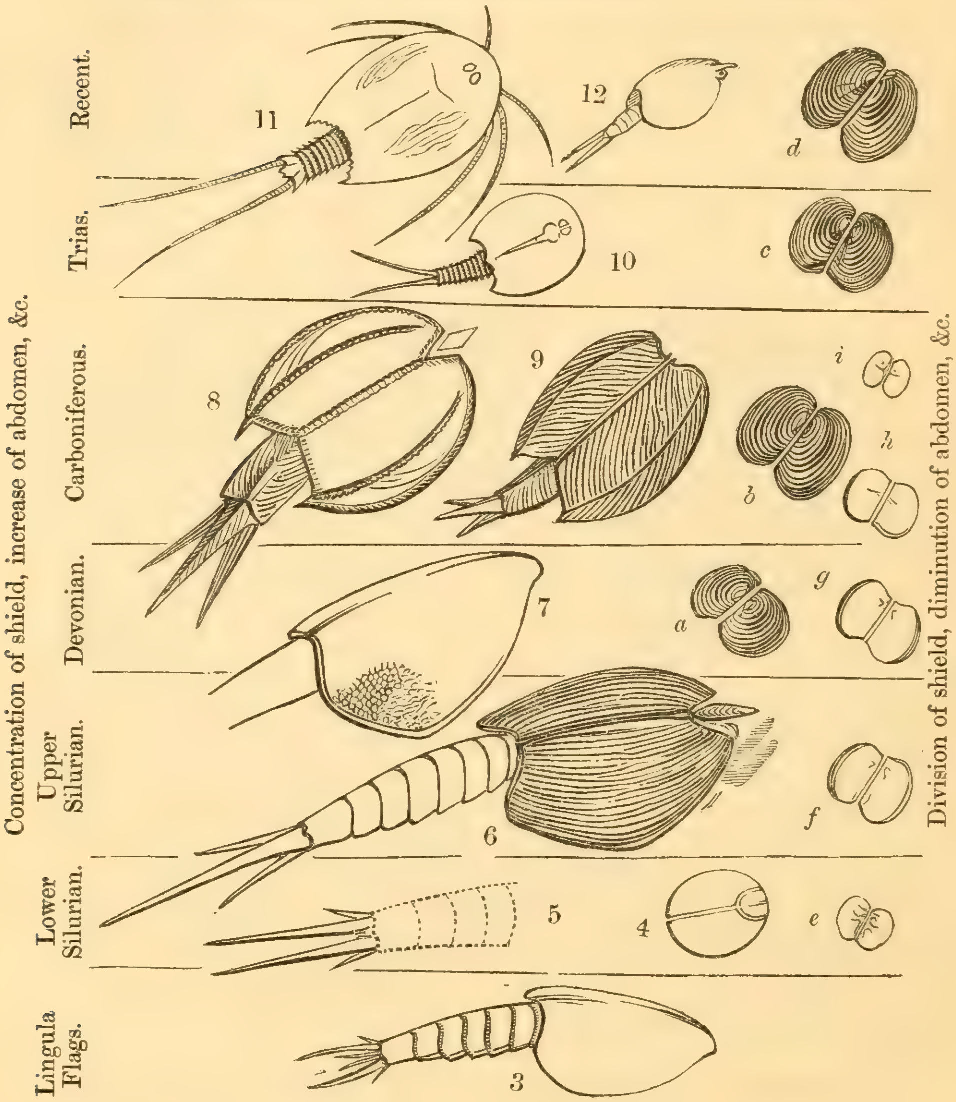


Fig. 3. *Hymenocaris*, Salter. Lingula-flags or Primordial zone.
4, 5. *Peltocaris*, Salter. Lower Silurian (Llandeilo or Caradoc).
6. *Ceratiocaris*, M'Coy. Upper Silurian.
7. *Dictyocaris*, Salter. Upper Silurian and Lowest Devonian.
8. *Dithyrocaris*, Scouler. } Carboniferous.
9. *Argas*, Scouler. }
10, 11. *Apus*. Trias to Recent.
12. *Nebalia*. Recent.
Figs. 3–12 are somewhat reduced; fig. 7 is less than one-tenth the natural size.
a–d. *Estheria*, Strauss. Natural size.
e–i. *Leperditia*, *Beyrichia*, &c. Natural size.

In *Peltocaris* this habit was certainly absent, and the whole contour indicates a flat, shield-shaped carapace, though divided into three parts. In *Dithyrocaris* (fig. 8) the sutures themselves are lost, as they are in *Nebalia* (fig. 12).

Peltocaris would seem to be, in some sort, intermediate between the shield-bearing *Dithyrocaris*, whose valves are soldered into one, and the bivalved genera. And, if we had the body preserved, we might probably find a still nearer relation to a more ancient genus, found in the Lingula-flags, I mean the *Hymenocaris* (fig. 3), now becoming pretty well known.

I beg leave to express what appears to me to be the series of affinities of this and other known *Phyllopodous* forms in a diagram, which shall at the same time give their chronological order. The numbers correspond with those on the woodcut.

Fig. 3. Beginning with what I must call the more generalized type, *Hymenocaris*. In this the shield is neither flat nor bivalved, but simply bent; and without any rostrum. There is a medium number of free body-segments; while the appendages of the *tail* are irrelatively multiplied. (Lingula-flags or Primordial Zone.)

Fig. 4. A form (*Peltocaris*) in which the carapace is marked out, as it were, into three portions, not yet intended to enclose the animal. The body and appendages are not known; but a Crustacean certainly existed in the Llandeilo-flags in some respects intermediate between *Hymenocaris* and *Ceratiocaris*, and we may perhaps be justified in provisionally referring to *Peltocaris* such tracks as those described below (page 93).

Fig. 5. *Peltocaris* (?)*.—Known only by tracks made by a double instrument which *may* have been part of a more complex tail (see p. 93).

Fig. 6. *Ceratiocaris*.—Here the rostrum is narrowed, but still not soldered to the carapace. And the valves have free motion, and partly enclose the body. The tail-appendages are three; the telson being enlarged to make the third and larger prong.

Fig. 7. A very imperfectly known form of immense size occurs in the Lower Devonian and Upper Silurian; but all that is known of it is that the carapace is undivided and reticulate (*Dictyocaris*).

Figs. 8 to 12. From this point the larger Phyllopods (for, though I have inserted them, figs. *a* to *i*, it may be a question yet whether *Leperditia* and its allies be undoubted Phyllopods) diverge (in a geological sense only) into two groups; the one becoming more decidedly shield-shaped, and with exserted abdomen and large caudal styles; the other starting at once with a bivalved carapace, completely enclosing the small abdominal segments and their minute appendages (*Estheria*).

I do not pretend to have shown every link, but have given all I

* I hope I may be allowed to insert in this figure (which is only a diagram) the caudal appendages at least of the hypothetical Crustacean whose existence in the Llandeilo strata I cannot doubt (see next paper). It might be too much to surmise that it belonged definitely to *Peltocaris*, or that the *P. Harknessi*, a Llandeilo species, actually produced the tracks.

could find of published data, and here exhibit the series in a diagrammatic form, that the naturalist may judge for himself whether it bear out the view of Darwin, or no.

I do not think, judging by the carapace only, that many links are wanting between the Llandeilo-flag *Peltocaris* and the Upper Silurian *Ceratiocaris*. But there is evidently a still nearer connexion (probably we want an intermediate Devonian form) between *Ceratiocaris* and *Dithyrocaris*. The *Argas* of the Lower Carboniferous rocks, and a huge bivalve Crustacean not here described*, were close relations of the *Dictyocaris* and *Ceratiocaris* of the Upper Silurian, differing only in having the anterior joints of the abdomen concealed, and the rostrum minute or possibly (but not probably) absent.

The links between these Coal-measure forms and those of recent times are many of them wanting; but in *Nebalia* we have a good representative of the compact, shield-shaped form of *Ceratiocaris*, the two valves soldered into one, and the rostrum attached,—the eyes being still beneath the carapace. *Apus* is the most complete and decided form, and it is one of the latest of this group, as it commences in the Trias. The abdomen is not only greatly increased, and the caudal styles elongated beyond the telson, but the styles are jointed appendages; and the feet and antennæ have also taken on a development wholly beyond that of the rest of the order.

The other group, the truly bivalved and enclosing Phyllopods, do not present the same variety of forms. From the period of the Middle Devonian, where *Estheria* first makes its appearance, till now, there has been but little change, except a gradual increase in size. And, as I do not feel sure that we have in the *Estheria* or *Leperditia* the oldest member of the series, I will only place them as they stand in the diagram, and abstain from discussing the affinities of any but the larger and shield-bearing Phyllopods.

I may be permitted to say, that even of these the series, as here exhibited, is not quite satisfactory in a Darwinian point of view. The transition, if it be such, from *Hymenocaris*, with an entire shield, to a form with sutures, and then valves, returning afterwards to a more completely soldered and compact form, may be regarded as an oscillation of character by those who do not see a more embryonic representative in the thin undivided carapace (without rostrum, suture, or external eye) in the primordial form. *Apus*, however, is unquestionably the most highly developed; and it is the latest.

On some Tracks *of* Lower Silurian Crustacea. By J. W. Salter, Esq., F.G.S., A.L.S., of the Geological Survey of Great Britain.

[Read May 21, 1862.]

This short communication seemed hardly worth the Society's notice, and would have been long delayed, but for the appearance of a most interesting photograph-plate in the 'Transactions of the

* *Dithyrocaris Pholadomya*, MS., a species with a carapace 7 inches long, from the Carboniferous Shales of Berwickshire.

Linnean Society of Normandy,' 1861. This shows the entire surface of a slab of sandstone, observed by the author of the paper, M. de Brébisson, in a small quarry at Noron, in the Falaise; which sandstone, overlain by beds of red and brown schist, the author is disposed, with M. Morière, to consider of Cambrian rather than of Lower Silurian age. The geologic position may be somewhat doubtful; but at least these sandstones and schists are overlain by the quartzose rocks referred to the age of the Caradoc sandstone, which is now tolerably well known in Normandy.

The surface of the sandstone is split up by a compound cleavage, and the slabs could not be detached; casts only and photographs could be taken, but these are quite sufficient to show the whole nature of the imprints. These, though doubtfully referred by M. de Brébisson to gigantic *Algæ*, are (by the consent of four British palæontologists) clearly referable to the tracks of some Crustacean. I shall endeavour, after describing a similar track from British rocks, to show in what respects the two differ, and in what way the tracks were formed.

Track of Peltocaris (?).

The track to which I would first draw attention was presented to the Museum of Practical Geology* by the late Rev. T. T. Lewis, of Aymestry. He found it in a picturesque glen (Wilmington Dingle), near Chirbury, Salop, in beds of the age of the Llandeilo-flags, which, in various localities near, contain abundance of the characteristic *Ogygia Buchii* and *Lingula granulata*. In these beds, up to the present time, no other Crustaceans than Trilobites have been discovered.

The surface of the slab, broken unfortunately in two by some meddling collector, was evidently once continuous, and must have been fully 2 feet long by 1 foot broad. On this surface three broad ripple-ridges, with intervening shallow depressions, may be seen; and the ridges are cut in all directions by the marks to be presently described, while the depressions are left untouched.

I draw attention to this striking feature, because it at once shows us that the creature swam so near the bottom, that every stroke of the extremity of the tail impinged upon the muddy ridges, and not so close to the bottom but that the instrument, whatever it was, did not strike it when the animal passed over the more depressed surface.

The tracks vary not a little in length. The deeper ones are often 2 inches long, and occasionally even more; the shallower ones sometimes not more than $1\frac{1}{2}$ inch to less than $\frac{1}{2}$ an inch. But all are of the same breadth; and all, without exception, have been made by the same instrument. They are very numerous, as many as twenty-three being crowded (and crossing each other at all angles) in a space of 4 inches on one ridge. In other portions not above a dozen occupy the same space. They are broad and shallow at the abrupt end, deep and narrower in the middle, and taper a good deal toward the smaller end; and at both extremities the mud has been driven up

* Wall-case IV. $\frac{\text{S. 1}}{\text{No. 12.}}$

Track of Peltocaris (?).

into a ridge by the stroke; while along the deeper middle portion the matrix has fallen in after the instruments (there were two of them) had passed, and appears as a rounded, tumid border.

That there were two instruments or styles used to produce the stroke is clear from the shape of the indent. In very shallow imprints the marks of the two prongs (set rather widely apart) are visible along the whole length of the indent, and keep at an equal distance along this space. When the indent deepens, the prongs appear to have been pressed together as the stroke proceeded, for the imprint is narrower at the deeper part; and then, as the stroke was ended, they did not in all cases spring open to their full width, but remained half closed until the prongs were withdrawn. But at the first impact they are always about two lines apart; and, as before stated, when the stroke has been a shallow one, this breadth is preserved to the extremity of the imprint.

The mud must evidently have been very soft when these impressions were made; for there seems to have been no resistance, save that which the natural density of the substance would readily account for. That two prongs were used in the operation is equally clear; and we must look, therefore, for a Crustacean which must have possessed such a pair of caudal appendages. There is no probability whatever of the markings having been produced by lateral feet, for the stroke has in every instance been unique.

The question next arises, what Crustacean could have formed such a track? We know of many large forms in the Upper Silurian rocks which have strong prong-like tails; and it is to these I should naturally look for comparison, were it not that all the species of *Ceratiocaris* known, besides being strictly Upper Silurian, have the median prong, or telson, of the tail so strong and large that it alone would have made the imprint. Such a creature might indeed easily drag its long telson along with a wriggling motion, and produce the wavy, zigzag trail observed on the slab of Normandy sandstone. The wavy line is just what would be produced by a weapon trailed slowly along a ridge of muddy silt, which detained it, while the intervening hollows would not be even touched by the instrument. I refer that track to *Ceratiocaris*, or an allied genus. But the double imprint of our specimen is to be interpreted differently. Either we must conceive a genus allied to *Ceratiocaris*, but with the median tail-prong abortive and the two lateral ones only developed, or we must look to rocks of a higher antiquity than the Llandeilo-flags for its analogue. I have lately learned that the caudal appendages of *Hymenocaris*, from the Lingula-flags of Wales, were composed of six pieces, four short and two long ones (fig. 3, p. 90). If we have not yet discovered the large Crustacean which made these broad and vigorous imprints, we may feel pretty certain, from analogy with forms found both on higher and lower horizons, that it was a great Phyllopod, with a prong-like tail, intermediate (in all probability) between the two genera above named. A single track becomes in this way the witness of an undiscovered form. It may possibly belong to *Peltocaris* (p. 90).

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From July 1st to September 30th, 1862.

I. TRANSACTIONS AND JOURNALS.

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American Journal of Science and Arts. Second Series. Vol. xxxiv. No. 100. July 1862. *From Prof. B. Silliman, For. Mem. G. S.*

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F. Roemer.—Notiz über das Vorkommen von *Nautilus bilobatus*, Sow., im Kohlenkalke Schlesiens, 695.

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PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 17, 1862.

Richard Richardson, Licentiate of the Royal College of Physicians of Edinburgh, Rhayader, Radnorshire, and John Wickham Flower, Esq., Park Hill, Croydon, were elected Fellows.

The following communications were read:—

1. *On the* Skiddaw Slate Series. By R. Harkness, Esq., F.R.S., F.G.S., Professor of Geology in Queen's College, Cork. *With a Note on the* Graptolites, *by* J. W. Salter, Esq., F.G.S., A.L.S.

Contents.

1. Introduction.
2. The Skiddaw Slates of the west side of Derwentwater, Bassenthwaite, and Binsey Crag.
3. The Skiddaw Slates east of Derwentwater and Bassenthwaite Lakes.
4. Carrock- and Caldbeck-fells.
5. The Skiddaw Slates of the eastern margin of the Lake-district.
6. The Skiddaw Slates of Black Comb.
7. Conclusion.

§ 1. *Introduction.*

The several memoirs by Professor Sedgwick on the older Palæozoic rocks of the north of England, published in the 'Transactions' and 'Quarterly Journal of the Geological Society,' have indicated the nature and the arrangement of the older Palæozoic rocks as they occur in the Lake-district. Among these rocks, and forming the base of the sedimentary series in the north of England, is a mass of strata designated the *Skiddaw Slates* by Professor Sedgwick, from the circumstance that these slates comprise the Skiddaw range of mountains. They have hitherto been regarded as all but unfossiliferous, the described organic remains consisting only of *two* species of *Graptolites* and *four* forms which have been attributed by Professor M'Coy to Fucoids.

The Skiddaw slates occupy a large area in the northern portion of the Lake-district. They also occur in the south-western extremity of Cumberland, where they form the mountain of Black Comb; and they are seen in Westmoreland on the eastern margin of the Lake-district, exhibiting themselves in *three* small patches. The object of this memoir is to point out in detail the circumstances under which they occur in their several areas, and to show that they are more fossiliferous than they have hitherto been regarded, and also to point out their equivalents elsewhere.

§ 2. *The Skiddaw Slates of the West Side of Derwentwater, Bassenthwaite, and Binsey Crag.*

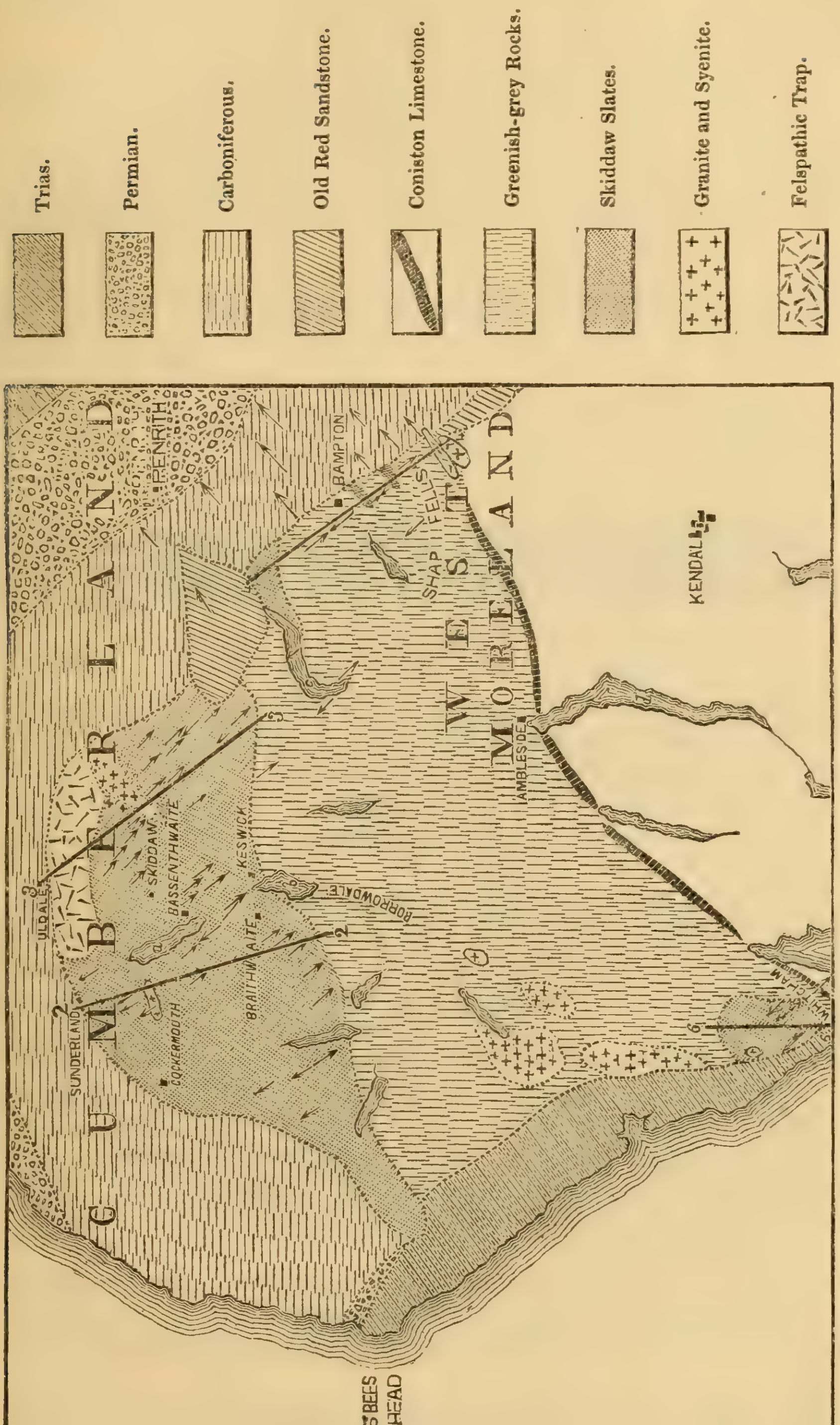
The Skiddaw slates on the west of Derwentwater and Bassenthwaite Lakes, and Binsey Crag, form a portion of the area where they exhibit themselves in their greatest development, both geographically and geologically. The south-eastern boundary of this western part of the Skiddaw slates of Cumberland runs from the lower end of Derwentwater, by the Cat Bells, through Newlands to the head of Crummock-water. From thence it continues westward, and then, passing by the lower end of Ennerdale Lake, turns south-westward round the base of Dent Hill.

The western margin of this area is marked by the Carboniferous rocks of West Cumberland; and these rocks, in their eastern extension from Cockermouth, run along the northern edges of Binsey Crag and Caldbeck-fells, forming the northern limit of the older rocks of Cumberland.

The eastern boundary of the district under consideration is formed by the lower portion of Derwentwater, the River Derwent, Bassenthwaite Lake, and the ridges extending to Binsey Crag.

Commencing at Newlands, on the southern border of the Skiddaw slate area, we have, in the hills which lie south of Newlands, the greenish-grey rocks, containing lead-veins, which appertain to the series immediately overlying the Skiddaw slates. On crossing the Newlands valley northwards, the Skiddaw slates make their appearance at the southern base of the ridge of hills which contains Aiken Knot and Keskadale Knot. The strata here dip S.S.E., passing under the greenish-grey rocks, and consist of hard, slaty, grey shales, with interstratified coarser beds not exhibiting the same amount of cleavage as the finer deposits. On the north side of Keskadale Knot there are considerable masses of *débris* which have fallen from the outcrop of the Skiddaw slates. This *débris* is locally called "Screes," and among it fragments containing fossils are found. These "Screes" occur also on the south side of Keskadale Knot, and yield the same fossils as those

Fig. 1.—*Map of the Skiddaw Slate District.*



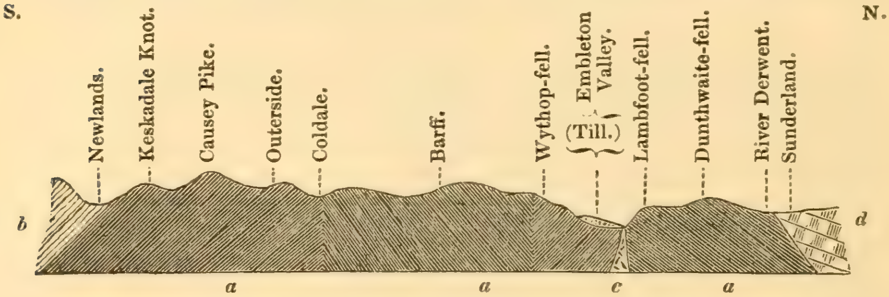
a. Bassenthwaite Lake. *b.* Derwentwater. *c.* Ullswater. *d.* Winandermere. *e.* Coniston Water.

The number attached to each line of Section refers to the Figure in which that Section is represented.

of the north side of this hill, viz. *Graptolites sagittarius* and a branching Graptolite. Tracks likewise are seen on the surfaces of some of the more flaggy strata.

On their strike, the rocks of Keskadale and Aiken Knots extend W.S.W. through Whiteless to the head of Crummock-water. At Whiteless they have afforded Professor Sedgwick *Graptolites latus* and *Chondrites informis**. From their position, and the relation which they have to the greenish-grey beds, the rocks of Keskadale Knot and Aiken Knot are among the highest of the Skiddaw slate series.

Fig. 2.—*Section from Newlands to Sunderland* (11 miles).



a. Skiddaw Slates. *b.* Green slates and porphyries.
c. Syenite. *d.* Carboniferous Limestone.

Northwards from the ridge just alluded to there occurs another, of which Causey Pike forms the highest summit, and in which a great development of slaty rocks is found. A short distance to the north of Causey Pike, and forming the southern side of the Coldale valley, is a lower ridge than that of which Causey Pike forms a part.

A portion of this ridge is known under the name of Outerside, and in its northern and more precipitous slope, facing Coldale, there is a considerable development of "Screes" under a rocky escarpment. The lower portion of this escarpment consists of cleaved rocks, the dip of the *cleavage* being N.W. Above these cleaved rocks flaggy strata are seen, dipping S.S.E. 30°. Among the "Screes" derived from the flaggy rocks fossils occur, and this is one of the localities among the Skiddaw slate series which, both in quantity and variety, is most prolific in organic remains. These fossils consist of Crustaceans, several forms of *Graptolites,* including the branching form which is seen at Keskadale, tube-like bodies apparently allied to the modern *Terebella,* and tracks.

East from this, at Hodgen-holm, near Portingscale, rocks of a flaggy character also occur, which, besides dipping S.S.E. at a high angle (60°), also contain evidences of animal life, usually in the form of tracks.

The Coldale valley, which lies N. of Outerside, affords no satisfactory dips among the strata, the rocks being for the most part of a slaty nature. North of this valley, inclinations are seen among the

* Quart. Journ. Geol. Soc. vol. iv. p. 223.

strata having an opposite direction from those on the south side, viz. N.N.W.

This valley seems to indicate the position of a well-marked anticlinal extending, in a W.S.W. direction, through the Skiddaw slates which lie to the westward. At Barff, which is situated near the head of Bassenthwaite, on the west side of the lake, these N.N.W. dips are very apparent. The south side of this hill, from the base for a considerable extent upwards, is covered with "Screes" composed of fragments of slaty rocks mixed with fragments of coarser flags, and with the outcrops of the Skiddaw slates well seen above them. These outcrops consist of slaty rocks interstratified with flaggy beds; and while the faces of the former are perpendicular, from the rocks exfoliating along the cleavage-planes, the latter have a regular N.N.W. dip at an angle of about 30°.

The "Screes" of the hill of Barff, like those of Outerside, afford abundance of fossils of a nature similar to those of the latter locality. Some of the fossils which occur at Barff were obtained by Professor Sedgwick at Scawgill, in Whinlatter-fells, which is immediately on the strike of the Barff strata.

These Scawgill fossils consist of *Graptolites sagittarius* and *G. latus*; and at Kirkfall, near Scawgill, *Palæochorda major* is found*.

The position and mode of occurrence of the fossiliferous strata of Outerside and Barff show that they are the representatives of the same zone on opposite sides of the anticlinal already alluded to, and their proximity to this axis leads to the conclusion that their horizon is low down in the Skiddaw slate series.

Northwards from Barff slaty rocks without very definite bedding occur. On approaching Wythop-fell from the south, the flaggy beds, having S.S.E. dips, again begin to make their appearance among the more slaty rocks. On the west side of Bassenthwaite Lake, a short distance south of the landing-place, near the Pheasant Inn, the flaggy beds with S.S.E. inclinations are seen intercalated among the slaty rocks; and immediately contiguous to the landing-place a thick mass of slate makes its appearance, underlying the flaggy rocks. On the northern escarpment of Wythop-fell, a short distance west of the Pheasant Inn, the slaty rocks with the intercalated flags are well seen, dipping S.S.E. 30°. There is every reason for inferring that the flaggy rocks seen here are the representatives of the fossiliferous strata of Barff and Outerside, and their opposite inclination to those of Barff shows the occurrence of a synclinal axis between the latter locality and Wythop-fell. North of Wythop-fell is the Embleton valley, which is about a mile wide, extending westward from Bassenthwaite Lake to the valley of Lorton, and is occupied by till and soil, exhibiting no rock *in situ*.

* Barff, being only five miles from Keswick, and close to the high road leading from thence to Cockermouth, is by far the most accessible locality in the Lake-district for obtaining Skiddaw slate fossils. In such profusion do they occur here, that in the course of an hour I obtained a bagful. There is also a comfortable small inn, called "The Swan," at the base of Barff.

Besides the localities alluded to as furnishing Professor Sedgwick with fossils, there occur, S.W. of the places named, other localities in the area under consideration which also afforded him organic remains. At Knockmurton-fell *Graptolites latus* and *G. sagittarius* have been found. Here the dip of the Skiddaw slates, which are hard and flaggy and of a grey colour, is W.; but this is a local dip. In this locality the Skiddaw slates yield iron-ore, one vein of which, about five feet in thickness, striking N. and S., and with an inclination towards the E., is here wrought.

To the east of this, at Blake-fell, Professor Sedgwick also obtained *Palæochorda minor*; and at Lowes-fell, on the north side of Loweswater, he mentions *Chondrites acutangulus* as occurring. Besides this, I have found here *Diplograpsus pristis.* The general dip of the strata in this part of Cumberland is N.N.W., and some of the fossiliferous rocks are on the line of strike of the beds of Barff and Whinlatter-fell. The anticlinal axis, previously mentioned as traversing the country W.S.W. from Coldale, seems to run to the southward of these fossiliferous rocks, and to cross Mellbreak, which is situated on the west side of Crummock-water, and is a hill having S.S.E. dips on its southern flank. In proceeding northwards from Crummock-water, down the Vale of Lorton, the mountains on both sides of this valley are made up of strata which correspond and conform with those on the west side of Bassenthwaite Lake, and are an extension W.S.W. of the rocks of that locality. There is an abundance of "Screes" on the flanks of the mountains on both sides of the Vale of Lorton, and also on Mellbreak, which would doubtless afford abundance of fossils if they were well examined.

On the north side of the Embleton valley are seen ridges of comparatively low hills, separating this valley from the vale of the Derwent. On the south side of these ridges there occurs at Lambfoot-fell a syenite which, when well exposed in its interior, is seen to be made up of very distinct crystals, but which near the outer margins becomes fine-grained and more trappean in its aspect. In this latter condition it is seen at the farm of Crag, near Bassenthwaite Lake, and eastward from Lambfoot-fell on its line of strike. Immediately north of this syenite, at Lambfoot-fell, are seen hard, flaggy Skiddaw slates, dipping N.N.W. 20°.

This inclination is the reverse of that which occurs on the opposite or south side of the Embleton valley, and indicates the presence in this valley of another anticlinal axis, parallel to the one which manifests itself to the southward. The Skiddaw slates of Lambfoot-fell incline towards a small valley separating this hill from the Hay, which forms part of another ridge north of the Lambfoot-fell range. In the Hay the Skiddaw slates are of a similar nature to those of Lambfoot-fell, and also have the N.N.W. inclinations. East from the Hay the ridge becomes higher, and forms Dunthwaite-fell, where, at Elba Plains, there are the same hard, grey, flaggy rocks, with intervening slaty beds, as seen at the Hay. Here also the dip is N.N.W. 35°, and the rocks, as well as the hill, slope away towards the River Derwent.

The rocks north of the Embleton valley differ somewhat in their mineral character from the Skiddaw slates which lie south of this vale, being harder, of a lighter colour, and having a greater affinity to the greywacke sandstones and shales of the Southern Highlands of Scotland.

North of the River Derwent, in the district between this and the margin of the Carboniferous rocks, the country is comparatively flat, and no good exposures of rock occur. In the course of a stream called Scalegill, which flows from the west side of Binsey Crag into the Derwent, there are seen at intervals small exposures of rock *in situ*. Several of these occur in the course of this rivulet through the flat moory country which lies between Binsey Crag and Sunderland, and exhibit soft black shales, considerably contorted, resembling the Skiddaw slates as they occur in the small areas of Westmoreland, rather than the rocks lying westwards of Bassenthwaite Lake and Derwentwater. Although considerably contorted, the prevailing inclination in this most northerly district of Skiddaw slate is N.N.W., and on the northern margin of this moory tract the Carboniferous formation makes its appearance, as seen at Sunderland.

With reference to the section extending from Newlands on the south to Sunderland on the north (fig. 2), no fossils have been obtained from that portion of the Skiddaw slates which lies north of the Embleton valley. There is, however, every reason to believe that, when the rocks in this portion of the area have been carefully examined, they too will furnish the same organic remains as occur in the strata lying on the south side of this valley. In the more southern portion of the area under consideration, the mode in which the rocks occur and the localities in which the fossils are found justify the conclusion that, notwithstanding the cleaved character of the great mass of the deposits, there are strata in which this structure is only very imperfectly developed, and which possess a well-marked flaggy nature. These flaggy beds occur at intervals through the whole of the Skiddaw slate series; and, wherever they present themselves, they yield fossils which are identical throughout the series, marking these deposits as palæontologically the same through the whole of the group.

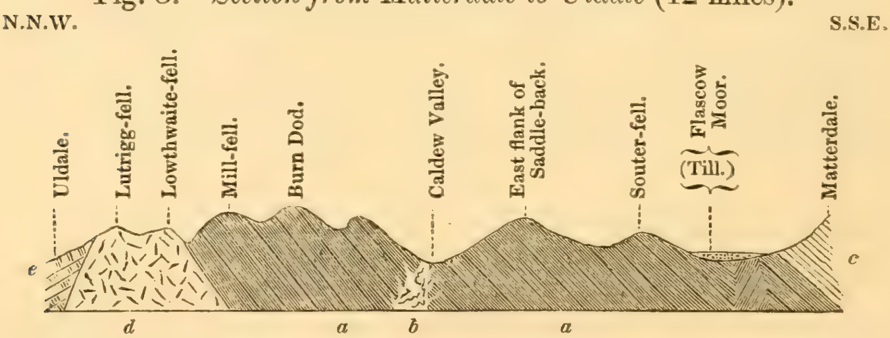
§ 3. *The Skiddaw Slates of Cumberland, east of Derwentwater and Bassenthwaite Lakes.*

The north-eastern portion of the Lake-district is occupied by an extension eastwards of the Skiddaw slates which occur in the area already described. This portion has for its western boundary the eastern limits of the district just alluded to, being flanked on this side by the northern end of Derwentwater, the River Derwent, and Bassenthwaite Lake. Its northern boundary is the porphyritic rocks of Caldbeck-fells. On the east it is margined by Carboniferous rocks which skirt Carrock-, Bowscale-, and Mungrisdale-fells; and on the south the greenish-grey rocks which occur north and west of Matterdale, forming the northern flanks of Great Dod, White Pike, and Wanthwaite Crag, and, extending from the entrance into the

Vale of St. John westward to Keswick, bound the Skiddaw slates of this portion of Cumberland.

The southern portion of this area rarely exhibits the rocks *in situ*. The Skiddaw slates in this district occupy Flascow Moor, a large tract of barren country lying between the Keswick and Penrith Road on the north, and the base of the hills just referred to on the south. Two streams, having their origin among the greenish-grey rocks on the south, intersect this moory district in their course to the Glendermaken River, which flows into the Greta near Threlkeld. The most easterly of these streams, called Troutbeck, after passing over the greenish-grey rocks, reaches the moory country, and begins to exhibit in its course the Skiddaw slates. In a small brook which flows into Troutbeck from the west, these slates are considerably contorted, but have predominant S.S.E. dips. A short distance above the hamlet of Troutbeck this inclination is well seen, the angle being 40°; and a gritty quartz-rock, strongly impregnated with iron-pyrites, is here seen associated with the Skiddaw slates. For a considerable distance below this hamlet, through the moor, no exposures of rock occur; but when the stream reaches near to the Keswick Road, parallel to which it flows for some distance, we have good sections of the Skiddaw slates, principally on the line of *strike*. The stream in this portion of its course is called Gills-beck, and here the Skiddaw slates, which are thin-bedded and of a dark colour, have prevailing N.N.W. dips. Intercalated with the strata are masses possessing the structure known as cone-in-cone, a feature which accompanies the Skiddaw slates in some other localities. In some portions of this section there are great contortions in the bedding, and quartz-veins are abundant, running along the lines of the contortions.

Fig. 3.—*Section from Matterdale to Uldale* (12 miles).



a. Skiddaw Slates. *b.* Granite. *c.* Green slate and porphyry.
d. Felspathic Traps. *e.* Carboniferous rocks.

Westward from this stream we have the Skiddaw slates exhibited in the course of another brook, which also traverses Flascow Moor from the south. This, which is known as Mosedale-beck, rises from the northern flank of Great Dod, and its upper portion is likewise over the greenish-grey rocks. The junction of these with the Skiddaw slates in the course of this brook is not seen, in consequence of the peaty nature of the country at the base of the crags of the greenish-grey rocks. Below this peaty interval the Skiddaw slates occur, and are seen in Mosedale-beck, consisting of contorted black shales, like those of Gills-beck, having the cone-in-cone masses imbedded among them.

The Skiddaw slates in the course of this stream have a prevailing N.N.W. inclination. They yield *Graptolites sagittarius* *.

The interval of country between the Keswick Road on the south and the Glendermaken River on the north affords no exposures of rock. In the Glendermaken, as it flows along the eastern base of Souter-fell and south from Mungrisdale, the Skiddaw slates, of a dark colour, are seen at intervals dipping S.S.E. At Mungrisdale these Skiddaw slates are worked, and have a well-marked cleavage; but the surfaces of some of the strata very frequently show distinct tracks. Tracks similar to those of Mungrisdale also occur at Two-seats, near Threlkeld, on the south base of Saddle-back, which is on the line of strike of the Mungrisdale beds. The strata at Mungrisdale, some of which are flaggy, dip towards the S.S.E. at 55°.

With reference to the Souter-fell ridge, which lies between Mungrisdale and Saddle-back, on its south side it has a very regular slope, while on the north side it is more abrupt and marked by escarpments, from which results a considerable development of "Screes."

Among these "Screes," tracks are found resembling those of Mungrisdale, and the rocks which produce the "Screes" dip S.S.E. about 30°. On the opposite side of the valley of the Glendermaken, north of Souter-fell, the ridge known as Bannerdale-fell is seen. In the south spur of this ridge a considerable mass of chiastolite-slate makes its appearance, and has been extensively wrought here.

The first appearance of this mineral in the Skiddaw slates is marked by the occurrence of chiastolite in the form of very small dots, and some of the rocks so marked contain tracks. Following the southern spur of Bannerdale-fell northwards, the chiastolite is seen to become more abundant, and, on the higher portions of the hill, obtains to such an extent as to constitute chiastolite-rock; and rocks of this nature form the ridges which occupy the southern side of the Caldew valley. A southern spur from Bowscale-fell, called Tongue, parallel to the southern spur of Bannerdale-fell, exhibits similar rocks to those just described.

Following the Glendermaken, between Souter-fell and Bannerdale-fell, to its source, tracks occur, on the south-west flank of Bannerdale-fell, in the unchanged Skiddaw slates which dip S.S.E. Towards the north these slates become more black and glossy, and have spots of chiastolite in them. A short distance brings on the chiastolite-slates, and at the summit of the low ridge connecting Bannerdale-fell and Saddle-back the chiastolite-rock occurs.

* The streams which intersect Flascow Moor cut through a fine mass of glacial *débris*, consisting of sandy clays containing imbedded boulders of the several rocks which occur in the northern portion of the Lake-area. These boulders are often very beautifully striated; and on the surface of the moor large erratic blocks are very common.

From this ridge northwards, in passing into the Caldew valley, a still greater exhibition of the metamorphic changes produced on the Skiddaw slates by the influence of the granite of the Caldew valley is seen. In Black Hazel-gill, a stream which flows from the north side of Saddle-back into the River Caldew, the following changes in the metamorphic rocks occur. In the higher portion of the stream chiastolite-rocks are found; below these there comes on dark-coloured hornblendic rock, which passes downwards into hornblendic gneiss, and in some cases into mica-schist, the whole dipping S.S.E.; and, in the bed of the Caldew, granite appears. A similar sequence of metamorphic rocks is seen in the course of other streams which flow from the southern ridges of the Caldew valley.

Professor Sedgwick has described a nearly similar sequence of metamorphic rocks as occurring on the south side of the Caldew valley.

On crossing the area occupied by the granite of the Caldew valley, and following the course of the streams which flow from its northern slope, we have the metamorphic series of the Skiddaw slates, but not so well developed on the north side of the River Caldew as on the south.

Wiley-gill is one of the tributaries of the Caldew from the north, and enters this river a short distance above the junction of Black Hazel-gill, flowing from the south. The lower portion of Wiley-gill is over granite, which forms the south base of the hill on its eastern side.

This granite is not seen in the stream, the lowest rocks shown *in situ* having a gneissose character; but the exposures of rock in this brook are by no means good. At the junction of a small stream which joins Wiley-gill from the east, slates having a chloritic nature are seen dipping S.S.E. at a high angle; and at the head of Wiley-gill rocks of nearly the same nature occur, having a glossy aspect and a light-grey colour. Here they are almost vertical, but still the prevalent dip is S.S.E.

On crossing over the watershed at the head of Wiley-gill, northwards, there is the head of a stream called Whitehouse-gill; ordinary Skiddaw slates of a grey colour, having a vertical cleavage and a well-shown S.S.E. inclination of 30°, here present themselves. The south side of the hill called Burn Dod, forming the northern side of the valley drained by Whitehouse-gill, is covered with small blocks of a coarse, gritty character, containing occasionally fragments resembling Skiddaw slate. Similar coarse rocks are alluded to by Professor Sedgwick as occurring in the mass of Skiddaw. At the south-west base of Burn Dod, Whitehouse-gill is joined by Frozen-gill, flowing from the north-east; and the hill called Cockup-fell, lying on the north side of this stream below the junction, exhibits the mode of association of the grits, which are seen covering the south side of Burn Dod, with the Skiddaw slates. On the south-west side of Cockup-fell, where these gritty beds have been wrought, they are seen interstratified with the Skiddaw slates, and dipping at a high angle towards the S.S.W. On the east side of Cockup-fell and in the lower portion of Frozzen-gill, these grits also occur under like circumstances.

In following up Frozzen-gill to its source, the Skiddaw slates are well seen; they consist of grey beds considerably contorted, but with prevailing S.S.E. dips; and on both sides of the stream abundance of "Screes" occur, from which Graptolites were procured, including the branching form before alluded to, and also tracks.

North of the head of Frozzen-gill, on the opposite side of the water-shed, is the source of the Ellen, the river which enters the sea at Maryport. The banks of the stream, at its highest part known as Ellen-gill, afford exposures of rocks *in situ*, consisting of grey Skiddaw slates also dipping S.S.E.; and on following down its course, as it flows between Lowthwaite-fell and Mell-fell, the Skiddaw slate is again seen, dipping S.S.E. 35°.

There are numerous "Screes" on the sides of this stream yielding ordinary Graptolites and the branching form, the latter in considerable abundance *. The Skiddaw slates prevail down Ellen-gill for a considerable distance, when they are succeeded by rocks of a trappean nature, as these are exhibited in the enclosed ground on the north side of Lowthwaite-fell. East from this, at the head of Red-gill, and partially also at the head of Silver-gill, the Skiddaw slates make their appearance †.

The western side of the district of the Skiddaw slates under consideration is well seen among the rocks forming the western skirts of Skiddaw. In this portion of the district, to the north of a thick mass of quartz-veins known as "White Stones," above a plantation on the south-west side of Skiddaw, there is an escarpment of flaggy rocks; they dip S.S.E. 30°, and are associated with cleaved strata. Beneath this escarpment "Screes" are found which furnish *Graptolites sagittarius*, *G. tenuis*, *Diplograpsus pristis*, *Tetragrapsus* (the branching Graptolite before referred to), Crustaceans, Annelid-tubes, and tracks.

The whole of the fossils here have a great resemblance to those of Outerside, on the opposite side of Bassenthwaite Lake, and the position of the rocks here shows that they are an extension E.N.E. of the strata of that locality. Northwards from the escarpment of the south-west of Skiddaw, along the eastern skirts of the Dod-fell, although cleavage with a north-west inclination greatly prevails, the direction of the dip of the strata is on the whole S.S.E.; and the same dip may be seen on the road along the western base of Dod-fell, between Bassenthwaite and Keswick.

North of Dod-fell, which is the western spur of Skiddaw, on the side of the hill immediately north-east of Mirehouse, another escarp-

* On merely passing over the "Screes" of Frozzen-gill and Ellen-gill, I found the fossils alluded to in considerable quantities, especially in the latter locality. There is every reason to infer that if these "Screes" were well examined, they would afford numerous fossils, some of which might probably prove to be new.

† Red-gill is the only locality in England which affords the rare mineral caledonite—the cupreous sulphato-carbonate of lead. This, however, is not obtained from the Skiddaw slates, but in igneous rocks occurring here which will subsequently be alluded to.

ment is seen, from which "Screes" have originated. The strata here are contorted, but on the whole the dip is S.S.E. They have a mineral nature like the rocks north of White Stones, and like them they also afford Graptolites, among which *Graptolites sagittarius* is most abundant *.

In the Skiddaw slate district lying east of Keswick Lake and Bassenthwaite Lake there is no axis distinctly shown. Sections along the western side of this area and along its eastern margin alike manifest a succession of S.S.E. dips from the northern portion of the Skiddaw slates almost to their southern limits. In this area also, wherever the Skiddaw slates occur, if they do not exhibit a highly metamorphic condition, nor a great development of cleavage, they yield the same fossils throughout the series.

§ 4. *Carrock- and Caldbeck-fells.*

Allusion has already been made to the granite of the Caldew valley, the Skiddaw Forest granite of Professor Sedgwick. This rock is seen extending down the course of the Caldew at intervals to near the junction of the stream flowing from the north, called Brandy-gill. It forms the south-east flank of the hill lying west of Brandy-gill, the surface of this flank being strewed over with granite-blocks.

From this hill it is well seen in the lower portion of the Brandy-gill rivulet, where it occurs in the condition of a fine-grained granite, much intersected with quartz-veins.

On the east side of Brandy-gill the same fine-grained granite is seen, forming the western spur of Carrock-fell, also much intersected by quartz-veins. From this spur eastwards, the crest of Carrock is flat, and covered with peat and vegetation, exhibiting very few traces of rock; but when the east side of the north spur of Carrock is reached, a very felspathic granite, approaching somewhat to porphyry, makes its appearance, and this forms also the summit of Carrock-fell. Although differing in its texture somewhat from the granite seen in Brandy-gill, I have little doubt of its being a continuation of the same mass, which, following the strike of the stratified rocks, extends W.S.W. into the valley of the Caldew, and E.N.E. through the northern half of Carrock-fell. On the south side of the granitic area there is seen, forming the southern mass of Carrock, and in close contact with the fine-grained granite of the western spur of Carrock-fell, a rather singular felspathic rock, consisting of two felspars, orthoclase and labradorite, and having an aspect greatly resembling that of a greenish-coloured syenite. This rock is not however confined to Carrock, but occurs also among the Caldbeck-fells †.

* The localities in the neighbourhood of Keswick which afford fossils, viz. Outerside, Barff, Skiddaw, Longside, and Mirehouse, were, I believe, first recognized as fossiliferous by Mr. Joseph Graham, mineral-dealer, Keswick.

† The quartz-veins of Carrock-fell are famous for the rare minerals which they afford. Besides wolfram, which is found in considerable abundance, they yield scheelite (tungstate of lime), apatite, telluric bismuth, molybdenum-glance, and also, to the north-west of Carrock, in Caldbeck-fells, fine specimens

On the north side of the granite of Brandy-gill, in the course of the stream, hard, grey, crystalline rocks devoid of bedding occur; and rocks of this character are seen likewise in the courses of Thief-gill, which flows from the north side of the western spur of Carrock-fell into Brandy-gill. Although devoid of bedding, these rocks often show traces of lamination, and they appear to be the representatives here of those gneissic rocks which are so well developed on the south side of the plutonic area. What they pass into northwards is not seen, the flat summits of the Caldbeck-fells being extremely peaty.

The interval between the north end of Carrock-fell and the south side of High Pike, the adjoining mountain, does not exhibit the rocks *in situ*, so that the relation between the plutonic masses of Carrock-fell and the igneous rocks of the Caldbeck range is not apparent. The brook-courses in the interval also afford no Skiddaw slate, and there is strong reason for concluding that no sedimentary rocks intervene between these plutonic and igneous masses.

High Pike itself is composed, for the most part, of claystone-porphyry, which is well seen in the course of the Pottsgill-beck, a stream flowing from the north side of this mountain by Caldbeck into the Caldew. This claystone-porphyry has a greyish-drab colour, and contains yellow crystals of felspar, which are generally partially decomposed. The stream which flows to the west of Pottsgill passes over rocks which have a similar nature.

In the upper portion of Roughten-gill, a stream which rises among the flat summits of Caldbeck-fells and flows northwards through these mountains, there is a more varied series of igneous rocks. On the moors at the head of this stream claystone-porphyry, similar to that just alluded to, occurs; on passing down the stream, a mass of compact felspar makes its appearance; and this is succeeded by a considerable development of a rock composed of orthoclase and labradorite, like that forming the south side of Carrock-fell, and in which the lead-veins at Roughten-gill principally occur.

One of the best exposures of the porphyritic rocks of Caldbeck-fells is seen in the course of a stream called Charlton-wath, flowing between Brae-fell and Langlands-fell. The upper portion of this stream is over claystone-porphyry, being an extension westwards of that at the head of Roughten-gill. Lower down the stream, and near the junction of a rivulet flowing from the south-west, a grey trap makes its appearance. For some distance below this junction no rock is seen; but after the barren interval is passed over, we come upon a fine-grained, greenish-grey, felspathic rock, beyond which is a small development of claystone-porphyry. Still lower down the stream we meet with a rock having a singular aspect. This rock is much broken up in structure, has a mottled appearance, and seems to be composed of white and green felspars. It is usually partially decomposed, and its mottled character is well seen on its weathered

of phosphate of lead. There occur also arsenio-phosphates, sulphates, cupreous sulphates, and cupreous sulphato-carbonate of lead; and along with these are seen radiated malachite, brochantite, and other minerals.

surfaces. This mass of rock is probably the same as the double-felspar rock of Roughten-gill, with larger crystals, which appear to have undergone changes from chemical action. Below this mottled rock, in the course of the stream, we come upon a grey felstone, well developed, and succeeded by a purplish claystone which, on passing downwards, assumes a porphyritic nature, containing small white crystals of felspar. This last-named rock is seen immediately above the moor-road to Caldbeck, and a short distance below this road the Carboniferous rocks occur *.

The felspathic rocks extend still further to the north-west. The mottled rock is seen on the west side of Langlands-fell, and in it copper has been partially worked. The grey felspathic traps occur in Lowthwaite-fell, and from thence they extend to the north side of Overwater, being well seen at Latrig-fell, which lies immediately north of this small lake; they are also well exhibited in Binsey Crag, where they are principally of a porphyritic nature. Here sometimes they occur in the form of strata, and seem to be composed of masses of felspathic ash, containing fragments of felspar-porphyry. When presenting this aspect, they have a conglomeratic nature, and are excessively hard. On the north side of Binsey a fine purple porphyry, with greenish crystals, is seen; to the north of this, on the ridge called Whitehouse Hill, hard grey rocks make their appearance, being succeeded northwards by the Carboniferous series. To the west of Binsey Crag and Whitehouse Hill there again occurs a flat moory country like that before described in connexion with the Skiddaw slates.

I believe that Professor Sedgwick is disposed to regard the felspathic traps of the Caldbeck-fells Range as the northern equivalents of the greenish-grey rocks which, to the south, succeed the Skiddaw slates.

5. *The Skiddaw Slates of the Eastern Margin of the Lake-district.*

At the lower end of Ullswater, a small stream called "Ellerbeck" enters the lake from the south; it crosses the road leading from Pooley to Howtown, and, at a short distance above, divides into two branches. The more southerly branch is known as Eggbeck; the lower portion of its course is over gravel and large blocks of stone derived from the boulder-clays of Doveack Moor. On ascending the stream, after passing through the enclosed ground, a plantation is reached which marks the boundary of the cultivated land, and above which rocks are seen, *in situ*, in the bed of the brook.

These rocks consist of contorted shales, dark in colour, thin-bedded, and having a great resemblance to the graptolitiferous shales of Dumfriesshire, but they do not present beds so highly anthracitic as those of the south of Scotland; as they are much broken up by closely approximated joints, they have a very shivery character.

On ascending the stream, above the dark shales others are seen

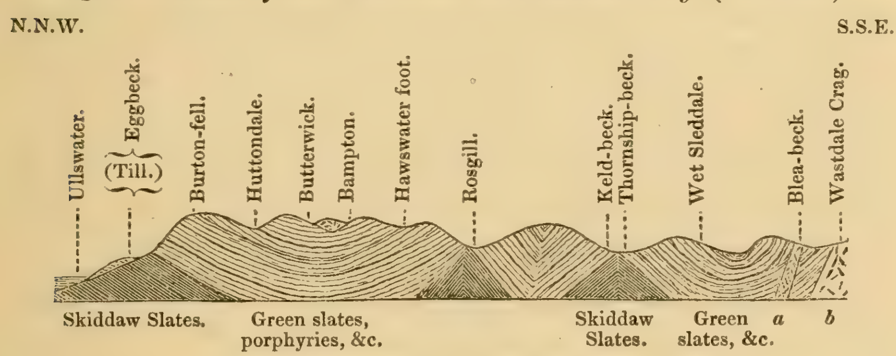
* I am indebted to Mr. Joseph Peat, of Caldbeck, for directing me to the several streams in this district where good sections occur, and also for information concerning the igneous rocks and mineralogy of Caldbeck-fells.

of a lighter colour, which are again succeeded by dark shales resembling those below, and containing Graptolites. Drab shales are seen above these in the course of the brook, having intercalated grey beds, the whole presenting a shivery aspect.

Above the foregoing shaly strata, for a short distance no rocks are seen in the bed of the stream; but a little above where the main road from Barton to Martindale crosses Eggbeck, a greenish-grey porphyry, with orange-coloured crystals of felspar, makes its appearance, and continues to occupy the bed of the stream to near its source, having occasionally ashy masses intermixed with it.

The Graptolites which occur in the dark shales of Eggbeck consist of *Graptolites sagittarius* and *Didymograpsus geminus*, together with the branching form previously referred to. These fossils are by no means abundant here, and, owing to the shivery nature of the strata, they are usually in a fragmentary condition.

Fig. 4.—*Section from Ullswater to Wastdale Crag* (11 miles).



a. Trap. *b.* Syenite.

Lying west from Eggbeck is Barton-fell. At the top of this hill is a greenish, ashy-looking grit; and in the stream which separates Barton-fell from Swarth-fell, the hill still further westwards, the porphyries of Eggbeck are well seen, together with greenish rocks, which are not porphyritic, intercalated among them, but having no distinct bedding. The rocks here are rudely prismatic, and to the S.S.E. they seem to pass upwards into the greenish-grey rock above alluded to.

Eggbeck is the only spot in this neighbourhood where the Skiddaw slates are seen. To the north of Barton-fell and Swarth-fell, both of which rise boldly above Ullswater, exhibiting escarpments on their north sides, there is a comparatively low tract of country; but there no rocks *in situ* appear, the interspace from the south side of Ullswater to the adjoining hills being covered by soil and *débris*. The contour of the country, however, justifies the conclusion that the Skiddaw slates extend some distance along the northern base of Barton-fell and Swarth-fell, but that they soon become covered up by the porphyries, ash-beds, and green slates, which are so extensively developed along the margin of Ullswater, from Howtown to Patterdale, and also in the mountainous district lying southwards.

There are strong reasons for inferring that the presence of the Skiddaw slates at Eggbeck is the result of an anticlinal axis crossing this portion of the Lake-district and extending in a W.S.W. direction. Proofs of the existence of this axis can be seen in the neighbourhood of Patterdale. On the east side of this portion of Ullswater several slate-quarries have been wrought, at Blowick, along the western base of Place-fell.

These slates usually show very imperfect stratification, and the cleavage commonly intersects the bedding. In some localities, however, the dips are apparent, being S.S.E., generally at an angle of 30°, which is also the prevailing dip of the Skiddaw slates at Eggbeck. On examining the arrangements of the lines of lamination among the slates here, they also are found to conform to the dips of the strata. Among the more regularly stratified beds east of Patterdale, there is often a rapid thinning-out of the strata.

On the opposite side of the lake, in the face of the cliff looking towards Ullswater, immediately north of Patterdale Hall, the strata, which consist of a dark greenish-grey grit, spotted with red, so as to have almost a porphyritic appearance, dip towards the N.N.W. about 35°, an inclination directly opposed to that on the east side of the lake.

These features support the inference that the axis before referred to extends through Place-fell, and, crossing the upper reach of Ullswater, passes through Grisedale, from whence it runs in the direction of the granite-area in the lower part of Eskdale, in West Cumberland.

To return to the section along the eastern margin of the Lake-district. To the south of the porphyries and greenish-grey rocks associated with them in the higher portion of Eggbeck, we have in Heltondale a development of the greenish-grey grits with indistinct dips, but apparently inclining S.S.E. These also occur further south at Butterwick, where they are intersected by north and south joints; and here likewise the stratification is imperfect. Southward from this, at Bampton, the greenish-grey rocks are also seen, being worked here for building-purposes.

In this locality, besides the ordinary greenish-grey rocks, there occur others which contain angular fragments of a hard, grey rock, not unlike some of the harder varieties of the Skiddaw slates, imbedded in a greenish-grey matrix. A similar rock is seen on the road from Ullswater, leading over Kirkstone Pass, and is also worked for a building-stone in Borrowdale.

The rocks at Bampton dip N.N.W. about 40°, and in the interval between this and Butterwick a synclinal axis occurs. Southward from Bampton, in the neighbourhood of Thornthwaite Hall, situated on the stream which flows out of Haws-water, there is a large mass of the greenish-grey rocks; they continue southwards, forming the ridge called Scaleborrow, that separates the Haws-water valley from Swinedale. Here too the rocks are equally devoid of stratification, but are much intersected by joints, which often assume so regular an aspect as to look like bedding.

On the south side of Scaleborrow, in Rossgill-beck, which flows into the stream draining Swinedale, the Skiddaw slates are again seen; and here they were formerly worked for slate-pencils. In this locality the slates, which are somewhat shaly, are, by cleavage and fine jointing, cut up into long thin pieces. Intercalated with them are masses possessing the cone-in-cone structure, and which on decomposing produce abundance of hydrated peroxide of iron, showing their affinity in composition to iron-stone. The strata here are much contorted, but on the whole dip S.S.E.

Higher up Swinedale than the junction of Rossgill-beck, where the rocks become prominent on both sides of the dale, they consist of the hard greenish-grey grits, equally without distinct bedding with those lying northwards, and to such an extent cut by vertical joints that they have a columnar aspect. This exposure of the Skiddaw slates in Rossgill-beck is doubtless the result of another anticlinal, which, like that before alluded to, has a W.S.W. strike.

In the course of the River Lowther, southwards from the junction of Swinedale-beck, no rock is seen for a considerable distance. On the east side of the river occurs the Carboniferous series, which bounds the Silurians on the east. The lower part of the Carboniferous rocks is well seen in the escarpment on the east side of the Lowther, immediately above the ruins of Shap Abbey; here also the equivalents of the green slates and porphyries are seen in the stream, and, in consequence of having been stained by the beds of the Carboniferous series, they present a purple colour.

Above Shap Abbey, a small stream enters the Lowther opposite to the hamlet of Keld, and is called Keld-gill. Between this and the Abbey there are abundant exhibitions of rock in the course of the Lowther, all of which possess the greenish-grey colour and an imperfectly bedded character.

Southwards from Keld-gill, over that portion of Rafland Moor which lies between this and another small stream, called Thornship-gill, no good exposures of rock occur; and this remark applies also to the River Lowther in the interval between the junctions of these streams.

The lower part of the course of Thornship-gill is over gravel composed of small rounded fragments of Skiddaw slates; and on following up the stream for a short distance, these rocks are seen *in situ.* They consist of dark-coloured, shaly beds, like those of Rossgill and Eggbeck, enclosing masses which have also the cone-in-cone structure. The strata here are much contorted, but the prevailing dip is N.N.W. Quartz-veins intersect the beds, and have a N.W. and S.E. strike. The slates here, like those of Rossgill, are much broken up by cleavage and jointing; and they have also been extensively wrought for slate-pencils. This locality also affords fossils, among which we have *Graptolites sagittarius*, the branching forms, and others too imperfect to determine. In one locality on the N.E. side of Thornship-gill, porphyry is seen, which, from the dip of the slates, must overlie the latter, and here consequently we have the same sequence of strata that occurs at Eggbeck.

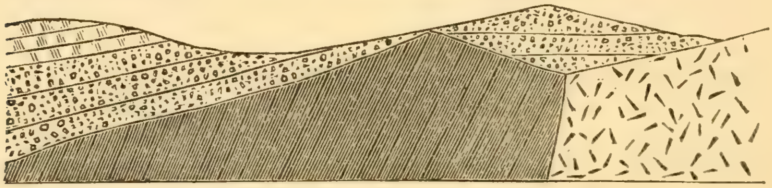
The appearance of the Skiddaw slates in this locality must be referred to the same cause to which those of Rossgill and Eggbeck have been assigned, namely, the occurrence of another anticlinal parallel to those already mentioned.

In following up the Lowther from the junction of Thornship-beck, we have at intervals many exposures of the imperfectly bedded, greenish-grey rocks. These are well seen at Cragg Mill on the north side of Shap Moor, and among the rocks here are found the masses which have the imbedded angular fragments already mentioned as occurring at Bampton and elsewhere. Like the same rocks at Bampton, it is probable that they mark the position of a synclinal, the rocks on their N.N.W. side having a S.S.E. dip, while in Wet Sleddale, on the south side of the Lowther, an opposite dip obtains. In the streams flowing from Wastdale Pike and Harrup Pike, which are tributaries to the Lowther from the south side of Wet Sleddale, the prevailing dips are also N.N.W.

On the high road leading from Shap to Kendal, owing to the moory nature of the ground, the greenish-grey rocks are not well seen in the interval between Shap Common and Wastdale Crag.

In this interval we have, however, at Blea-beck, a mass of basalt crossing the road, and extending north-eastwards to the Lancaster and Carlisle Railway, where, at the summit-cutting, this basalt and its relations to the Silurian and Carboniferous rocks can be distinctly made out (fig. 5).

Fig. 5.—*Section at the Summit-cutting on the Lancaster and Carlisle Railway.*



The principal mass of this cutting is the basaltic trap, which on its north side has greenish Silurian shales dipping N.N.W. at a high angle (above 50°). Upon them, and also upon a portion of the trap, conglomerates occur, made up of fragments of Silurian shales, quartz, chert, and trap, and dipping N.E. 10°. The conglomerates have purple grits above them, the total thickness of both being about 20 feet; and an irregular, nodular limestone, averaging a foot in thickness, lies upon the latter. On this irregular limestone, 8 feet of purple shales with limestone-nodules are seen, being succeeded by grey shales about 5 feet thick, having upon them another nodular limestone 18 inches in thickness, above which is a white grit, supporting the hard limestone which is wrought on Shap Moor.

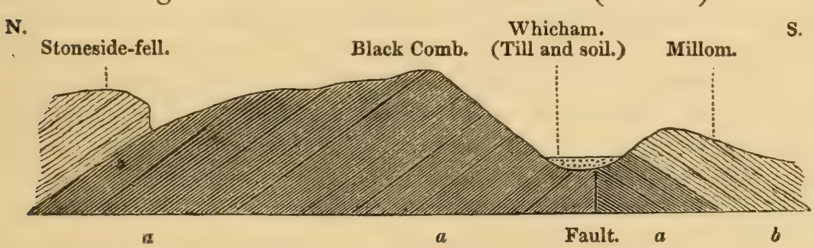
The junction between the greenish-grey rocks and the porphyritic syenite of Wastdale Crag is nowhere very apparent. There is seen, however, on the east side of the high road, a small quarry in which a felstone occurs, intermediate in character between a syenite and the greenish rocks; and a similar rock is also seen south-west from Wastdale Crag in the direction of Long Sleddale, where it is known under the name of "flint." It is probably a mass of plutonic rock having the same origin as the Wastdale Crag syenite, but possessing a less crystalline nature in consequence of more rapid cooling from having been in immediate contact with the greenish-grey rocks.

§ 6. *The Skiddaw Slates of Black Comb.*

The most southerly position occupied by the Skiddaw slates in Cumberland or in Westmoreland is Black Comb, a mountain rising abruptly to the height of 1919 feet, in the south-west of Cumberland; it is surrounded on all sides, except the west, by the greenish-grey rocks which succeed the Skiddaw slate series in the north of England. On the west side, Black Comb is margined by a comparatively low and flat tract of country, composed of the Trias sandstones extending southward from St. Bee's Head, and flanking on the west side the Silurian rocks and their accompanying granites and syenites.

To the south of Black Comb there is a flat tract of country which separates this mountain from the greenish-grey craggy rocks of Millom, and in which no rocks are seen, the area being covered with till and soil. Still further south, greenish-grey rocks occur, exhibiting their usual broken outline, and presenting bold escarpments towards the north—a feature generally accompanying their line of outcrop, while on their dip they present commonly a less rugged aspect. To the S.S.E., at Millom, these greenish-grey rocks pass under the Coniston limestone and Coniston flags, which also dip S.S.E.

Fig. 6.—*Section across Black Comb* (5 miles).



a. Skiddaw Slate. *b*. Green slate, porphyries, &c.

On the north side of the Whicham valley (the flat interspace just alluded to, where the southern flanks of Black Comb exhibit the Skiddaw slates) the beds dip N.N.W.

Portions of the southern escarpments of this mountain have been wrought for slate; and among the *débris* of the quarries Graptolites may be found, though from the Black Comb beds I have obtained only one species, namely, *Graptolites sagittarius*. The position of the strata here shows that they are very low down in the Skiddaw slate series.

The rocks on the southern flank of Black Comb consist of strata with slaty cleavage, interstratified with flaggy beds, the latter yielding fossils and dipping N.N.W. Along the course of the stream flowing from near the summit of Black Comb southwards, and which is known as Black Comb Beck, a coarse slaty cleavage prevails among the rocks, which also dip N.N.W. These rocks abound in quartz-veins, in which cobalt has been sought, but without profitable success.

Towards the south-west side of Black Comb, a little above Whicham Church, the Skiddaw slates are also seen. Here they are hard, and possess somewhat the nature of flinty slate. In this locality also cobalt has been attempted to be worked. Continuing along the west side of the range, the Skiddaw slates still have the N.N.W. inclination, but at varying angles; they are well seen at Whitebeck and also at Foss-beck *.

North of Foss-beck, near Hole-beck, and on the south side of the latter stream, a fine-grained grey granite occurs, which has been worked; but it seems in no way to affect the general arrangement of the Skiddaw slates. This granite was described as occurring here by Mr. J. G. Marshall at the Manchester Meeting of the British Association, 1861. The Skiddaw slates of Black Comb continue northward to near Bootle, where the porphyries associated with the greenish-grey rocks begin to make their appearance.

The Skiddaw slates of the Black Comb range do not extend northwards beyond the parallel of Bootle, the road from this place over the hills to Broughton exhibiting no Skiddaw slate. At Fell Green, a mile east of Bootle, on this road, the greenish-grey series and the accompanying porphyries are seen, and the country between this and Stoneside-fell is composed of rocks of a similar character. At Stoneside-fell, on the south side of the road, a dark porphyry with light-grey crystals appears in this greenish-grey series; and the outline of Corney-fell, a hill on the north side of this road, indicates that the rocks which compose it also belong to the same greenish-grey series. At the Druids' Temple, about a mile south-east of Stoneside-fell, they also occur, while at Swineside, a short distance to the west, the Skiddaw slates make their appearance, dipping N.N.W. 40°, and having a greyish-drab colour.

The section of the Skiddaw slates of Black Comb shows an almost continuous N.N.W. inclination, from their appearance on the southern flanks of this range until they are succeeded by the greenish-grey rocks of Stoneside-fell. Their relation to the greenish-grey series on the south, at Millom, is seen in Professor Sedgwick's section †.

In the Whicham portion of the section there is a great fault, from which the rocks dip in opposite directions. The continuous exposures of N.N.W. dips in the Skiddaw slates of the Black Comb range, from the southern flank for about three miles N.N.W., lead to the conclusion that on the south side of this range some of the lowest

* There are abundant "Screes" on the west side of the Black Comb range; and, if well examined, they would no doubt afford fossils.

† Quart. Journ. Geol. Soc. vol. ii. p. 111.

beds of the series are exposed. This conclusion shows that Graptolites occur very low down in the series,—an inference which is justified by the sections of these rocks as seen in other localities.

§ 7. *Conclusion.*

The lithology of the Skiddaw slates varies considerably in the several areas where they occur, and, with reference to geological position, there is in some cases a difference in their mineral nature. This, however, is not of so uniform a character as to admit of this series being divided into subgroups marked by mineral aspects. The fossil contents are even less applicable for subdivisions than mineral nature, since, as already stated, the same organisms are disseminated through the whole of this portion of the Lower Silurians as they occur in Cumberland and Westmoreland. Under these circumstances, I am induced to look to other evidence for relative position among the strata forming the Skiddaw slates.

The physical geology of the various areas under consideration shows that in all of them, except that which lies west from Derwentwater and Bassenthwaite Lake, axes are by no means well exhibited. Even in that large area south of Caldbeck-fells there is no well-defined axis, but a continuous S.S.E. dip from the northern limits of the Skiddaw slates almost to their southern margin. The area west of Derwentwater and Bassenthwaite affords two well-marked axes; and the nature of the rocks between them shows that the Skiddaw slate series is made up of fine indurated shaly beds with well-developed slaty cleavage, having intercalated through them coarser strata almost devoid of cleavage, possessing a flaggy nature, and affording fossils.

From Newlands, where the upper members of the Skiddaw slates are seen with the superposed greenish-grey rocks, to Coldale, where the most southern of the axes just alluded to occurs, the distance is less than three miles measured along the dip, which averages 30°. This portion of the section (see fig. 2, p. 116) would give a thickness of Skiddaw slates, from the greenish-grey rocks above to the lowest beds exposed at Coldale, of about 7000 feet; and this is probably their average thickness where best seen in the north of England.

The thickness of the succeeding greenish-grey rocks is not so easily made out. There are, however, circumstances which render it probable that these latter rocks do not exceed in thickness those of the Skiddaw slate series; so that between the base of these latter and the Coniston limestone, the equivalent of the Bala limestone, there is a varied mass of rocks of 14,000 feet in thickness, the lower half consisting of rocks of a sedimentary nature, while the upper half is composed of rocks which had an igneous origin, and which consist principally of porphyries and ashes. This thickness of rocks, which in Cumberland and Westmoreland lies below the Coniston limestone, corresponds with the thickness of the Llandeilo flags*.

The Skiddaw slates yield some forms of Graptolites which occur in the southern Highlands of Scotland, indicating some palæontological

* 'Siluria,' 2nd edit. p. 194.

affinity between the rocks of these areas. There is, however, in the former, so far as we yet know, an absence of the genus *Rastrites*, which is well represented in the south of Scotland; but we miss in the Scotch deposits the genera *Dichograpsus* and *Tetragrapsus*, which make their appearance in the Skiddaw slates. But with reference to the fossils from this series, their nature and the evidence they afford as to age are discussed in a note which Mr. Salter has kindly added to this memoir.

If we take into consideration the direction of the *strike* of the strata in the north of England and in the south of Scotland, we find in this a great conformity, the *prevalent strike* in both countries being W.S.W. and E.N.E.; and, with reference to the dips, the direction generally obtaining north of the Border is N.N.W., while to the south thereof the most common inclinations are S.S.E. The physical geology of the older rocks of the north of England and south of Scotland supports the conclusion that the disturbing forces which acted upon them operated in both areas at the same geological epoch; and also, judging from the arrangement of the metamorphic rocks of the Highlands proper, that the strata of the north of Scotland owe their elevation to the same period.

The general arrangement of the older rocks of the north-west of England shows that not only have the Lower Silurians been subjected to elevations producing a W.S.W. and E.N.E. strike, but also that the succeeding Coniston limestone, Coniston flags, Coniston grits, Ireleth flags, and Kendal group of Professor Sedgwick—deposits occupying the horizons of the Caradoc, the Llandovery, the Wenlock, and the Ludlow series of Sir R. I. Murchison—were elevated at the same time as the older Silurian deposits.

In Cumberland and Westmoreland, the older palæozoic rocks are succeeded unconformably either by the Upper Old Red Sandstones or by the Carboniferous strata, both of which have *strikes* totally at variance with the older rocks; and consequently we are led to infer from this evidence that the elevations of the Silurian series, both in the northern and southern Highlands of Scotland and in the north of England, took place during the earlier portion of the Old Red Sandstone epoch.

Denudation has removed from the northern Highlands probably all the Upper Silurians (the metamorphic character of most of these rocks does not allow of their being assigned to very definite Silurian zones), and in the southern Highlands nothing remains of the older palæozoic rocks except the Lower Silurian series. In that portion of the north of England which most nearly approximates to the Silurian area of the south of Scotland, we have also only the lower members of this series represented, while further to the south, denudation not being so powerful, the whole of the Upper Silurian rocks occur.

The eastern edge of the older palæozoic rocks of Cumberland and Westmoreland had suffered a considerable amount of denudation antecedent to the deposition of the Upper Old Red series, for, in these latter, fragments of Skiddaw slates are, in some localities, very abundant. The exposure of the Skiddaw slates at Black Comb also shows that the south-west margin of the area of the older palæozoic rocks has likewise been subjected to great denudation.

As concerns the age of the Skiddaw slate series, the sequence of the strata above it, its position, and also its depth below the Coniston limestone would lead to the inference that it occupies the horizon of the Llandeilo flags; and the fossils corroborate this conclusion. Mr. Salter has already pointed out the affinity of these fossils to those of the lower portion of the Llandeilo series* ; and in a note he informs me that the Skiddaw slates are referable to "that group which is best represented in the rocks of Shelve, and which occurs in North Wales overlying the Tremadoc group, and *underlying* the mass of the Llandeilo,—a series containing the earliest and most varied forms of Graptolites, and which is at once the birth-place and metropolis of the family, as nowhere else are there so many genera or such complex forms." This evidence, combined with the sequence of the rocks in the Lake-district, distinctly places the Skiddaw slate series on the horizon of the Lower Llandeilo, and also places the Quebec group of Sir William Logan, as suggested by Mr. Salter, in the same position.

Note on the SKIDDAW SLATE FOSSILS. By J. W. SALTER, Esq., F.G.S., A.L.S., of the Geological Survey of Great Britain.

THE persevering labours of Prof. Harkness have been again rewarded. But little was known, notwithstanding the old explorations by Prof. Sedgwick, of the fauna of the Skiddaw slates till within the last three years, when, at my request, Mr. Bryce Wright took advantage of a short residence each year near Skiddaw to search for organic remains in what proves to be a rich formation. The Museum in Jermyn Street and the Cambridge Museum have received, since that time, many accessions through Mr. Wright's labours. The fauna proved to be of a newer date than had been assigned to it in Prof. Sedgwick's table of classification: not, indeed, relatively to the other rocks of the Lake-district, for the Professor has put it in its right place with respect to them; but instead of being, as suggested, an equivalent of the great formation of the Lingula-flags, its fossils indicate it to be of the age of some part of the Llandeilo-flags; and I shall endeavour to show that it must be the lower portion of that formation.

Two species of Graptolites and some imperfect remains (considered as sea-weeds by Prof. M'Coy) were the fossils known to Prof. Sedgwick at the time of the publication of his great work in 1851†.

Mr. Wright fortunately discovered at least six more Graptolites, and a Crustacean with a curious, elongated carapace of two valves, which I shall here term *Caryocaris* (fig. 15), as it has long wanted a name. An obscure figure of it appeared in the 'Geologist' of February 1861, together with a figure of the most remarkable of the

* 'Geologist,' vol. iv. p. 74.

† 'Synopsis of the Classification of the Palæozoic Fossils in the Woodwardian Museum.'

new Graptolites—a doubly and triply branched form which I termed *Dichograpsus*, after ascertaining its identity with those remarkable fossils discovered by Sir W. Logan near Quebec, of which he sent drawings to England many years back, and which, admirably engraved, were to be seen in the Canadian Department of the Great Exhibition.

There were also with these forms some foliaceous Graptolites, which I have referred to *Phyllograptus*, Hall, together with the now well-known species *Graptolites sagittarius* and *G. tenuis*, the latter very abundant. Mr. W. West, of Wimpole Street, has since made some notable additions to this list, and some of his specimens are figured on p. 137.

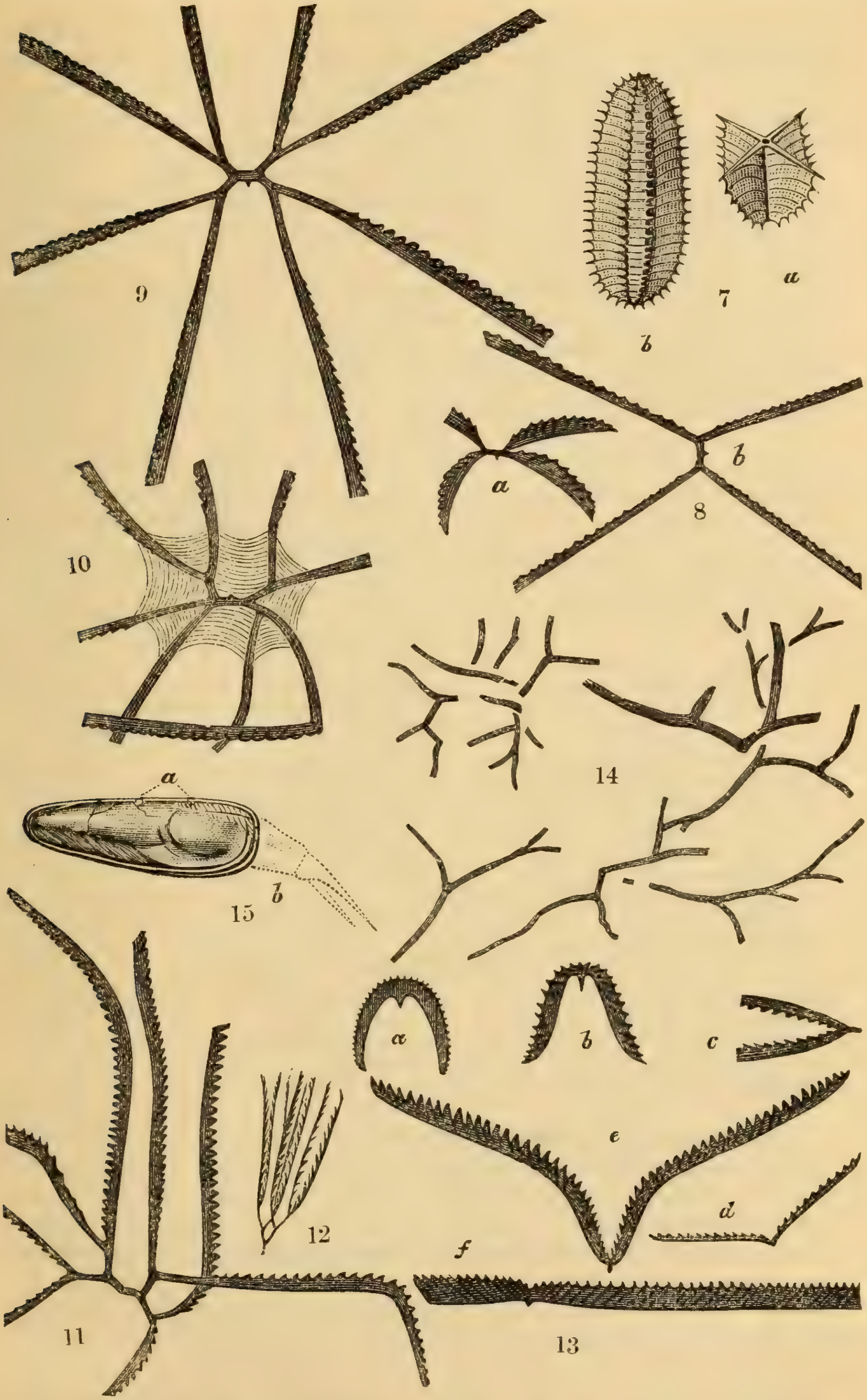
Prof. Harkness has not only added to our correct knowledge of the beds from which these are obtained, but has also furnished a few new forms to the British list; among them, especially, the beautiful *Didymograpsus caduceus*, a swallow-tailed form, formerly described by myself, from Canada.

Indeed, the most interesting point about these collections is the positive identity that appears to obtain between the fossils of the Skiddaw slates and those of the Quebec group of Canada. In both we have the ordinary genera of Lower Silurian Graptolites—*Graptolites*, *Diplograpsus*, and *Didymograpsus*; but mixed up with these are some others peculiar to this horizon, viz. *Phyllograptus*, the *Dichograpsus* mentioned above, and a kind of double *Didymograpsus*, for which it is perhaps admissible to form a new genus—*Tetragrapsus*.

The series of forms in the Graptolite group is now so perfect, that it may well be surmised that we have pretty nearly exhausted the variations.

There are simple Graptolites with a single row of cells, unbranched or only irregularly proliferous—*Graptolites*. Straight Graptolites with a double row of cells—*Diplograpsus*. Twin Graptolites, having a single row of cells only on each branch, the bifurcation taking place from the root—*Didymograpsus* (figs. 13 *a* to 13 *f*); again, a form in which this bifurcation takes place twice, the branches patent or nearly close—*Tetragrapsus* (figs. 8 *a*, 8 *b*); *Phyllograptus* (Hall), also composed of four stems, *i. e.* doubly branched, but the stems close together, and giving the appearance of a cruciform *Diplograpsus* (figs. 7 *a*, 7 *b*). *Tetragrapsus* comes near to the Canadian genus *Dichograpsus*, which is doubly branched, and again dichotomous more than once, in most of the species. But the main character which distinguishes *Dichograpsus* is the presence of a corneous plate which envelopes all the lower part of the branches (fig. 10), and which is not known in any other genus of the group; it has not, indeed, been seen in more than two or three species of *Dichograpsus*, but it may not have been preserved in all cases. I still believe that the best analogy for this plate is in the basal plate of *Defrancia*, a Bryozoon compared with it several years back by Huxley. Lastly, we have the extremely branched form *Dendrograpsus* (Hall), the name of which sufficiently expresses its ramose character. The branches in this

Figs. 7–15. *Sketches of* Graptolites *from the Skiddaw Slates.* (Natural size.)



7. *Phyllograptus*, Hall. 8. *Tetragrapsus*, gen. nov. (*a.* is the typical form; *b.* may possibly be a form of *Dichograpsus*). 9. *Dichograpsus aranea*, Salter. 10. *Dichograpsus*, Salter, with its corneous cup (from Logan). 11. *Dichograpsus Sedgwickii*, Salter. 12. Branchlet of *Dichograpsus*. 13. Several forms of *Didymograpsus*. 14. Branching *Bryozoon*? 15. *Caryocaris Wrightii*, Salter.

genus have no connecting bars; but in *Dictyonema*, which is the oldest form of the Graptolite group, the rods are held together by very regular processes, that give the whole frond, which is tubular, exactly the aspect of a *Fenestella*. The presence of the projecting Graptolitoid cells and the horny texture, however, prevent its being confounded with that genus; but the resemblance is very close, and I think we have here a real affinity,—a conclusion strengthened by the general agreement of the long-celled Graptolites with recent genera of the *Tubuliporidæ*.

I herewith give figures of the new species of *Dichograpsus*, *Tetragrapsus*, &c.; and I subjoin a list of all the known Skiddaw slate fossils. Those marked W. were collected by Mr. Bryce Wright; those marked H. are due to the researches of Prof. Harkness; and those marked 'West' are from that gentleman's collection.

Fossils.	Localities near Skiddaw.
Radiating Worm-burrows	Skiddaw, Longside (H., West).
Annelid-burrows	Hodgson, Holm (W.), Keswick, &c.
Nereites...	Skiddaw, Longside (H.).
New Crustacean—Caryocaris Wrightii, n. s., fig. 15.	Outerside, Barff, Skiddaw, Longside (W., H., West).
Graptolites sagittarius, *His.*	Scawgill, Hakengill, Mirehouse, Braithwaite Brow (W., H.).
—— tenuis, *Portl.*	Keswick (W., H.).
—— Nilssoni, *Barr.*	Braithwaite Brow (W.).
—— latus, *M'Coy*	Braithwaite Brow, Whiteless, Scawgill (Sedgw.).
—— sp.	Keswick.
Diplograpsus pristis?, *His.*	Braithwaite Brow (W.).
Didymograpsus sextans, *Hall*	Braithwaite Brow (W.).
—— hirundo (MS.), fig. 13 *f*	Ellengill (W., H.).
—— geminus, *His.*, fig. 13 *c*	Eggbeck, Ullswater (H.).
—— caduceus, *Salter*, fig. 13 *a, b*	Keswick (H.).
—— sp. like G. Pantoni, *M'Coy*, fig. 13 *e* (D. V-fractus, MS.)	Keswick (West).
Phyllograptus angustifolium, *Hall*, fig. 7 *a*, 7 *b*	Barff, Keswick (W., H.).
Dichograpsus Sedgwickii, fig. 11	Braithwaite (W.).
—— sp., small branches, fig. 12	Keswick (H.).
Tetragrapsus bryonoides, *Hall*, fig. 8 *a*...	Frozzengill (H.).
—— crucialis, n. s., fig. 8 *b*	Keswick.
Dichotomous Bryozoon?, fig. 14	Barff, Keswick.

A few words will suffice to show the relations of this fauna with that of the corresponding beds in other countries. In the grouping of the Graptolites of the Skiddaw slates there is the closest resemblance to that group discovered by Logan near Quebec, and which is known to some authors under the name of the Taconic system. All the forms are representatives in the two cases, and several of the species are, I believe, identical; but as the Canadian figures have not yet received their long-desired publication, we cannot identify the names except in a few instances.

Moreover, there is a remarkable coincidence, even to minutiæ of character, between the Skiddaw slates and the Graptolite-bearing rocks of Melbourne, Australia. In the collections sent over by

Prof. M'Coy and Mr. Selwyn to the International Exhibition, a large series of Graptolites appeared; and these agreed, genus for genus, and almost specifically, with our North-of-England forms. I cannot think this accidental, and believe, therefore, that there is a peculiar zone or horizon of the Llandeilo rocks of which these genera of Graptolites are characteristic*.

The mass of the Llandeilo strata is not tenanted by such compound forms. The species of *Didymograpsus* known in the Upper Llandeilo have the branches diverging at a moderate angle, while the strata known as Lower Llandeilo in England have the widely diverging forms of this genus, and such are found in the Skiddaw slates.

In Canada the age of the Quebec series is still under discussion; but all agree in placing it low down in the Silurian series†. Here the association of these Graptolites with Trilobites is such that we must either refer them to the Primordial group itself, which is unlikely, or allow that they represent the lowest beds of Lower Silurian rocks, the passage-beds from the Primordial zone to the Llandeilo flags,—the age, in fact, of the Tremadoc slates and Lower Llandeilo.

With regard to the so-called sea-weeds, fucoids, &c., I have shown elsewhere reason for believing that nine-tenths of these are due to the action of marine worms. In the Skiddaw slate series there are found abundant traces of these markings.

Caryocaris, gen. nov. C. Wrightii, sp. nov. Fig. 15.

A long, pod-shaped, bivalved carapace (with distinct hinge-pits), rounded anteriorly, subtruncate behind, and with the back and front subparallel. The surface is smooth, or with only oblique wrinkles near the margins, but with no parallel lines of sculpture. Body? Telson and appendages?

All I know of this pretty little Crustacean, an inch long, and rather more than one-third of an inch wide, is contained in the above note. I was fortunate enough to find the tubercles (Huxley found them also in *Ceratiocaris*), which I suppose indicate teeth (and corresponding pits) at each end of a short hinge-fulcrum. They are marked *a*.

The shelly carapace is solid for its size: it appears to have a good deal of lime in its composition. The genus is evidently distinct, though so little is known of the entire form.

Loc. Everywhere in the Skiddaw Slate district. I have named it after Mr. Bryce M. Wright, of Great Russell Street.

Dichograpsus, gen. nov. Figs. 9 to 12.

Frond repeatedly dichotomous from a short basal stipes into 8, 16,

* There is even a Crustacean, apparently of the genus *Caryocaris*, which M'Coy has done me the favour to name *Hymenocaris Salteri*.

† Hall has definitely added (see Proc. Amer. Phil. Soc. 1862) his opinion to give weight to the idea that the Quebec Graptolite-group (including the Hudson slates west of the river, as decided by Logan's discovery of the great fault) implies simply a different condition of the Calciferous Sandstone. "Quebec group" would surely be a better term; or why not "Skiddaw group"? It is the oldest.

24, or more branches, each with a single row of cells—not a double row as supposed by Prof. Hall, who must have seen the ends of the cells crushed vertically upon the narrow stipes.

TETRAGRAPSUS, gen. nov. Figs. 8*a*, 8 *b*.

Fronds twice dichotomous near the base, of simple, long-celled stipes; the base of the branches not connected by a corneous plate (the branches sometimes patent, sometimes closely reflected: M'Coy, *in literis*).

PHYLLOGRAPTUS, Hall. Figs. 7 *a*, 7 *b*.

There are two species of this beautiful genus in the slates; but I prefer to leave the description of them open for the present. Prof. Wyville Thomson is hard at work on this group, and it is a pleasure to put good materials in the hands of so good a naturalist.

Two of the most remarkable of these Graptolites (see figures 8 and 13) were drawn from specimens in the collection of Mr. W. West, of Wimpole Street. I refer specially to the rare *Tetragrapsus crucialis*, and the *Didymograpsus* marked *e*, fig. 13, which is exceedingly like *D. Pantoni*, M'Coy, from Victoria. I have called it *D. V-fractus*. In truth, no one can collect in this region without doing some good; for the Skiddaw slate is the metropolis of the Graptolites.

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2. *On* FOSSIL ESTHERIÆ *and their* DISTRIBUTION. By T. RUPERT JONES, Esq., F.G.S., Professor of Geology and Mineralogy at the Royal Military College, Sandhurst.

Introduction.—In 1856* I offered to the Society some remarks on the probably Crustacean character of the little fossil that used to be termed *Posidonomya minuta*, on its Estherian relationship, and on some points in the geological distribution of *Estheria*†. Much of the material that I have used for my 'Monograph of Fossil Estheriæ,' published by the Palæontographical Society, was then in my hands, but much information and very many specimens have been contributed since by friends, abroad and at home, so that I am now enabled to recognize fourteen fossil species, with several varieties. These are from the freshwater or brackish-water deposits of the Devonian, Lower and Upper Carboniferous, Permian, Triassic, Rhætic, Oolitic, Wealden, and Tertiary formations.

Though often imbedded in shales or marls in close proximity to other beds containing truly marine organisms, and even near beds impressed with casts of salt-crystals, yet the fossil *Estheriæ* have

* Quart. Journ. Geol. Soc. vol. xii. p. 376.

† In this paper *Estheria* was erroneously referred to as a *marine* Crustacean; and a mistake was made in the allusion to a *Silurian* Nummulite. The limestone containing this Nummulite is Carboniferous; but, coming from a Silurian district in Shropshire, it was at first mistaken for Aymestry limestone.

rarely any unmistakeable sea-shells associated with them in the same bed; and, when such do occur (as in the case of *Lingula tenuissima*), the marine mollusk sometimes appears to have been dwarfed by deteriorating influences. From what we know of the habits of existing bivalved Entomostraca, it is probable that some degree of saltness could be borne by *Estheriæ*, temporarily or continuously; but the recent *Estheriæ* (of which 22 species are known) have been mostly found in rain-water pools and other fresh waters, and a few only have been met with in brackish marshes, and none in the sea. So also, of the allied *Limnadia* and *Limnetis*, their six or seven species have all freshwater habitats.

If living in lagoons communicating with the sea, the old *Estheriæ* would have occasional marine companions; and those associated shells that seem to have belonged to the sea from their supposed relationship to existing marine mollusks may really have been inhabitants of brackish water, or of more or less saline lakes. Where, therefore, *Estheriæ* occur by themselves, or in the company only of Fishes and Plants (as is often the case), it appears to me that they may be regarded as having lived and died in fresh (or possibly brackish) water. Where they are mixed with shells of presumed marine habitat, they probably indicate either that they inhabited brackish lakes having a quasi-marine fauna (such as the Caspian Sea), or that fresh water was in close proximity to the place of deposit; or that they had lived in fresh water that had been perhaps frequently replaced by the sea.

The fossil *Estheriæ* will serve the geologist as useful indicators of even transient changes of fresh- and salt-water conditions, either in shallow water on coasts, or in inland lakes, where evaporation and influx of rain-water, each varying in amount periodically, may have produced freshwater, brackish, and saline deposits alternately.

I refer to the 'Monograph' for full descriptions and illustrations, and for copious references to the works of others on the subject.

Table of the Fossil Estheriæ *and* Leaiæ*.

Genus and Species.	Locality.	Geological Stage.
Estheria membranacea, *Pacht*, sp.	Livonia; Caithness; Orkney.	Old Red Sandstone.
—— striata, *Münster*, sp.	Bavaria; Belgium	Lower Carboniferous.
—— ——, var. Tateana ...	Berwickshire	Lower Carboniferous.
—— ——, var. Beinertiana	Silesia; Lancashire; Lanarkshire.	Lower Coal-measures.
—— ——, var. Binneyana	Derbyshire	Lower Coal-measures.
—— ——, var. Beinertiana	Lancashire	Middle Coal-measures.
—— tenella, *Jordan*, sp. ...	Lancashire; Lanarkshire; France (Autun); Schwarzwald (Murgthal).	Upper Coal-measures, or Permian.
—— ——	Saxony (Salhausen)	Lower Permian.
—— exigua, *Eichwald*, sp.	Russia (Orenburg and Kazan).	Permian.
—— Portlockii, *Jones*	Tyrone, Ireland	Permian.

* *Leaia* is a problematical ally of *Estheria*.

Table (continued).

Genus and Species.	Locality.	Geological Stage.
Estheria minuta, *Alberti*, sp.	Alsace; Hanover	Bunter.
—— ——	Germany (Würtemberg, &c.).	Lettenkohle.
—— ——	Hanover; Worcestershire; Warwickshire; Somersetshire.	Keuper.
—— ——, var. Brodieana	Gloucestershire; Somersetshire; Morayshire (Linksfield).	Rhætic.
—— Mangaliensis, *Jones*...	Mangali, India	Triassic or Rhætic.
—— ovata, *Lea*, sp.	N. America (Pa. Va. Ca. &c.)	Triassic or Rhætic.
—— Kotahensis, *Jones*......	Kotah, India	Jurassic or Rhætic.
—— concentrica, *Bean*, sp.	Yorkshire	Oolite (Lower).
—— Murchisoniæ, *Jones*...	Skye..........................	Oolite (Oxfordian).
—— elliptica, *Dunker*	Hanover	Wealden.
—— ——, var. subquadrata	Hanover; Sussex	Wealden.
—— Forbesii, *Jones*.........	Cacheuta, South America	Mesozoic?
—— Middendorfii, *Jones*...	Tourga, Siberia	Tertiary?
Leaia Leidyi *, *Lea*, sp. ...	Pennsylvania	Lower Carboniferous.
—— ——, var. Salteriana	Fifeshire	Lower Carboniferous.
—— ——, var. Williamsoniana.	Lancashire	Upper Coal-measures.

1. *Estheria membranacea*, Pacht, sp., was described by me in 1859 † under the name of *Estheria Murchisoniana* ‡. It is found abundantly in the fish-bearing flagstones of the Old Red Sandstone of Caithness § and Orkney; and in a marl at Kokenhusen, Livonia, which belongs also to the Old Red or Devonian group. This species has more nearly equilateral and orbicular valves than most of the known *Estheriæ*, and the umbones are more nearly centrade than in any except *E. concentrica*; the valves resembling in outline those of a minute *Posidonomya* or *Aviculopecten* ‖. Owing to its suborbicular shape, Dr. Pander, to whom I am indebted (through Von Helmersen) for a valuable bibliographical note on this species, retains Pacht's generic term "Asmusia" for this fossil; but I do not see any necessity for it, as the difference in outline between this and other *Estheriæ* is one of degree only, and not essential.

The only fossils that are associated with *E. membranacea* are Fishes in Caithness and Orkney, and Fishes and *Lingula bicarinata* in

* *Cypricardia Leidyi*, Lea. † Quart. Journ. Geol. Soc. vol. xv. p. 404.

‡ I thought that the name "*membranacea*" was preoccupied for a fossil *Estheria* (of the Wealden); but, although used in collections, it had not been applied in books; and if it had, the ground of its application, namely the supposition that *Cyclas membranacea*, Sow., is an *Estheria*, is baseless. *Cyclas subquadrata*, Sow., is a Wealden *Estheria*.

§ Banniskirk, Caithness, is another locality, in addition to those mentioned in my 'Monograph,' judging from a specimen that I lately saw in the Newcastle Museum.

‖ Mr. S. P. Woodward suggested its crustacean character in 1854; and Dr. Pander also regarded it in that light not long afterwards. Sir R. Murchison, Mr. C. Peach, Mr. J. Miller, and others (including Dr. Pander and M. d'Eichwald in Russia) have helped me in working out the history and nature of this *Estheria*.

Russia. *Lingulæ* occur also with *Estheriæ* in the Triassic beds of Germany, and certainly must be accepted as evidence of marine conditions, according to palæontological rules; but the Triassic *Lingula tenuissima*, in successive beds, appears smaller and smaller in size, until it is dwarfed and disappearing, when *Estheria minuta* comes in; as if more and more fresh water invaded the area, unfavourably to the *Lingulæ*, and ultimately bringing in the *Estheriæ*. The *Lingula bicarinata* has been referred to as presenting "traces" only, in some instances, in the Estherian marl of Kokenhusen; hence these *Lingulæ* may have been "derived" fossils; or more probably they may have been truly of marine and local origin, but destroyed by the invasion of the fresh water which favoured the *Estheriæ*. The fossil Fishes of Scotland and Russia, associated with the *Estheria*, do not bear any exact testimony of marine conditions (although occurring in some places with truly marine fossils); their recent allies are the *Polypteridæ* and *Siluridæ*, inhabitants of rivers and lakes; and they may have been at home in both fresh and salt water.

2. *Estheria striata*, Münster, sp., does not bear the true Estherian characteristics so clearly as *E. membranacea*. The brown, horny, wide-ridged, neatly sculptured valves of the latter are here replaced by black, filmy, closely striated valves, which, however, by their tenuity, their ovato-oblong shape (similar to that usual among *Estheriæ*), and even by their close striation, different from that of *Aviculidæ* and *Anthracomyæ*, and not unlike what occurs in some *Estheriæ* under certain conditions of growth, appear to me to belong to this genus. Their gregariousness and their associating with Fishes and Plant-remains are also habits common to them and *Estheriæ*. In one instance (Lammerton) I have seen reticulate texture in the valves, and that helps to place them aright. Further, they present subquadrate or rather suborbicular individuals (Lammerton), a peculiarity found also with two or three known species of *Estheriæ*,—the difference of form being probably of sexual significance. Lastly, in the Coal-measures there are smaller *Estheriæ*, with distinct ridges, interspaces, and sculpturing; and, were the large and the small found together (as the large and small of *E. ovata* and *E. elliptica* are found together presenting similar differences to those under notice), I should be inclined to regard them as presenting stages of growth; for we find not unfrequently that the older individuals of *Estheria* cease to develope evenly separated concentric ridges and neat uniform interspaces, and produce layer after layer at the edge of the valve so rapidly that nothing but a series of close concentric striæ is to be seen; and this growth seems also to occur sometimes in small specimens that have not had favourable conditions of growth.

E. striata has passed about from name to name* in palæontological works; in collections too the specimens have been doubtfully placed; and such good geologists as Mr. G. Tate and Mr. E. W. Binney refused to give them a place among the Mollusca; they independently suggested an Estherian relationship for specimens which they

* *Sanguinolaria striata*, Münster and Goldfuss; *Cardiomorpha striata*, De Koninck.

each confided to me some years since. So also Geinitz and Beinert eliminated *E. striata* of Silesia from amongst the mollusks.

Count Münster's specimens came from the Lower Carboniferous shales near Hof, Bavaria; De Koninck's from the same horizon at Visé, Belgium. The many specimens that have come under my notice differ, for the most part, in some slight degree as to their outline; and, as they belong to several different localities, and to different horizons in the Lower and Upper Carboniferous formations, I have regarded these slightly different features as of varietal importance. Thus, *E. striata*, as recorded by Goldfuss and De Koninck, serving as the type, we have a very similar form from Silesia (Lower Coal-measures, Beinert), from Lancashire (Middle Coal-measures and upper part of the Lower Coals, Binney), and from Lanarkshire (Lower Coal-measures, Binney). This is distinguished as *E. striata*, var. *Beinertiana*, after Dr. Beinert of Charlottenbrunn, who collected the Silesian specimens in the Lower Coal-measures at Volpersdorf, in the Duchy of Glatz. *E. striata*, var. *Tateana*, less oblique in shape, is from the Lower Carboniferous shale at Lammerton on the Berwickshire coast, where Mr. G. Tate, F.G.S., found it abundantly in one bed, with remains of Plants, Fishes, and *Cypridæ**. Occasional evidence of reticulate structure accompanies these *Estheriæ*, and among them are individuals with the subquadrate or suborbicular valves above referred to.

Estheria striata, var. *Binneyana*, has a fine large carapace with oblong valves, and occupies a shale found (by Mr. Binney, F.R.S., F.G.S.) near Chesterfield, Derbyshire, and lying between the Winnmoor Coal, below, and the Black Shale or Silkstone bed, above (distant about 70 yards).

With regard to the possibly freshwater or marine character of *Estheria striata*, as indicated by its associates, leaving out the Fishes as altogether doubtful witnesses, I can only say that, excepting the occasional proximity of those dubiously marine forms, the *Anthracosiæ* and *Anthracomyæ*, and the presence of *Spirorbis* at Lammerton, sea-shells are wanting in the shales and cannel-coal in which this *Estheria* has been found. As for the presence of *Spirorbis*, Sir C. Lyell has before now pointed out that the occasional influx of salt water into a marshy jungle can destroy terrestrial vegetation, and leave, on retiring, *Serpulæ* and *Cirripedia* attached to the stems†.

3. *Estheria tenella*, Jordan, sp., is the true Estherian species to which I have alluded above as occurring in the Carboniferous strata, and fit to stand as the young of *E. striata*, had we the evidence of collocation and gradational conditions of growth to support the supposition.

I have not, however, seen them in the same bed, and the largest

* One specimen only of these Cyprids is sufficiently preserved even for partial examination. To indicate its seeming alliance, and the circumstance of its discovery, I have named it (in the Appendix to my Monograph on Fossil *Estheriæ*) *Candona? Tateana.*

† Some of the so-called *Spirorbes* and *Microconchi* found in the Coal-measures have of late been looked upon by Continental palæontologists as being possibly due to minute parasitic plants.

individuals of *E. tenella* yet met with (from Bradford Pit, Manchester) have not taken on the thickly striated valve-surface, such as is seen in the other form.

This *Estheria* was first noticed in the Autun shales*, regarded as of Permian age by some (Geinitz), and as Upper Carboniferous by others; it was thought to be a small *Posidonia* (with some doubt) by Michelin; A. d'Orbigny, Landriot, and Naumann, however, regarded it as being probably a bivalved Crustacean. Jordan found it again in the Upper Carboniferous strata of the Murgthal, near Sulzbach, in the Schwarzwald, and, with Bronn, named it *Posidonomya tenella*†. This is also the species that occurs in the Brandschiefer of the Rothliegendes at Salhausen, near Oschatz, in Saxony‡. I have it also from the Upper Coal-measures at Astley and Bradford in Lancashire (Binney and Salter), and from the Upper Coal-measures of Lanarkshire (Mr. Grossart). Lastly, I am inclined to think that *E. exigua*, d'Eichwald, from a Permian marl at Burakova, Russia, may possibly prove to be the same§.

E. tenella is a relatively small form, and often occurs in immense numbers. In one instance (Astley, Lancashire) it is associated with *Beyrichiæ* (*B. subarcuata*), of a form not far removed from the common *B. arcuata* of the Coal-measures, but differing, in the less distinct lobation of the valves, from the Lower Palæozoic species. If this *Beyrichia* were as truly marine as the Silurian *Beyrichiæ* proper, *E. tenella* must have lived in salt water; perhaps, on the other hand, these associates were brought together, to the hurt of one or the other, by the inroad either of salt or fresh water, respectively. *Spirorbis* again appears in company with *Estheria* (in Lanarkshire), and may possibly indicate permanent sea-conditions, as must also *Avicula* in the same locality, since it occurs as a participator of the same bed, unless sudden changes of fresh and salt waters have left their effects in one and the same deposit, or unless we are looking at the quasi-marine fauna of an old brackish lake. *Anthracomyæ* (Lancashire) and *Anthracosiæ* (Lanarkshire) are also associated with *E. tenella*.

4. *Estheria exigua*, Eichwald, sp., is known to me by a few very small specimens on a little piece of Permian marl from Burakova, Kazan, Russia, where it is found, with Plant-remains, in some abundance. These specimens (sent by M. d'Eichwald) are not equal to those described by Kutorga and d'Eichwald; but they constitute the only basis on which I can at present form an opinion. My materials being limited, I keep this form distinct from *E. tenella*, to which the Russian specimens (small as they are) present much resemblance. If they belong to the same species, the name *E. exigua* will have priority; and, further, we have one more instance of community of specific forms in the Carboniferous and Permian deposits; indeed *E. tenella* itself proves as much, if the Permian character of

* I have not seen specimens from this locality.
† Dr. Sandberger has sent me specimens.
‡ Professors Naumann and Geinitz have aided me with specimens.
§ In which case the name given by d'Eichwald in 1846 would have priority. I have not yet seen enough specimens from Russia to decide by.

the Brandschiefer of Oschatz is unmistakeable, and if the carbonaceous shales of Autun and the Murgthal should prove to be really Permian, as some suppose.

E. exigua is accompanied by a feebly developed *Beyrichia* (*B. Pyrrhæ*), to which the remarks made above on *B. subarcuata* equally apply.

5. *Estheria Portlockii*, Jones.—A unique specimen, and that a cast, in an isolated deposit, is the basis for the determination of this species. Yet it bears such evident proofs, in shape, surface, and relative size, of its Estherian relationship, that I do not hesitate to dedicate it to the eminent geologist who first noticed it (under the name of "*Posidonia minuta*") as occurring at Rhone Hill, near Dungannon, Tyrone, where he found it in the shale-seams between beds of the red sandstone containing *Palæoniscus catopterus*.

The Geological Survey will ultimately clear up all doubt as to the geological place of this sandstone; in the meantime I follow Sir P. Egerton and Professor Morris in alluding to it as of Permian age; and its position on the map does not seem inimical to this view.

Palæoniscus may or may not have had both marine and freshwater species, like many recent genera of fishes; and therefore no collateral evidence at present exists as to the habitat of *E. Portlockii*.

6. *Estheria minuta*, Alberti, sp.—This little Cyclas-like Crustacean has long been a type-fossil for the Keuper, and more especially for the lignitic deposits (Lettenkohle) at the base of the Keuper, which have been sometimes grouped as Lower Keuper and sometimes as Upper Muschelkalk. *E. minuta* occurs in the Lower Bunter of Eastern France (Soultz-les-bains, Bas Rhin); in the Upper Bunter at Gersfeld in the West Rhon (Hassencamp), and near Dassel in Hanover (Volger); in the Muschelkalk† at Durlach in Baden (Sandberger), and at Weimar in Thuringia (Seebach); in the Lettenkohle of Haute Saône and Bas Rhin, Baden, Würtemberg, Bavaria‡, Hanover, and Thuringia; in the Lower Keuper at Hall in Swabia (Von Dechen); in the Upper Keuper of Tübingen in Würtemberg (Bronn).

Table of the Distribution of Estheria minuta *in the European Trias.*

Members of the Trias.	England.	Eastern France.	Baden, Würtemberg, and Bavaria.	Hanover.	Thuringia.
Upper Keuper	*	*	*	*	
Lower Keuper	......	......	*		
Lettenkohle	......	*	*	*	*
Muschelkalk	......	......	* ?	......	* ?
Upper Bunter	......	......	*	*	
Lower Bunter	......	*	* ?		

† The "Lower Keuper" and the "Muschelkalk" in this list may both really have reference to the Lettenkohle group.

‡ In his 'Geognostische Beschreibung des bayerischen Alpengebirges,' &c., 1861, Gümbel states that "Posidonomya minuta" (*Estheria minuta*) occurs in each of the three divisions of the "Lettenkohlengruppe," the lowest division of the Keuper in the Bavarian Alps,—the "Hauptdolomit-Gruppe" being the middle,

In England *E. minuta* is abundant in the upper portion of the Keuper of Somersetshire (C. Moore), Worcestershire (Symonds), Warwickshire (Strickland, Murchison, Brodie), Leicestershire (Plant), and Cheshire (Hull); and does not appear to have been met with in any other division of the English New Red Sandstone.

The sources of information and material that have aided me during the last ten years in working up the history of *E. minuta* are very numerous, and I have gratefully acknowledged the help of my Foreign and English friends—including the veteran Von Alberti, the late lamented Bronn, and many others, in the 'Monograph' before referred to.

Habitat of Estheria minuta.—In Alsace, Baden, Würtemberg, Bavaria, Thuringia, and Hanover, *Estheria minuta* is associated with *Lingula tenuissima*, a marine shell, which has been subjected apparently to the deteriorating influence of fresh water. (See Monograph, p. 48.) Other marine mollusks also, such as *Myacites*, *Gervillia*, *Trigonia* or *Myophoria*, *Pecten*, and *Pleurophorus*, accompany *E. minuta* at various localities over this wide district, occurring for the most part, however, in beds amongst which the Estherian shales are occasionally intercalated. The general occurrence of the *Estheriæ* in interlaminated shaly beds strengthens the opinion that they existed chiefly at the intermediate periods when fresh water had gained some predominance in the shallow seas, lakes, or lagoons. In the Bunter-sandstone of Alsace, land-plants occur in the Estherian clays; and here, whilst the freshwater *Apus* is one of the associates of *Estheria*, a *Limulus* (?) intrudes itself in accompanying strata of the same age.

In some of the beds of the Keuper, crystals of salt have left their casts abundantly, showing both the saltness and the shallowness of the seas or lakes in which the Upper Keuper beds were deposited. But however near to these salt-bearing beds the *Estheriæ* occur, they are never found in them. Such pseudomorphic salt-crystals occur near Lüneberg, in the shales with *Lingula tenuissima*, alternating with limestones, just above the Lettenkohle group, in the dolomitic beds of which latter *Estheria minuta* occurs (sparingly) with *Myophoriæ*, &c.

In England there are no marine organisms (fishes being excluded as doubtful witnesses) accompanying the *Estheriæ* of the Keuper; and these might have been at once regarded as of equally freshwater habits with their recent congeners, were it not that the salt condition of the waters depositing much of the Keuper sandstones and shales is proved by the masses of rock-salt and by the casts of the cubical crystals of salt occurring abundantly in some beds all over the country of the Keuper. Still *Estheriæ* have not been found (to my knowledge) in these salt-bearing beds. They appear to keep a definite line above the horizon of the rock-salt and beneath that of the salt-pseudomorphs, and may represent a nearly, if not quite,

and the *Avicula contorta* (Bone-bed) series and the Dachsteinkalk constituting the Upper Keuper, according to Gümbel. He states also that it occurs in the "Buntsandstein" on both sides of the Alps.—March 28, 1863.

freshwater condition of the waters of the Upper Triassic period for the horizon and localities in which they occur.

E. minuta, var. *Brodieana*, is closely related to its type, but is uniformly of less size, has a relatively smaller reticulation, and is only found in the next succeeding group of strata above the Keuper, namely the Rhætic*, formerly known as the Lower Lias shales, including the Bone-bed. Sections of these beds at Aust Passage, Wainlode, and Westbury, on the Severn, have been published by Strickland, Brodie, and Wright; and Mr. Etheridge, F.G.S., has supplied me with an accurately measured section of the Garden Cliff, Westbury, in which the exact position of the Estheria-bed and its relation to the immediately underlying marine limestone are carefully attended to (see Monograph, p. 70). Sections of the same series in Warwickshire (Binton and Wilmcote) have been made and published by Mr. Kirkshaw, F.G.S., and Dr. Wright, F.G.S. Near Frome in Somersetshire, Mr. Charles Moore, F.G.S., has recognized the Rhætic group containing this *Estheria*; and he has found these strata near Ilminster and elsewhere.

In the north, the Rhætic beds are represented by the fossiliferous shales of Linksfield, near Elgin, long ago referred by the late Dr. Malcolmson and Mr. Patrick Duff† to the Purbeck or Wealden series; afterwards to the Lower Oolite by Professor Morris; and lastly to the Rhætic group by Mr. Charles Moore.

At Linksfield *E. minuta*, var. *Brodieana*, is of somewhat larger growth than is usual with the Rhætic specimens of Somerset and Gloucestershire; and its reticulation is slightly modified, having sometimes a more linear arrangement of the meshes. It occurs here in company with hosts of *Cypridæ*, that are referable to one species only, as far as I can see, and that is very close to some of the fossil and recent freshwater *Candonæ*. As Mr. P. Duff referred to it some years since as *Cypris globosa*, I retain the trivial name for this *Candona*. The so-called *Mytilus* and other shells of the Linksfield shales do not occur in the Estherian marls.

Habitat of E. minuta, *var.* Brodieana.—In Gloucestershire, Worcestershire, and Warwickshire, the Rhætic *Estheria* occurs along a certain zone immediately above a stratum full of marine shells, which, like others belonging to this Rhætic stage, appear to be dwarfed, as if they had been the inhabitants of an unfavourable locality, or lived in sea-water under the influence of large freshwater affluents. In the Estheria-bed itself no marine shells are found. Fragments of terrestrial Plants and of Insects in the associated beds indicate the near proximity of the land to the waters in which these deposits were formed. Here, as in the Keuper, we may suppose that the *Estheriæ* flourished in brackish, if not in fresh, water, at intervals when the saltness of the sea (or lakes) was more or less reduced by the land-waters.

* Grouped by Herr Gümbel in the Upper Keuper, in his 'Geogn. Beschreib. bayer. Alpengeb.,' a work which I have only lately seen.—March 28, 1863, T.R.J.

† The death of this esteemed geologist, who worked so long and so well at the geology of Moray, took place during the printing of my 'Monograph,' after I had received his friendly assistance both by specimens and letters.

The absence of *Estheriæ* in the Rhætic beds (or *Avicula contorta* zone) of Germany is coincident, apparently, with their more decidedly marine character; more constant marine conditions, perhaps, having obtained during the Upper Triassic period in that area than in the Western European region.

7. *Estheria Mangaliensis*, Jones.—At Mangali in Central India, about sixty miles south of Nagpur, the Rev. Messrs. S. Hislop and R. Hunter discovered in 1853 a fossiliferous, brick-red, laminated sandstone*, which contains remains of Plants, of Ganoid Fishes, and of Labyrinthodont Reptiles (*Brachyops laticeps*, Owen), and widespread thin layers of *Estheriæ*. These, though of various sizes and somewhat different outlines, are all referable to one species, conditions of growth being sufficient, in my opinion, to account for all the seeming varieties. This *Estheria* (*E. Mangaliensis*) is not without close alliances (as far as the carapace is concerned) to other species, fossil and recent, as is generally the case; but it gives no direct evidence as to its geological horizon. The Geological Surveyors of India seem inclined to regard the Mangali beds as of Upper Palæozoic age,—with doubts in favour of its Triassic relationship. Mr. Hislop used to think that it was Lower Jurassic, but now believes it to be Upper Triassic; and I am much inclined to this opinion.

The absence of marine remains in the Plant-bearing and Reptiliferous sandstone of Mangali goes far to indicate the freshwater habitat of the *Estheriæ*, which it so abundantly contains. Another locality for *Estheriæ* in Indian strata of approximately the same age has been found by Mr. W. T. Blanford near Pa‘cheet in Bengal. Dr. T. Oldham kindly sent me a sample of this Estherian shale; but I cannot say more than that this *Estheria* seems to be the same as the smaller specimens from Mangali.

8. *Estheria Kotahensis*, Jones, is from Kotah (or Kotá) on the River Pranhíta, Central India, and was found by Mr. Hislop in a shale occupying a relatively higher geological place than *E. Mangaliensis*, and regarded by him, probably with reason, as of Lower Jurassic age. It is more nearly allied in some respects to the Wealden *Estheriæ* than to that from Mangali. Ganoid Fishes (*Lepidotus Deccanensis*), *Cypridæ* (*Candona Kotahensis*, Jones), Insects, an obscure Unio-like shell, and some Plant-remains accompany this *Estheria*; and other remains of Plants (Ferns), Fishes (*Lepidotus* and *Æchmodus*), and Reptiles (*Teleosaurus*) are found in the associated limestone and bituminous shales. Similar strata with Fish-remains and *Estheriæ* have been discovered by Mr. Hislop at Katanapali, fifteen miles north of Kotá.

None of the organic remains yielded by these Estherian beds have marine characters, the fishes being excluded as doubtful witnesses.

The accompanying Table shows the probable correlation of the Estherian and Plant-bearing strata of Central and North-eastern India:—

* Quart. Journ. Geol. Soc. vol. xvii. p. 347.

Synoptical Table of the Mesozoic and the Palæozoic Formations of Central and North-eastern India.

Dr. Carter.	Messrs. S. Hislop and R. Hunter		Geological Survey of India.
I. Panná Sandstone.	Upper Sandstone Series.	Group A. Near Nágpur, 25 ft. thick; at the Mahádewa Hills, 2000 ft.	6th. Mahádewa and Lameta Series. [Cretaceous (?), Hislop.]
II. Kattrá Shales.	Laminated Series.	Groups B and C. Fish-shales, limestone, and *Estheria-shales* of Kotá. Coal-shales of Umret. Plant-sandstones of Nágpur. *Estheria-sandstone* of Mángali, with *Reptile*, *Fishes*, and *Plants*. Argillaceous shales of Korhádi, track-marked. Ceratodus-clay of Máledi. Group D. Limestone: Near Nágpur, about 100 ft. thick. In Moodelaity, 310 ft. thick.	5th. Upper Damúda and Rájmahal Series. 4th. Panchét Series. (*Estheria.*) True Damúda Series. (Coal-bearing.) The upper beds form the Ráníganj Group. (*Reptiles.*) Lower Damúda (of Medlicot) or Bárákar Series. 3rd. Talcheer Series. Sandstone, Conglomerate, &c., without Coal. 2nd. Vindyhan Series. Bundair Group. Rewah Group. Kymore Group. Sandstone and Shale, without Coal.
III. Tará Sandstone.	Lower Sandstone Series.	Moodelaity and Bundelcund.	1st. Sub-Kymore Series. Semri Group. Timowan Limestone. Metamorphic (?) and unfossiliferous. Bijawur Group.

9. *Estheria ovata*, Lea, sp., is as important in the palæontology of North America as *E. minuta* is in Europe; but its exact geological place is not defined without difficulty. It has long been recognized as an abundant fossil in some of the shales and flagstones accompanying the carbonaceous deposits of South and North Carolina, Eastern Virginia, and Pennsylvania; and its importance has been indicated especially by Prof. W. B. Rogers and Sir C. Lyell. It has passed under the names *Posidonomya* and *Posidonia*; and Dr. I. Lea and Prof. E. Emmons have given several names to what at first sight may appear to be distinct forms of this fossil; but, after a careful comparison of specimens, figures, and descriptions, as far as the means at my command allow (and I have been liberally aided by my friends the Brothers Rogers and Mr. C. M. Wheatley, of Phœnixville, Pennsylvania, as well as by Sir C. Lyell), I have come to the conclusion that only one form really exists in these North American Estherian shales, namely, *Estheria ovata*, Lea, sp. The rarely perfect condition of the valves, owing to the crushing they have usually suffered, and to the imperfect exposure of the edges of the imbedded valves, render it difficult to find trustworthy specimens; and every one of the forms, figured by Dr. Emmons *, however different from the perfect valve they may appear to be, are, I am sure, only squeezed and imperfect specimens, more or less badly drawn.

Throughout the wide area in which these Estherian shales occur (500 miles from N. to S.), and at two horizons separated by an estimated thickness of upwards of 2000 feet of strata (on the Deep River), the same species occurs. The only real difference that I have detected in the many specimens I have seen being such modifications of the reticulate sculpture of the interspaces as occurs in other species, and an occasional crowding-together of the ridges into numerous striæ, such as we see in *Estheria striata*, *E. concentrica*, and others.

As for the geological age of these Estherian and carbonaceous shales of the Atlantic Slope, we all know that they were formerly grouped as Lower Jurassic (Liassic) by Rogers, Lyell, Bunbury, Marcou, and others; that Marcou has since argued in favour of their Triassic relationship †; and that Prof. Emmons makes them Triassic in the upper part, and Permian in the lower ‡;—partly on

* American Geology, &c.

† Both on account of certain geognostic features, and Prof. O. Heer's opinion of the Triassic character of some of the fossil plants of Virginia. See Bullet. Soc. Géol. France, 2e sér. xii. p. 870, &c., and especially 'Geology of North America,' 4to, Zurich, 1858, p. 13 & *note*, where M. Marcou, after giving an account of various opinions held of the age of the Coal-formation of Eastern Virginia and Carolina, adopts Prof. Emmons's classification of the carbonaceous and Estherian shales of N. and S. Carolina, as being partly Permian and partly Triassic; both, according to M. Marcou, belonging to one great system, more nearly related to the Secondary than the Primary formations.

‡ The occurrence of a Bird's bone in the upper part of the series, and mammalian jaws (*Dromatherium sylvestre*) in the lower, as figured and described by Prof. Emmons, and of the tracks of bipeds and quadrupeds in the northern equivalents of these deposits, makes this series very interesting to the palæontologist.

account of his finding Reptilian remains supposed to be allied to the *Thecodontosaurus* of the dolomitic conglomerate of the West of England (formerly referred to the Permian group), and partly because of the great aggregate thickness of the Carolina series (upwards of 6000 feet), and the probable unconformity between the lower and upper portions.

Table showing the occurrence of* Estheria (E. ovata) *in the Lower Mesozoic Strata in North and South Carolina (from Orange to Anson, on the Deep River).*

			feet.
Triassic, according to Emmons.	*I.*	Red and mottled sandstones, shales, and marls. *Estheriæ* and *Cypridæ*; also a Fish-scale (in a Coprolite), Saurian bones, and a Bird's bone....	1000
	H.	Grey sandstone. Plants; Saurian bones....	300 to 500
	G.	Blue shale. Cycads and other Plants .. }	40
	F.	Conglomerate, including beds of sandstone }	
		There is probably an unconformity of the beds here.	
"Chatham group" (Emm.). Permian, according to Emmons.	*E.*	Grey, thin-bedded sandstone, often rippled. Fucoids.	1200
	D.	Bituminous shales (*Estheriæ* and *Cypridæ*), with calcareous shale in their upper part, and comprising coal-seams and iron-stones. Plants, *Entomostraca*, *Astarte* (?), *Mytilus* (?), Fishes, Reptiles, and Mammal (*Dromatherium*)	700
	C.	Bituminous shale alternating with grey sandstone, and passing downwards into red and brown sandstone (Coniferous Trees and Fucoids) ..	1000 to 3000
	B.	Conglomerate	50 to 60
	A.	Taconic slates.	

The measured thickness of these strata is not necessarily a vertical thickness, indicative of continued slow subsidence and vast lapse of time. In Prof. H. D. Rogers's "Essay on the Geology of the United States," in the last edition of A. Keith Johnston's 'Physical Atlas,' are some pertinent remarks on the stratigraphical conditions of the Mesozoic sandstones and shales under notice. Whatever may be the thickness of the several strata, measured perpendicularly and added together, yet, as these deposits have been formed in confined areas and on sloping shores, it appears to me that Prof. Rogers's observations must satisfy any dynamic geologist that no great vertical displacement of the area has been required for the accumulation of this sedimentary mass in the shallow waters of the old sub-Appalachian water-belts.

The Reptilian remains and Fishes are not of palæozoic genera; and the Plants, according to Prof. O. Heer, are such as are Triassic in Europe. The unconformity of the beds is no more than may be seen between the Bunter and the Keuper in England; nor is the estimated thickness of the whole of the series on the Deep River (North and South Carolina) very much greater than that of the New

* Compiled from Dr. Emmons's 'American Geology,' part 6, 1857.

Red Sandstone of Cheshire, estimated by Mr. E. Hull at about 5350 feet.

Isolated as these Lower Mesozoic shales of North America are, it is difficult to co-ordinate them with the European scale of strata. They are decidedly almost, if not quite, destitute of every trace of truly marine agency, and must have been formed in long lagoons, or brackish lakes, parallel with the Alleghany ridges (Rogers), under somewhat similar condition to those which led to the formation of the Lower Bunter of Alsace, the Lettenkohle of the Trias in Würtemberg, &c., the lignitiferous and Estherian Upper Keuper of Worcestershire and Warwickshire, the Rhætic Estherian shales of Gloucestershire and Morayshire, the coal-bearing beds of the Lower Lias of the Banat, and the plant-beds and coal of the Lower Oolite of Yorkshire and the Venetian Alps. The plant-beds with *Estheria* in Bengal and Central India are similarly circumstanced. From the time, then, of the Lower Trias to that of the Lower Oolite *, we see that shallow lagoons, if not inland seas, of brackish water, largely prevailed over some regions, and received the débris of a very similar flora; or we have before us the deposits of such waters, not truly contemporaneous, but presenting similar phenomena at different, but perhaps not far distant, periods. To class all these as "Lower Mesozoic" will be correct enough; but it is hazardous to adjudicate definite geological periods for all these several groups of strata. "Triassic" may be the right term for the Indian and North American Estherian shales and sandstones; but the Rhætic group may also claim them, as exhibiting both Triassic and Jurassic belongings. Nor may we forget that in all these instances we have to do with the freshwater fringes or the lacustrine equivalents of the great marine formations; which latter alone, as Godwin-Austen has so cautiously insisted upon †, should be strictly taken as the stratigraphical types, if, according to the accepted rule, the geologic scale be based on the sea-conditions of past periods. Thus the Old Red Sandstone and the Coal-measures will take rank, as transitional and terrestrial formations, with the Lettenkohle, the Jurassic and Cretaceous "Wealdens," and other more or less freshwater deposits of marginal lagoons and deltas, or of inland lakes, of the Primary, Secondary, and Tertiary periods, and not stand as independent groups or systems.

10. *Estheria concentrica*, Bean, sp., from the Plant-beds near Scarborough, is beautifully preserved in some instances, and at its first discovery was recognized (by Mr. W. Bean, in 1836) as belonging to

* Not that we are limited at this stage, except as regards the facies of the flora referred to. Freshwater and estuary conditions, however prevalent in the Lower Mesozoic period, were of equal importance in later Mesozoic times: not only in the Middle Oolitic (Oxfordian), but in the Upper Oolitic and Cretaceous periods, more or less known freshwater and terrestrial equivalents of the great marine deposits spread far and wide in Europe and America (north and south); and in the Tertiary formations, the freshwater and estuarine deposits have been fertile sources of discussion with geologists and palæontologists, who have often preferred a rich lake-deposit as a guide (however eccentric), in the puzzle-work of correlation, to the more uniform sea-beds.

† Quart. Journ. Geol. Soc. vol. xii. p. 54.

the *Crustacea*. Its place in the strata is indicated by Dr. Wright's section of the Lower Oolite of the Yorkshire coast *. It is rare, but is found in most, if not all, of the plant-beds of the series, and bears witness of their freshwater origin.

11. *Estheria Murchisoniæ*, Jones, found by Sir R. I. Murchison thirty-five years ago in the Isle of Skye, and then regarded as being possibly a *Tellina* †. This is a delicate and beautiful *Estheria*, well preserved, and probably a witness of freshwater conditions that obtained during the Oxfordian period. The estuarine Jurassic fossils from the Isle of Skye, described by Prof. E. Forbes ‡, belonging to the same area, were found by him to underlie the Oxford Clay §.

Since completing the 'Monograph of Fossil Estheriæ' for the Palæontographical Society, I have seen Dr. Baird's figures and description || of the recent *Estheria Jonesi*, from Cuba, and in G. West's beautiful illustrations of the ornamentation of this species we may see a near approach to that of *E. Murchisoniæ*, and in the shape of the carapace a close resemblance to that of *E. concentrica*.

12. *Estheria elliptica*, Dunker, was the first fossil rightly and clearly referred to *Estheria*. Of some it had been suggested that they might be bivalved crustaceans; and Mr. Bean and others had definitely given to some that have since proved to be *Estheriæ* the term "Cypris;" but Dr. W. Dunker (in 1843) was the first palæontologist who recognized and described a fossil *Estheria*.

E. elliptica is abundant in the Cyrena-shales of the Wealden of Hanover, where it presents two forms, the larger one elliptical or subovate in outline, the other nearly oblong or subquadrate; the latter variety Dr. Dunker described as *E. subquadrata* in 1843. Mr. J. de C. Sowerby in 1836 had given the name *Cyclas subquadrata* to a little *Estheria* found near St. Leonard's by Dr. Fitton ¶. This was found in abundance at Bulverhithe (the same locality) by Prof. Morris and myself a few years since (without our having recognized Dr. Fitton's locality, and Sowerby's notice and figures), and I have no doubt of its being the same as Dunker's *C. subquadrata*. This has also been found by Fitton, Binfield, Beckles, Baily, and ourselves in the East Cliff, Hastings, and near Tunbridge Wells by Dr. Mantell; but the large and typical *E. elliptica* has not yet been recognized in England.

Cypridæ (*Cypridea Valdensis*, &c.), *Cyrena*, *Paludina*, and Plant-remains are the associates of the Wealden *Estheriæ*, both in Sussex and Hanover; and these indicate only fresh, or, at the most, brackish water as the habitat of *E. elliptica* and its variety.

Obscure remains of *Estheria* have also been observed by Dunker

* Quart. Journ. Geol. Soc. vol. xvi. p. 31. † Geol. Trans. 2 ser. vol. ii. p. 311.

‡ Quart. Journ. Geol. Soc. vol. vii. p. 104.

§ Some years since, the late Dr. Mantell gave me a hand-specimen of Oxford Clay, from Wilts (probably from the railway-cutting near Trowbridge, Quart. Journ. Geol. Soc. vol. vi. p. 312), in which a Cyprid, extremely like *Cyprideis unicornis* of the Upper Eocene freshwater beds of Hempstead Cliff, Isle of Wight, occurs in abundance. This may indicate lacustrine or estuarine conditions of some portion of the Oxfordian group in the South of England.

|| Proc. Zool. Soc. 1862, p. 147, pl. 15. figs. 1–1*d*.

¶ Geol. Trans. 2nd ser. vol. iv. part 2. p. 177, and p. 345, pl. 21. fig. 8.

in the Lower Wealden of Hanover*. *E. elliptica* necessarily ranks as a Cretaceous fossil in geological relation to its Jurassic, Triassic, and Rhætic allies; for the freshwater Wealden group merges in its typical marine system of the stratigraphical series.

13. *Estheria Forbesii*, Jones.—David Forbes, F.R.S., F.G.S., brought many specimens of this elegant species home with him from South America in 1859 or 1860. He found it in abundance with plant-remains in a shale near Cacheuta, about 3500 feet above the sea, on the eastern slope of the Andes, south of Mendoza; and he thinks that possibly these beds may be related to those containing fossil trees that Mr. Darwin saw in the Uspallata Pass. This *Estheria*, however, gives no clear evidence of its palæontological age. It is somewhat allied to *E. ovata* of North America, and still less closely to *E. minuta* of Europe. It is probably of Mesozoic age; but it may be Tertiary. There is nothing to gainsay its freshwater origin.

14. *Estheria Middendorfii*, Jones.—This is from Siberia, and was recognized as Crustacean by J. Müller †, who regarded it as a *Limnadia*. It is one of the largest and most elegant of *Estheriæ*, and is probably of Tertiary age. Mr. C. E. Austin's paper ‡ on the locality where it was found, and Von Middendorf's note on it in his 'Sibirische Reise,' give all that is known of its geological relations.

Remains of Plants, Insects, and Shells (*Limnæus*?), all obscure, add little to our knowledge of its habitat; but what they do show is strengthened by the fact of the *Aspius*, which accompanies the *Estheria* in great numbers, being a Cyprinoid fish, such as is found in fresh water, and being also found in some of the Miocene freshwater deposits of Europe.

Leaia.—Together with the fossil *Estheriæ*, I have described and figured in my 'Monograph' some small enigmatical fossils that occur in the Carboniferous strata. Some of these were noticed twenty-six years ago by Prof. W. C. Williamson and Prof. J. Phillips §; but no conclusions were arrived at as to their probable relationship. They are dark-coloured, horny, thin, quadrangular valves, either lying separate, or with the dorsal edges approximate, and are marked with concentric furrows, running parallel with three sides of the valves, and by two oblique transverse ridges crossing the valve, from the umbo to the ventral angles. I know no recent Crustacean having such valves; but the horn-like appearance of the fossils, their small size, and their dissimilarity to any mollusk have brought them under my notice. I find that Dr. I. Lea has described and figured a cast of a similar little fossil as *Cypricardia Leidyi*, from the red sandstone at the base of the Carboniferous series in Pennsylvania; and there are but slight differences between this form and that of the specimens found by Williamson in the Upper Coal-measures at Ard-

* Mr. Harry Seeley, F.G.S., assures me that he has detected the cast of an *Estheria*, very like that found at Bulverhithe, in a specimen of Cyclas-bearing marl from the Lower Purbeck beds of Durleston Bay, near Swanage.

† A. Th. von Middendorf's 'Sibirische Reise,' vol. i. part 1.

‡ Quart. Journ. Geol. Soc. No. 73. p. 71.

§ Prof. Phillips suggested that they might be *Trigonellites*; but this supposition does not appear to me to be well founded.

wick, near Manchester, and of others found lately by Mr. Salter in the Lower Carboniferous strata of Fifeshire.

For convenience I have made the most of these differences of contour, and have termed the Ardwick specimen *Leaia Leidyi*, var. *Williamsoniana*; and those from Fife, var. *Salteriana*; keeping *Leaia Leidyi* as the name for the Pottsville specimen, instead of *Cypricardia Leidyi*.

They are found without any immediate associates, except Plant-remains and, at Ardwick, *Anthracosia* (*Unio*) *Phillipsii*.

Conclusion.—Having nothing but the carapace-valves of these little Crustaceans to guide us in working out their geological history, we certainly cannot pretend to know everything about them. Among the living Bivalved Entomostraca, different specific forms are found to have carapaces much like each other; and, again, nearly allied species have markedly different carapaces; and *Estheriæ* are not without their peculiarities in this respect. Still I think we may fairly believe that the marked differences of the Estherian carapaces found in the several deposits really indicate distinct species; and possibly some of the forms that I have kept apart as varieties may have been independent species characterized by stronger differences in limbs and other organs than their carapaces show.

That this genus should have clearly preserved its peculiarities during so large a portion of geologic time will not be disregarded by those interested in the study of "persistent types"; nor is it without Entomostracan allies equally tenacious of generic independence throughout the lapse of geologic time. Where freshwater conditions existed *Estheria* seems to have been often a ready comer. Probably we shall have many other localities and horizons for it in the fossil state as the little valves become better known to collectors *. Of the wide distribution of the species, both in Palæozoic and Mesozoic times, we have clear evidence (judging from the carapaces, and they appear to be distinct enough) in the occurrence of *E. membranacea* in the Old Red Sandstone of North Britain and of Livonia (900 miles apart); of *E. striata* ranging in the Carboniferous deposits, from western Scotland to Silesia (900 miles); and of *E. tenella*, with almost as wide a range †, and passing upwards from the Coal-measures into the Permian group. The apparently co-ordinal *Leaia* presents almost indistinguishable carapaces in Pennsylvania, Fifeshire, and Lancashire (through nearly 70 degrees of longitude), in the lowermost and the uppermost Carboniferous deposits. *Estheria minuta* is widely spread in certain strata of western Europe over a tract measuring at least 600 miles from N.E. to S.W.; but its variety *Brodieana* is not known, it seems, out of Britain, where its southern and northern localities are 400 miles apart ‡. *E. Mangaliensis* and its representative in Bengal are upwards of 400 miles apart. *E. ovata*

* They have hitherto been mistaken for various shells and for fish-scales.

† Much wider if *E. tenella* and *E. exigua* prove to be the same.

‡ *E. minuta*, var. *Brodieana*, has to be looked for in the Rhætic beds at the base of the Lias in the north-eastern counties of England.

occurs at isolated spots in a tract of 500 miles. The English *E. elliptica* is about 400 miles away from its Hanoverian type. These species were probably represented at their several epochs by isolated communities in distinct lakes, lagoons, and deltas; just as some of the recent species are recognized at different localities, occasionally far apart: thus *E. gigas* has been found in pools at Strasbourg, at Toulouse, and in Tunis (the first and last upwards of 800 miles apart); *E. Dahalacensis* is known to live in both Abyssinia and Mesopotamia (1600 miles apart); and *E. Melitensis* at Malta and in Sicily (at least 50 miles apart). There are, however, very many more species recorded as existing at the present period (22) than we have found fossil in the deposits of any one past period, only two at most being the number of known species for any one of the recognized great formations. This, however, is partly due to zoological distinctions founded on the limbs and other parts of the body in some of the existing species, but not recognizable in the fossil state; partly, perhaps, to imperfect search in the strata; and possibly, in some degree, to a greater differentiation of the more modern forms, if their specific distinctness is accurately determined *.

Further search for, and strict examination of, fossil and recent specimens, with careful records of the exact conditions of the strata imbedding the former, and of the habitats of the latter, are necessary before we can be satisfied on many of the points, referred to above, in the geological history of *Estheria* and its Phyllopodous allies.

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3. *On the* Flora *of the* Devonian Period *in* North-Eastern America. *Appendix.* By J. W. Dawson, LL.D., F.R.S., F.G.S.

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January 7, 1863.

SPECIAL GENERAL MEETING.

It was Resolved:—

I. That the number of Foreign Members be in future limited to Forty, instead of Fifty as heretofore.

II. That a Class of Foreign Correspondents be instituted, not exceeding Forty in number.

III. That the Foreign Members shall be elected out of the list of Foreign Correspondents.

It was also Resolved that the Meetings of the Society shall be held in the Society's Rooms at Somerset House, on and after the Anniversary Meeting next ensuing.

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* Some of the recent species are known only by their carapaces; and, if fossilized, would be with difficulty discriminated one from the other. The determination by the valve-characters alone is as likely to lead to an over-estimate of the number of recent species, as to a too cautious consideration of the fossil species.

ORDINARY GENERAL MEETING.

John Daglish, Esq., Hetton, Durham; Griffith Davies, Esq., 17 Cloudesley Street, Islington; John Walter Lea, Esq., B.A., The Grange, Shepperton Green, Chertsey; and Henry Michael Jenkins, Esq., Assistant-Secretary of the Geological Society, 22 St. George's Road, London, were elected Fellows.

The following communications were read:—

1. *On the* Lower Carboniferous Brachiopoda *of* Nova Scotia. By Thomas Davidson, Esq., F.R.S., F.G.S., &c.

[Plate IX.]

At the request of Dr. J. W. Dawson, F.R.S., F.G.S., Principal of M^c Gill University, Montreal, I have examined the *Brachiopoda* collected by him from the Lower Carboniferous formation of Nova Scotia, as well as those obtained by Sir C. Lyell during his first journey in America, and I now submit the result of this examination to the Geological Society.

The geology of Nova Scotia has already received the attention of several distinguished observers; and I may mention that, although prior to Sir C. Lyell's visit to the country in question Mr. R. Brown had described the limestone of East River and Cumberland as Lower Carboniferous, the limestones of Windsor and Shubenacadie were at that time regarded as "New Red Sandstone" or "Permian." Sir C. Lyell was the first to maintain that the whole was of Carboniferous age; and, by so doing, he unravelled a complication which might for a time have involved the geology of the country in much confusion. He may therefore justly claim to have been the first geologist who was able to determine the geological age of the Gypsiferous strata of Nova Scotia, which he considered to be a member of the Carboniferous group instead of the Triassic or the Permian, or both of them, as previously conjectured*. Dr. Dawson informs me that his first papers on the subject were the results of investigations which he made to test Sir C. Lyell's views, and that Mr. Brown and he followed up these observations, and accumulated a vast number of facts subsequently published in his 'Acadian Geology,' and from which I extract the following synopsis of the Carboniferous rocks of Nova Scotia†, in order to point out the horizons at which the *Brachiopoda* have been obtained.

Upper or Newer Coal-formation.

Greyish and reddish sandstones and shales, with beds of conglomerate, and a few thin beds of limestone and coal; the latter not of economic importance. Thickness, 3000 feet or more.

Fossils:—Coniferous wood, *Calamites*, Ferns, &c.

* See Sir C. Lyell's 'Travels in North America, with Geological Observations on the United States, Canada, and Nova Scotia,' vol. ii. p. 204, 1845.

† "An Account of the Geological Structure and Mineral Resources of Nova Scotia," &c. 1855.

Localities:—Cumberland, north of the Cobequid Mountains; Northern Colchester, Pictou; well exposed on the Joggins coast, and on the coast of Northumberland Straits, west of Pictou Harbour.

Lower or Older Coal-formation.

Grey and dark-coloured sandstones and shales, with a few reddish and brown beds; valuable beds of coal and ironstone; beds of bituminous limestone, and numerous under-clays with *Stigmaria.* Thickness, 4000 feet or more.

Fossils:—*Stigmaria, Sigillaria, Lepidodendron, Poacites, Calamites,* Ferns, &c., erect Trees *in situ,* remains of Ganoid Fishes, *Cypris, Modiola,* and three species of Reptiles.

Localities:—Cumberland, north of Cobequid Mountains, Pictou, especially East River, Port Hood, Inhabitants' Basin, and other places in Inverness and Richmond; eastern part of Cape Breton; parts of Colchester, south of Cobequid Mountains. The finest exposures are in the South Joggins, and near Sidney, Cape Breton.

Lower Carboniferous or Gypsiferous Formation.

Great thickness of reddish and grey sandstones and shales, especially in the upper part; conglomerates, especially in the lower part; thick beds of limestone (with marine shells) and of gypsum. Thickness, 6000 feet or more.

Fossils:—*Productus, Terebratula,* Encrinites, Madrepores, and other marine remains in the limestone. Coniferous wood, *Lepidodendron, Poacites,* &c., in the shales and sandstone. Scales of Ganoid Fishes very abundant in the shales associated with the lowest beds, in which are also coaly seams and bituminous beds.

Localities:—Northern Cumberland, Pictou, Colchester, and Hants; Musquodoboit, in Halifax county; Guysboro (in part), parts of Inverness, Richmond, Cape Breton, and Victoria.

All the *Brachiopoda,* with one exception, are stated to have been derived from the Lower Carboniferous or Gypsiferous formation; and, although the fossiliferous rocks submitted to my examination vary considerably in composition and texture, it is evident that the larger number of the species continued to live together for a considerable period of time. There is a compact, light-yellowish-grey limestone, full of *Spirifera glabra, Terebratula sacculus, Productus Cora,* &c.; while some limestones, with the same fossils, are almost black in colour; others are arenaceous, yellow, and full of small cavities, the interior of the shells being often hollow; and, again, other limestones, as that of Brookfield, are formed almost entirely of shells, *Bryozoa,* &c., so closely packed that there appears in some cases to be hardly any cementing material or intervening matrix. Some shales also contain flattened valves of *Streptorhynchus crenistria.* Dr. Dawson believes that this remarkable lithological difference in the Lower Carboniferous rocks of Nova Scotia may have been caused through the limestones having been deposited in limited basins or narrow straits, and probably at a time of much volcanic disturbance;

hence the great local diversity. He is, moreover, inclined to consider that in each locality the "Lower Limestones" are darker in colour, more laminated, and less fossiliferous than the upper; also that the individual beds become darker, more impure, and less fossiliferous as they approach the high lands which formed the old shorelines; but that there are, of course, exceptions to these statements.

The very remarkable shell-rock above described occurs at Brookfield, a little east of the Shubenacadie River; it was first discovered by the late Mr. G. Dunkin, and by him made known to Dr. Dawson. It is in the line of strike of the Shubenacadie beds, and is doubtless a continuation of them. This rock has such a great general resemblance to certain Permian shelly limestones, with which I am acquainted, that, had the specimens been submitted to me without any indication as to their geological age, I should certainly have felt somewhat puzzled to determine whether I had to deal with a Permian or a Carboniferous rock and its fossils; and, indeed, when M. de Verneuil determined these fossils for Sir C. Lyell in 1845, he enumerated, among others, *Terebratula elongata* and *T. sufflata*, Schl., *Spirifera cristata*, Schl., *Avicula antiqua*, Münster, a *Modiola*, a *Littorina*, and one or two other fossils which he considered to be common to both the Permian and the Carboniferous strata. Although I may modify to some extent the lists of species published by Sir C. Lyell and Dr. Dawson, I quite coincide with what is stated by the former author, at p. 205 of his 'Travels,' viz., "That geologists should at first arrive at this result (of considering the rocks in question as the equivalents in age of the Permian of Russia) will surprise no one who is aware how many of the fossils of our Magnesian Limestone and Coal resemble each other, or who studies the lists given at p. 218, in which several species both of shells and corals from Nova Scotia, identical or closely allied to well-known Permian or Magnesian Limestone forms, are enumerated."

This is important to note: for it was written in 1845, just at the time the celebrated authors of the great work on Russia in Europe and the Ural Mountains (published in 1845) arrived from that country; and it denotes how strongly impressed they were that a certain number of Carboniferous species had continued to exist during the Permian period. Subsequent researches have confirmed this view, and considerably multiplied the number of species common to the two epochs; and it has been proved in the most satisfactory manner that the Permian formation is the natural continuation of the great Carboniferous system, of which it composes the upper portion, although it is desirable to distinguish the group by the separate designation of "Permian." It is not the *Mollusca* and Plants of the Permian period alone which, as M. Marcou supposes, have a Palæozoic aspect, but, as M. de Verneuil *, Mr. Kirkby †, and others have already shown, the whole bulk of the animal and vegetable remains found in the Permian rocks bear the most unmistakeable Palæozoic stamp. But, again, it would be fallacious to

* Bulletin de la Soc. Géol. de France, 2e sér. vol. xix. pp. 599, 627 (1862).
† Annals and Mag. Nat. Hist. 3rd Series, vol. x. Sept. 1862.

suppose, as many have done, that at the expiration of each of the supposed great divisions of the sedimentary crust of the earth, namely, the Palæozoic, Mesozoic, and Cainozoic, there was a complete extinction and renewal of life. Such an idea in 1863 would be completely out of place; for it has been shown over and over again that many Palæozoic genera have not only continued to be represented during a greater or less portion of the Mesozoic time, but also throughout the entire geological sequence of sedimentary strata. It is also quite evident that the admirable science of palæontology, notwithstanding its rapid strides and great discoveries, is far from having revealed all its secrets, and is still in its youth. It cannot, therefore, be expected that those who are now endeavouring to decipher its difficult language can yet be in a position to furnish the key to the genealogy of the numerous forms they daily meet with in almost every rock and latitude, or that they can link together the multitudinous and varied forms composing any class, and far less the whole animal kingdom.

It is quite true that, in the present state of our knowledge, there appears to exist between the Palæozoic and Mesozoic divisions or periods a much wider break or difference in the life-groups than between the individual systems of which these divisions are composed. It is, however, highly probable that, when our science is more advanced, a closer agreement will be obtained. Experience has taught us that no genus or species, once become extinct, is ever re-created; and it is to my mind quite certain that, as long as the same genus is represented in any successive geological formations, this alone is a positive proof that life was not interrupted during that period. We are all aware that a certain number of *genera* of different classes passed from the Palæozoic into the Mesozoic period; but I will not at present enter into the discussion of this subject further than to mention that, among the Brachiopoda, *Terebratula, Spirifera, Spiriferina, Cyrtia, Athyris, Rhynchonella, Leptæna, Crania, Discina,* and *Lingula* passed from the Palæozoic into the Mesozoic division. The Triassic species have not yet been sufficiently compared with those from our Palæozoic deposits; but a glance at some of the St. Cassian forms, or even at Klipstein's and Münster's figures, will suffice to remove the idea that there was a complete extinction of life at the close of the Palæozoic period and an *entire* renewal of species at the commencement of the Mesozoic epoch.

Geologists and palæontologists are fully aware that the Permian fauna is not nearly so rich in species as that of the Carboniferous period. When we, therefore, compute the percentage of species common to the two, the Permian fauna must be taken as the standard, not the Carboniferous. The subject of the recurrence of Carboniferous species in the Permian period is far from having been completely worked out; but, since 1845, it has attracted the attention of several competent observers, amongst whom I may mention Messrs. de Verneuil, Brongniart, Gœppert, Gutbier, Geinitz, Kirkby, King, Howse, Rupert Jones, and myself, in Europe; Messrs. Meek and Hayden, Swallow and Hawn, Dr. Shumard and Mr. Newbury, in America.

M. de Verneuil informs us* that Dr. Gœppert is of opinion that, in general, the Permian flora offers in its composition a great resemblance to that of the Coal-formation, fourteen or sixteen species being common to the two. I shall not pretend to offer a complete list of those hitherto recognized, but shall merely quote the following:—

1. Calamites approximatus, *Schloth.* Tynemouth; Manchester.
2. —— Cistii, *Schloth.* Tynemouth.
3. —— nodosus?, *Schloth.* Tynemouth.
4. —— Suckovii, *Brong.* Tynemouth; Manchester.
5. Sigillaria reniformis, *Brong.* Tynemouth.
6. Odontopteris Schlotheimi, *Brong.* Tynemouth.
7. Neuropteris Soretii?, *Brong.* Tynemouth.
8. —— angustifolia, *Brong.* Tynemouth.
9. Cyatheites arborescens, *Schloth.*
10. —— villosus, *Brong.* Manchester.
11. —— Oreopteridis, *Gœpp.* Manchester.
12. Alethopteris Mertensioides, *Gutb.*
13. —— Lonchitidis, *Sternb.* Manchester.
14. Sphenopteris latifolia, *Brong.* Tynemouth.
15. —— irregularis, *Sternb.* Manchester.
16. —— coralloides, *Gutb.* Manchester.
17. Walchia piniformis, *Schloth.*
18. Guglielmites umbonatus, *Sternb.*
19. Trigonocarpum postcarbonicum, *Gümbel.*
20. —— Nœggerathi, *Lindl. & Hutt.* Tynemouth.
21. —— oblongum, *Lindl. & Hutt.* Tynemouth.
22. Cyclocarpon marginatum, *Artis*, sp.
23. —— tuberosum, *Gein.* †
24. Nœggerathia palmæformis, *Gœpp.* Tynemouth.
25. Araucarites Schrollianus, *Gœpp.*
26. —— Brandlingi, *Lindl. & Hutt.* Tynemouth.
27. Sagenaria dichotoma, *Sternb.* Manchester.
28. Dictyopteris neuropteroides, *Gutb.* Manchester.

The thirteen species to which the locality "Tynemouth" is attached were identified by Mr. R. Howse as common to the Lower New Red, or Rothliegende, and the Coal-measures of the north of England, the former of which he thinks should more properly be considered as the upper portion of the true coal-measures. Seven, namely Nos. 13, 14, 16, 17, 18, 21, and 23, are mentioned by Dr. Geinitz as common to the German Rothliegende and Steinkohlen-formation. Mr. Binney has also recorded the occurrence of common coal-plants of the genera *Sigillaria*, *Lepidodendron*, and *Calamites* in the Lower Permian strata of the north-west of England. Those to which I have appended the word "Manchester" are taken from p. 313 of Dr. Geinitz's valuable work 'Dyas.'

Among the *Entomostraca*, Messrs. Rupert Jones and J. Kirkby have identified the following species as being common to both periods in Britain:—

1. Cythere elongata, *Münster*, 1830.
2. —— inornata, *M'Coy*, 1844.
3. —— (Bairdia) gracilis, *M'Coy*, 1844.
4. Cythere (Bairdia) plebeia, *Reuss.*
5. —— (Bairdia) Schaurothiana, *Kirkby.*

Among the *Annelida*, Mr. R. Howse informs me that *Microcon-*

* Bull. Soc. Géol. Fr. 2me sér. vol. xix. p. 600.

† Mr. Howse considers these so-called fruits to be fish-scales (*Holoptychius*? sp.).

chus carbonarius, Murch., has been found in the "New Red" of Tynemouth, as well as in the Coal-formation.

Mr. J. Kirkby has also recognized the *Bryozoon*, *Fenestella plebeia*, M'Coy, as common to both periods in England; and, although Mr. Salter seems to doubt the identification of the Carboniferous form above named, it is quite evident that the *Fenestella* discovered by Mr. Kirkby in our Permian deposits is also represented by the same species in the Carboniferous strata of this country.

Among the *Pisces*, *Gyracanthus tuberculatus*, Ag. (*G. formosus*, Howse, Cat. Perm. Foss., non Ag.), has been stated by Mr. R. Howse to be common to the Lower New Red and the Coal-measures of England, and he considers that a species of *Holoptychius*? has been found in the Rothliegende and the Coal-measures of Germany.

It has been very justly observed that, with the Plants, the *Brachiopoda* have, up to the present time, received the greatest attention; and it has appeared to Mr. Kirkby and myself, after a minute and lengthened examination, that, out of the eighteen or nineteen species of British Permian *Brachiopoda* hitherto discovered, half at least, or 50 per cent., are common to the Permian and Carboniferous periods; and in support of this statement I must refer the reader to pages 266–270 and 279–280, and Plates 54 and 55 of my Monograph of Carboniferous *Brachiopoda*, in addition to Mr. Kirkby's paper already mentioned.

To the following list I have added, between brackets, the names of those palæontologists who have acknowledged the recurrence:—

1. Terebratula sacculus, *Martin*, 1809, C. = T. sufflata, *Schloth.*, 1816, P. (King, De Verneuil, Kirkby, Davidson, Salter.)
2. Athyris Royssii, *L'Eveillé*, 1835, C. = A. pectinifera, *Sow.*, 1840, P. (De Verneuil, Kirkby, Davidson.)
3. Spirifera Urii, *Flem.*, 1828, C. = Martinia Clannyana, King, 1848, P. (Davidson, Kirkby, De Verneuil, Salter.)
4. Spiriferina octoplicata, *Sow.*, 1827, C. = Sp. cristata, *Schloth.*, 1816, P. (De Verneuil, Davidson, Kirkby, Salter.)
5. Camarophoria crumena, *Martin*, 1809, C. = T. Schlotheimi, *Buch*, 1834, P. (Morris, Davidson, Kirkby, King, De Verneuil, Salter.)
6. Camarophoria globulina, *Phil.*, 1834, P. = T. rhomboidea, *Phil.*, 1836, C. (Davidson, Kirkby.)
7. Discina nitida, *Sow.*, 1812, C. = D. Koninckii, *Geinitz*, 1848, P. (Davidson, Kirkby.)
8. Lingula mytiloides, *Sow.*, 1812, C. = L. Credneri, *Geinitz*, 1848, P. (Kirkby, Davidson.)

It may be further observed, that it is hardly possible to distinguish the Permian *Crania Kirkbyi*, Dav., from the Carboniferous *Crania quadrata*, M'Coy; and it is almost certain that *Spiriferina multiplicata*, King, occurs likewise in our Carboniferous strata. *Strophalosia Morrisiana*, so characteristic of the Permian period in Europe, has been found by Mr. Purdon (and described by myself in this Journal *) in the Carboniferous limestone of the Punjaub, as well as another larger species, which closely resembles the Russian *Aulosteges Wangenheimi*, Vern. (*A. variabilis*, Helmersen). Mr.

* Quart. Journ. Geol. Soc. vol. xviii. p. 32.

Kirkby has also recently found, in the Lower Permian limestone of Hartley Quarry, Sunderland, a species of *Chonetes*, which I believe will turn out to be identical with the Carboniferous *C. Hardrensis*. It must also be remembered that M. de Verneuil has stated, in the work on Russia, that *Chonetes sarcinulata* has been found to range throughout the whole Silurian, Devonian, Carboniferous, and Permian periods; but it is probable that the Carboniferous and Permian form is more properly referable to *C. Hardrensis* than to the Silurian species (?); so that we may further estimate that out of the eighteen or nineteen British Permian species, eleven are common to the two periods. Now of the remaining seven.

Terebratula elongata has often been considered to be Carboniferous as well as Permian, but of the absolute identity of the two forms I do not profess to feel quite certain.

Spirifera alata has not hitherto been positively recognized in rocks older than the Permian; but there are certain Devonian and Carboniferous Spirifers to which it is somewhat related.

Camarophoria Hambletonensis, Howse, has not hitherto been found except in Permian rocks.

Streptorhynchus pelargonatus, Schloth., bears much resemblance to certain varieties of *Strept. crenistria*, although probably specifically distinct.

Productus horridus and *P. latirostratus* are not known up to the present time, except in Permian rocks; but in their shape and character they are not extremely distant from certain Carboniferous forms.

Strophalosia Goldfussi is still characteristic of the Permian period.

This rapid examination of British Permian *Brachiopoda* will, I trust, suffice to show that there exists not only a general close affinity between the Permian and Carboniferous *Brachiopoda*, but also that the majority of the species of the former period are identical with some of the latter: and I may likewise mention, that although the Permian rocks of Russia, Germany, Spitzbergen, and other places present us with a few distinct forms, even some of these recall to mind certain Carboniferous species; nevertheless I dare not pronounce them identical; and it will require much further examination before they can be considered entirely distinct.

The *Gasteropoda* and *Conchifera* that occur in the Permian rocks are few in number, and have not yet been carefully compared with those of the Carboniferous period. Mr. Howse has informed me that the *Anthracosia aquilina*, Sow., sp., found by him in the Lower New Red of Tynemouth, is the same as that which occurs in the Coal-formation of England. Mr. Rupert Jones has also recently been able to add another link between the two formations in *Estheria tenella*, which is common to the Permian and Carboniferous rocks of Germany. M. de Verneuil observes, in his excellent paper published in the 'Bulletin de la Soc. Géol. de France,' 2^me^ sér. vol. xix., that, among the *Pteropoda*, there exist a species of *Theca* and one of *Conularia* so nearly related to certain Devonian (Carboniferous?) forms of the same genera, that it requires great attention to be able to distinguish them; and that, in addition to these, a species of *Bellerophon* and a Trilobite of the genus *Phillipsia* have been found by Messrs. Meek and Hayden in the Permian rocks of New Mexico, &c.

Although palæontological research is not in so advanced a state in America as in Europe, and though the species of that continent will require to be very carefully studied and compared with those of Europe before being definitely recognized, still it is probable that the relations between the Carboniferous and Permian deposits of the States of Kansas and New Mexico are very close, and that there exists no marked line of break between them. A single investigator might be mistaken; but it is hardly likely that Messrs. Meek and Hayden, Swallow and Hawn, and Shumard and Newbury, who have examined for themselves, should all be in error!

The species recorded by these American geologists and palæontologists as being common to the Carboniferous and Permian periods are the following; but I append their list with the greatest possible reserve on my part, and solely on their authority, as it is certain that several of their identifications will require revision prior to being definitely admitted:—

1. Productus semireticulatus, *Martin.*
2. —— Rogersii, *Norwood & Pratten.*
3. —— æquicostatus, *Shumard.*
4. Spirifera camerata, *Morton.*
5. —— plano-convexa, *Shumard.*
6. —— pectinifera, *Sow.*
7. Chonetes Flemingii, *Norwood & Pr.*
8. Orthisina umbraculum, *Buch.*
9. Orthisina Missouriana, *Swallow.*
10. Rhynchonella Osagensis, *Swallow.*
11. Terebratula (?) subtilita, *Hall.*
12. Myalina recta, *Shumard.*
13. —— subquadrata, *Shumard.*
14. —— Kansasensis, *Shumard.*
15. Allorisma Minnahaha, *Swallow.*
16. Naticopsis Pricei, *Shumard.*

Dr. Shumard mentions also that *Productus Calhounianus*, Swallow, has been found in both formations.

However imperfect may be the lists I have given of the recurrent species, it cannot be denied that, both by their genera and species, the life-groups of the Carboniferous and Permian periods are closely related, and that although the Permian epoch possesses a large proportion of species peculiar to itself, yet the general aspect of its fauna greatly resembles that of the Carboniferous period.

The immense material now in hand is piled up and carefully stored, but we have not yet had time to sort our treasures. The time and research hitherto required in the preparation and illustration of the Monograph entrusted to my care by the Palæontographical Society, and the necessity of keeping my collections for that purpose geologically and geographically arranged, have retarded the special investigation of the class I am desirous of attempting in order to respond to the request made me some time ago by Mr. Darwin, namely, "that I should endeavour to exemplify and work out in some detail, and with some single group, the theory of descent with modification, so as to test the value of his theory." It appears to me, however, preferable, and more advantageous to the point in view, that I should continue and complete my Monograph prior to rearranging my whole collection in a purely zoological order, and irrespective of all geological divisions. By this last operation, all the forms that most resemble each other, as well as those which gradually diverge, will be placed in regular order; and it will then be in my power to show, to a certain extent, what the *Brachiopoda* may do for the theory of descent with modification. The difficulties to contend with in such an investigation are, however, far greater than they are generally supposed to be; but it is quite evident, and my daily experience (which, as far as the *Brachiopoda* are concerned, exceeds twenty years) teaches me, that the number of supposed distinct species has been wonderfully exaggerated, and that a vast number of them are in all probability, and in many cases certainly, mere modifications in shape, or varieties in the Darwinian sense, which palæontologists will sooner or later be able to link together. Indeed, are we not continually puzzled to know how to find words or characters to distinguish our nearly related species? Are not our supposed distinctions often exceedingly uncertain? and are we not generally far more preoccupied with the desire to find out trifling differences than to examine whether a closely related form might not be due to descent with modification? To what extent variation has extended, our knowledge will not enable us to determine; and, therefore, we cannot pretend to know whether a supposed new form is in reality the result of a distinct and original creation. We may suppose it so, with more or less reason, founding the supposition on the imperfect state of the science, which leaves us no other alternative than to consider new that which we cannot connect or identify with what is already known. What, again, adds to the difficulty is the imperfect knowledge we possess as to what is really the value of the term "species,"—for on that primary question naturalists are far from unanimous*. I am of opinion that there has never been a total extinction of life since its first appearance, and consequently no sudden renewal of the entire fauna at any geological period. It is likewise quite certain that species have gradually and continually become extinct from the date when the first form was created, and that perhaps new species have appeared in the same ratio, to suit the different conditions of sea and land in which they had to exist†. It is also highly probable, if not quite certain, that there never has

* In 1860, Prof. Suess registered 1934 species of *Brachiopoda*; and this is far short of the total number that have been described; but it would be most erroneous to suppose that these 2000 or more names represent as many independently created species, a large proportion being either synonyms, varieties, or modifications in shape, of a limited number of original types.

† M. Deshayes states that "it is an *absolute* palæontological demarcation which serves to clearly separate the geological formations; that at St. Cassian not a single species has been known to pass from the Triassic into the Jurassic formation; and that the same thing takes place between the five great series of formations which he admits." (Bull. Soc. Géol. France, 2[me] sér. vol. xix. p. 397, 1862.) I am sorry to be obliged to dissent from this view, which is entirely in opposition to my experience; I neither believe in the existence of five *absolute* series of formations, or in any *absolute* palæontological demarcation between any geological systems that have been hitherto proposed, and for the reasons above specified. On the contrary, I entirely concur with M. de Verneuil while stating that he attaches less importance than do many geologists to those geological and palæontological divisions of the crust of the globe, which are

been a complete discontinuance of sedimentary deposition over the whole surface of the globe since the time when the first sediment was formed,—that there has always existed a sea somewhere or other upon the surface of the world, and that this sea has always been inhabited. It is also certain that a number of favoured species did escape for a time those local geological convulsions which have taken place at numerous intervals; for the idea that universal geological revolutions have ever taken place is now an all but exploded theory. Those hardy and favoured species have migrated (as M. Barrande and others have so clearly shown), and continued to exist, if not in their original home, in some other more distant place, for a greater or less lapse of time, while the larger number of the others may have been suddenly or gradually destroyed by those great changes in the configuration of land and sea which have no doubt taken place gradually or periodically.

It is not, therefore, surprising to find certain forms of an older period in newer strata, or to find certain species striving to exist for a greater or less extent of geological time, irrespective of the geological system in the strata of which they are imbedded.

Time and assiduous research will show how far we may speculate upon the origin of species; but, in the present state of palæontological science, all theories built upon such subjects, however admirably handled, as is that by Darwin, must, before admission, be tested by more unmistakeable evidence than science is at present in a condition to offer.

We cannot tell, in the present state of our knowledge, whether the species of any class, be it *Echinodermata*, *Brachiopoda*, *Crustacea*, *Pisces*, or any other, have been derived from a single or a hundred original progenitors. I will not say that future researches may not simplify the question, but in the present state of our experience we are very far from having arrived at any such conclusion. A similarity of original type has sometimes, by exception, occurred during a very prolonged period: thus, for instance, we have certain forms of *Lingula*, *Crania*, *Discina*, *Rhynchonella*, &c., which, to all outward appearance, appear to have varied but little during all the sequence of geological time; there is one form of *Crania*, for example, which occurs in the Silurian, Devonian, Carboniferous, Permian, Jurassic, Cretaceous, and Tertiary strata, and in the recent state, which, although possessing as many distinct denominations, is hardly specifically distinguishable, while other species of that genus varied considerably in the different geological periods.

But to return to the more immediate subject of this communication, I may observe that, although I quite agree with M. Marcou that there exist in the Permian formation some few forms which may recall to mind some which existed in the Mesozoic period, it must be allowed that that number forms the minority, and that, on the contrary, the great bulk of the Permian species, to whatever class

perhaps more in our idea than in nature, and conforming more to the actual state of science than to its complete development. (Bull. Soc. Géol. France, 2me sér. vol. xix. p. 612, 1862.)

they may belong, bears the most positive Palæozoic stamp, and that the species are in many cases the same that lived in the Carboniferous era, and some even in the Devonian.

Having sent my plate of Nova-Scotian species to Prof. de Koninck, he wrote back:—"It is to be remarked that all this little fauna completely recalls that of the Carboniferous limestone of Visé in Belgium;" and this urges me to remind the Society that it has been already shown by several palæontologists that there exists a great general similarity in the Carboniferous fauna in almost every portion of the globe where the rocks of that period have been discovered; and I have myself been able to confirm and extend this fact by the lengthened examination I have made of the *Brachiopoda* of that period from Europe and from many distant regions. It would, however, be hazardous in the extreme to affirm that the species found in one particular bed or at one horizon of the Carboniferous period of Nova Scotia were strictly contemporaneous with the same rock or forms found, for instance, at Visé in Belgium or elsewhere. They may, perhaps, have been so, but we have no direct means of arriving at so positive a conclusion; but, from the difference in the size of the specimens, we may say, for example, that the Carboniferous sea of the Punjaub, where many of the same species are found, was much more favourable to the development of the species than was that of Nova Scotia, where, as a general rule, the shells were all very much smaller; and I quite coincide with Prof. Huxley when he asserts that the term "contemporaneous" cannot always be made use of in its absolute or literal meaning. For instance, it is highly probable that in some portion of the world the Lower Carboniferous animals may have continued to exist unmolested, and to have been gradually imbedded, up to the time when the Permian era commenced; and by this means some of the species of the older formation may have been transferred to the newer; and all this whilst in other parts of the world the Middle and Upper Carboniferous sediment was being deposited. Two series of Carboniferous strata containing the same animals may, therefore, not be strictly contemporaneous, although they may both belong to the Lower Carboniferous series: the term should therefore be made use of in its widest and most general acceptation.

At pages 220–222 of his 'Travels,' Sir C. Lyell gives a list, with and without names, of sixteen species of Lower Carboniferous Brachiopods as having been found in Nova Scotia, namely, *Terebratula elongata*, *T. sufflata*, *Spirifer glaber*, *Sp. cristatus*?, *Sp. minimus*, *Sp. octoplicatus*, *Producta Martini*, *P. concinna*, *P. Lyelli*, *P. Scotica*, *P. spinosa*, *P. antiquata*, and four undetermined. But as several of the designations enumerated are synonyms, the number of determined species would be reduced to five; and, even of these, three names will require to be altered.

The study I have made of Dr. Dawson's and Sir C. Lyell's specimens has, however, enabled me to determine fourteen species, or in reality nine more than had been recorded by M. de Verneuil, and it is probable that a further search among the Lower Carboniferous rocks of that country may bring to light a larger number; and, indeed, there existed in the collections above named specimens of one or two more species, which I could not venture to determine on account of their imperfect preservation.

As a rule, the *Brachiopoda* of Nova Scotia are small when compared with the same species from some other countries—a result perhaps of the conditions, already described, under which the beds were deposited. I must not omit to mention that there occurs no marine limestone, with which Dr. Dawson is acquainted, over the productive coal-measures, except at one place, Wallace, where there is a thin band of limestone in the upper coal-strata, which contains a *Productus*; but this was found in too incomplete a condition to admit of determination.

1. Terebratula sacculus, Martin, sp., 1809, and varieties. Pl. IX. figs. 1, 2, 3.

Terebratula elongata and *T. sufflata*, De Verneuil, in Sir C. Lyell's Travels in North America, vol. ii. p. 220, 1845, and in Dawson's Acadian Geology, p. 219, fig. 27, 1855.

All the *Terebratulæ* from the Lower Carboniferous strata of Nova Scotia that have been forwarded to me by Dr. Dawson, as well as those brought from that country by Sir C. Lyell, are variable in shape, but are evidently referable to a single species. M. de Verneuil has identified this shell with Schlotheim's *T. elongata*, and mentions that a "gibbous variety of the preceding one" is referable to *T. sufflata* of the same author.

During a lengthened examination of *T. hastata* and *T. sacculus* from the Carboniferous rocks of Great Britain, as well as of *T. elongata* and *T. sufflata* from the Permian strata of the same kingdom, I was led to the conclusion that the specific identity of *T. sacculus* and *T. sufflata* was clearly established; and, when treating of the Carboniferous *T. hastata* and of the Permian *T. elongata*, I observed that, although it was an unquestionable fact that some specimens of these two so-called species could not be distinguished, more difference is shown between the greater number of *T. hastata* and *T. elongata*, and that the strong resemblance appeared to be the exception. It must also be allowed that it is often impossible to distinguish certain examples of *T. sacculus* and of *T. hastata*, which forms appear to merge the one into the other, and that the same may be said sometimes with reference to *T. sufflata* and *T. elongata*. All this proves how intimately connected are the British forms of Carboniferous and Permian *Terebratulæ*.

But to return to the Nova-Scotian specimens, I could not perceive in any of them the wide and gradually depressed or shallow sinus, which, in the larger valve of all well-shaped examples of *T. elongata*, commences towards the middle of the valve and extends to the front, and which produces in the frontal margin a convex curve. In nearly every specimen the ventral valve is uniformly convex or but very slightly depressed near the front, as is the case with the larger number of *T. sacculus* and of its synonym *T. sufflata*. I think, therefore, that it will be perhaps preferable to refer the Nova-Scotian *Terebratulæ* to Martin's *T. sacculus*; and in this view I am supported by Prof. de Koninck, notwithstanding some examples may resemble certain specimens of *T. elongata*, *T. fusiformis* (Vern.), or *T. hastata*. The largest specimen I have seen was not quite an inch in length, and the greater number were much smaller. The interior, with its perfect, short, simple loop, is often found, and is exactly similar to the one we find in Martin's species. Sir C. Lyell mentions that he obtained this shell at Windsor, Brookfield, Shubenacadie, Gay's River, Debert River, Middle River, and Cape Breton. Dr. Dawson obtained it in the same localities, to which he has added Pugwash, East River of Pictou, Lennox Passage, &c.

2. Athyris subtilita, Hall, 1852. Pl. IX. figs. 4, 5.

Athyris subtilita, in Howard Stansbury's Exploration of the Valley of the Salt Lake of Utah, p. 409, pl. 2. figs. 1, 2.

The Nova-Scotian specimens all appear to be small in size, but are exactly similar (except in dimensions) to those found in other parts of America and Europe. The spiral processes are often preserved.

This shell occurs by millions in the Lower Carboniferous limestone of Shubenacadie, Brookfield, &c.

Spiriferæ.

The four so-termed species referred to in the lists given by Sir C. Lyell and Dr. Dawson appear to belong to two, or at most three (?), species.

3. Spirifera glabra, Martin, sp. Pl. IX. figs. 9, 10.

Conchyliolithus Anomites glaber, Martin, Petrif. Derb. pl. 48. figs. 9, 10, 1809.

Spirifer glaber, De Verneuil, in Sir C. Lyell's Travels in North America, vol. ii. p. 221, 1845, and in Dawson's Acadian Geology, p. 376, 1855.

This appears to be a common fossil in the Lower Carboniferous limestone of Nova Scotia. It is identical in character with those found in Great Britain; one example brought home by Sir C. Lyell measured 13 lines in length by about 17 in breadth.

It occurs at East River of Pictou, Mabou, Cape Breton, Windsor, Brookfield, Merigomish, &c.

4. Spiriferina cristata, Schlotheim. Pl. IX. fig. 6.

Spirifer octoplicatus, Sow., Min. Conch. pl. 562. figs. 2, 3, 4; Dav. Mon. Carb. Brach. p. 38, pl. 7. figs. 37, 47.

At p. 221 of his 'Travels,' Sir C. Lyell mentions *Spirifer cristatus*, Schl., *Sp. minimus*, Sow., and *Sp. octoplicatus*, Sow., as having been found in the Lower Carboniferous limestone of Nova Scotia; but it is probable that at least two of the shells so termed, namely *Sp. cristatus* and *Sp. octoplicatus*, are referable to a single species. The

Nova-Scotian specimens of the shell under notice are all very small, none of those that have come under my notice exceeding 4 lines in length by 5 in width; they exactly resemble some specimens of the same species found in the Carboniferous shales of Capel Rig, East Kilbride, Scotland.

Sir C. Lyell mentions having found this shell at Windsor, Brookfield, Shubenacadie, and Debert River, in Nova Scotia; and Dr. Dawson adds East River, but that it is nowhere so plentiful as in the shell-conglomerate of Brookfield.

5. Spirifera acuticostata, De Koninck. Pl. IX. figs. 7, 8.

Spirifer acuticostatus, De Koninck, Description des Animaux Fossiles qui se trouvent dans le Terrain Carbonifère de la Belgique, p. 265, pl. 17. fig. 6.

Shell small and transversely oval; valves convex and ornamented with from twelve to fourteen small angular ribs. The mesial fold is comparatively wide, flattened, and longitudinally grooved along the middle. The sinus in the ventral valve has a small median angular rib, which commences at about the middle of the valve and extends to the front. Beak small, incurved; area triangular and of moderate dimensions. Length 4 lines, width 5 lines, depth 3 lines.

Upon sending a proof of the plate illustrating this paper to Prof. de Koninck, he wrote back that figures 7 and 8 were referable to his *Sp. acuticostatus*; and, except in size, they certainly resemble those given by the distinguished Belgian Professor. It must, however, be remembered that in some specimens of *Sp. cristatus*, or of its Carboniferous representative, *Sp. octoplicatus*, the mesial fold is flattened along its middle, and even possesses in some cases a shallow groove along its centre, as seen in De Koninck's *Sp. acuticostatus*. All these modifications in British specimens have been described and illustrated at pages 38 and 226 of my Monograph of British Carboniferous Brachiopoda.

This small shell is very abundant in the shell-limestone of Brookfield, Shubenacadie, and in some other localities in Nova Scotia, where it is always associated with *Sp. cristatus*, of which it may perhaps after all be no more than a modification.

Camarophoria and Rhynchonella.

The specimens referable to these genera sent me by Dr. Dawson, as well as those brought to England by Sir C. Lyell, are generally very small, and not in all cases sufficiently complete to warrant a satisfactory determination. I have, however, carefully represented the principal forms.

6. Camarophoria? globulina?, Phillips. Pl. IX. figs. 11, 12.

Terebratula globulina, Phillips, Encycl. Metr., vol. iv., Article "Geology," pl. 3. fig. 3, 1834.

Terebratula rhomboidea, Phillips, Geol. Yorksh. vol. ii. p. 222, pl. 12. figs. 18–20, 1836.

Hemithyris longa, M'Coy, British Pal. Foss. p. 440, pl. 3. D. fig. 24, 1855.

Of this very small shell I have been able to examine only three specimens; but it is stated to be abundant in a yellow arenaceous limestone at De Bert River, where, according to Dr. Dawson's experience, it is always small. I have also felt somewhat puzzled in the determination of this fossil; but, after having consulted Prof. de Koninck, I concluded to refer the specimens represented in figures 11 and 12 to the same species, notwithstanding the apparent difference they present. Prof. de Koninck referred fig. 12 to *T. rhomboidea*, Phillips, which is a synonym of *Camarophoria globulina*; and, after minutely comparing the Nova-Scotian specimens with the Carboniferous and Permian types, I could perceive no difference sufficient to warrant the creation of a new species. The three specimens were exactly of the same size, namely 3 lines in length by 3 in width and 2½ in depth. The uncertainty which both Prof. de Koninck and myself have experienced refers to fig. 11, which much resembles, in miniature, a form of *Rhynchonella acuminata*; but when we remember that Phillips himself figures a specimen of his *Terebratula rhomboidea* with a simple mesial fold, we need not be surprised to find the same peculiarity in one of those from Nova Scotia. Indeed, after carefully examining the three examples forwarded by Dr. Dawson, I cannot bring myself to believe that they should be specifically separated. It is well known that the same peculiarity occurs with *Rhynchonella acuminata*; and any one who examines plates 20 and 21 of my Monograph of British Carboniferous Brachiopoda must feel surprised at the immense variability of which some species are susceptible.

7. Rhynchonella Dawsoniana, n. sp.? Pl. IX. figs. 13, 14.

Shell very small, almost circular, a little wider than long; dorsal valve moderately and uniformly convex to about half its length from the umbone, at which point a very slightly elevated and flattened mesial fold begins to rise, and extends to the front; the surface of the shell is also either almost entirely smooth or ornamented with from eight to twelve slightly marked ribs. The ventral valve is gently convex, with a wide sinus; beak small and incurved. Length 3½ lines, width 4 lines, depth 2½ lines.

This small species does not appear to be rare in a black Lower Carboniferous limestone at Lennox Passage, and is not unlike, except in size, certain examples of M. de Verneuil's *Terebratula superstes*; but this last-named Permian shell belongs to the genus *Camarophoria*, while the one under description belongs to *Rhynchonella*. I have compared it with a number of equally small young examples of *Rhynchonella pugnus*, from which it appears to differ.

8. Rhynchonella Acadiensis, n. sp.? Pl. IX. fig. 16.

Shell small, obscurely rhomboidal, about as wide as long; dorsal valve rather more convex than the ventral, and presenting, when viewed in profile, a regular curve. The mesial fold commences towards the middle of the valve, while the surface is ornamented with twelve or thirteen small radiating ribs, of which four or five occupy the surface of the fold. The sinus in the ventral valve is of moderate depth, and the surface is ornamented as in the dorsal valve. The beak is gently incurved, and exhibits a small circular foramen under its angular extremity. Length 5 lines, width 5 lines, depth 3 lines.

Of this shell I have seen but two specimens, which I detached from a lump of the Brookfield shell-limestone, and of which one exhibited the two curved internal lamellæ characteristic of the genus *Rhynchonella*. It is quite distinct from young shells of *Rhynchonella pugnus* and *R. pleurodon*. In the last-named species the ribs that adorn the lateral portions of the dorsal valve are very much curved, while those of the ventral are nearly straight, with their extremities bent upwards; in addition to which, the ribs begin to be longitudinally grooved along their median portion at some distance from the margin. None of these characters are observable in the small *Rhynchonella* under description.

9. Rhynchonella, sp. Pl. IX. fig. 17.

Upon some fragments of Lower Carboniferous limestone brought from Nova Scotia by Sir C. Lyell are several imperfect, undeterminable valves of a *Rhynchonella* which differs from the preceding species by its size, as well as by the number of its small radiating ribs. Of these last I have counted as many as thirty-five or forty upon each valve. In size it appears to have measured about 7 or 8 lines in length by 9 in width. I abstain from proposing for it a specific denomination, as the material is so imperfect. The specimen belongs to the Geological Society.

In fig. 15 is represented another *Rhynchonella*, also undeterminable.

10. Rhynchonella pugnus?, Martin, sp., Petrif. Derb. tab. 22. figs. 4, 5, 1809.

Two or three very small specimens, received from Dr. Dawson after my plate had been completed, much resemble certain young shells of Martin's species; they are derived from the Lower Carboniferous limestone of Windsor and East River.

11. Strophomena analoga, Phillips. Pl. IX. fig. 18.

Producta analoga, Phillips, Geol. Yorksh. vol. ii. pl. 7. fig. 10, 1836.

Upon a specimen of dark, impure limestone brought from Nova Scotia by Sir C. Lyell, and now in the Society's Museum, I found a well-characterized example of this species, which, in Sir C. Lyell's list, had been confounded with *Productus Martini*.

12. Streptorhynchus crenistria, Phillips. Pl. IX. fig. 19.

Several crushed valves, referable to this species, occur on a specimen of Carboniferous shale from Shubenacadie, for which I am indebted to Dr. Dawson. These valves exactly resemble certain small specimens found in several British Carboniferous shales. Their surfaces are covered with numerous radiating raised striæ, with a smaller rib between the larger ones, the whole being closely intersected by fine concentric lines, thus giving to the longitudinal ribs a crenulated appearance. Prof. de Koninck coincides in my identification.

Productus.

Although Sir C. Lyell and Dr. Dawson mention seven species of this genus as having been found in the Lower Carboniferous rocks of Nova Scotia, all these, as well as the specimens I have been able to examine, can be referred to two species only, namely *P. semireticulatus* and *P. Cora*; and I may mention that Prof. de Koninck coincides in this view.

13. Productus semireticulatus, Martin. Pl. IX. figs. 20, 21.

Anomites semireticulatus, Martin, Petrif. Derb. pl. 32. figs. 1, 2, and pl. 33. fig. 4, 1809.

This species is so well known, that all I shall require to state is, that the Nova-Scotian specimens are exactly similar to those found in Europe. *Producta Martini, P. concinna, P. antiquata, P. Scotica,* mentioned by Sir C. Lyell at p. 220 (vol. ii.) of his 'Travels in America,' as well as by Dr. Dawson in various pages of his 'Acadian Geology,' belong to a single species, namely *Productus semireticulatus,* Sow. The "*P. spinosa,* Sow.? var. of *P. Martini,*" of Sir C. Lyell's list, belongs likewise to the species under description; but *P. spinosa,* Sow., specimens of which I have not seen from Nova Scotia, is a distinct species. Sir C. Lyell mentions Windsor, Brookfield, Shubenacadie, East River, Debert River, and Minudie. Dr. Dawson states that the shell is found almost everywhere, at Pugwash, near Amherst, Boulardarie, Cape Breton, Horton Bluff, Gray's River, &c.

The largest specimen measured one inch and a half in length by about the same in width. The variety *Martini* is also found in the same locality.

14. Productus Cora, D'Orbigny, 1842. Pl. IX. figs. 22, 23.

Productus Cora, D'Orbigny, Paléont. du Voyage dans l'Amérique Mérid. p. 55, pl. 5. figs. 8, 9, 10, 1842.

P. comoides and *P. Scoticus,* De Kon. 1843 (not of Sow.).

Producta corrugata, M'Coy, Synopsis of the Carb. Limest. Fossils of Ireland, pl. 26. fig. 13, 1844.

P. Lyelli, De Verneuil, Sir Charles Lyell's Travels in North America, vol. ii. p. 221, 1845.

P. tenuistriata and *P. Neffedievi,* De Vern., Russia and the Ural Mountains, 1845.

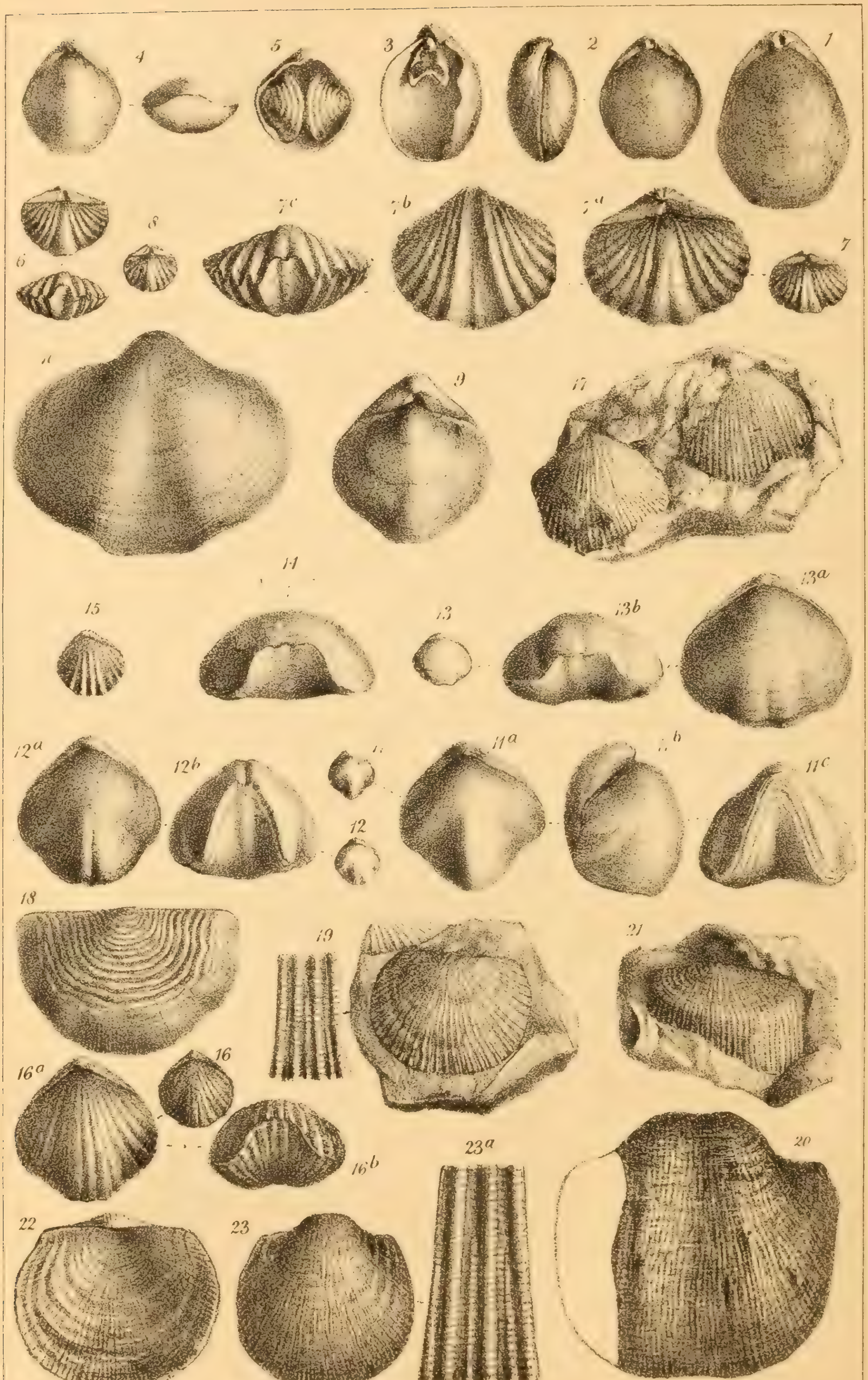
P. Cora, De Koninck, Mon. du Genre *Productus,* pl. 4. fig. 1, 1847.

P. pileiformis, M'Chesney, Descr. of New Species of Fossils from the Palæozoic Rocks of the Western States of America, p. 40, 1849.

P. Lyelli, Dawson, Acadian Geology, p. 219, fig. 9, 1855.

P. Cora, Dav., Mon. Carb. Brach. pl. 36. fig. 4, pl. 42. fig. 9, 1861.

After a very careful examination of nine or ten specimens of *P.*



Thos Davidson del. & lith

W West imp

Lower Carboniferous Brachiopoda from Nova Scotia

Lyelli from the Lower Carboniferous Limestone of Nova Scotia, I have reluctantly been obliged to place M. de Verneuil's species among the synonyms of *P. Cora*, the latter name (as may be seen by the list of synonyms above given) claiming three years' priority. All the Nova-Scotian specimens I have been able to examine were small, not exceeding about 11 lines in length by some 12 or 13 in width. But it must be remembered that, as a general rule, the Nova-Scotian species and specimens, although adult, are small, and in this respect are exactly similar to those we find in Scotland. The surface is covered with numerous longitudinal, straight, or slightly flexuous, narrow, thread-like, rounded striæ, with sulci, or interspaces, of rather less width; smaller striæ are also here and there intercalated between the larger ones. The ribs are also regularly and closely crossed by small concentric lines.

P. Cora is a widely spread Carboniferous species, having been found in many parts of America, India, Europe, &c.

Sir C. Lyell found this shell at Windsor, Horton Bluff, Shubenacadie, Gay's River, Minudie, and Cape Breton, in Nova Scotia. Dr. Dawson states that it occurs almost everywhere—at Pugwash, on the eastern coast of Cumberland, at Lennox Passage, M'Kenzie's Mill at the eastern extremity of Wallace Harbour, &c.

EXPLANATION OF PLATE IX.

Figs. 1, 2, 3. *Terebratula sacculus*, Martin.
„ 4, 5. *Athyris subtilita*, Hall.
„ 6. *Spiriferina cristata*, Schlotheim.
„ 7, 8. *Spirifera acuticostata*, De Koninck.
„ 9, 10. *Spirifera glabra*, Martin.
„ 11, 12. *Camarophoria? globulina?*, Phillips.
„ 13, 14. *Rhynchonella Dawsoniana*, n. sp.?
„ 15. *Rhynchonella* (undeterminable).
„ 16. *Rhynchonella Acadiensis*, n. sp.?
„ 17. *Rhynchonella* (undeterminable).
„ 18. *Strophomena analoga*, Phillips.
„ 19. *Streptorhynchus crenistria*, Phillips.
„ 20, 21. *Productus semireticulatus*, Martin.
„ 22, 23. *Productus Cora*, D'Orbigny.

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2. *On the* Gravels *and other* Superficial Deposits *of* Ludlow, Hereford, *and* Skipton. By T. Curley, Esq., C.E., F.G.S.

The plans and geological sections which I have now the honour to lay before the Geological Society are those of three towns recently drained by me, namely, Ludlow, Hereford, and Skipton.

Ludlow.—The Upper Ludlow rocks are, in my opinion, thrown up against the Old Red Sandstone by a fault running east and west, and taking the line of the Old Town ditch, below the Church and the Castle, as marked on the plan (p. 177). The relations of the intermediate "passage-beds," which connect the Silurian and Old Red systems, and are so well developed in the immediate neighbourhood of the town, have been rendered tolerably clear by the researches of the Ludlow geologists, and by the discoveries made during the progress of the drainage-works. Upon these "passage-beds" and the underlying Downton Sandstone the town is mainly situated. The overlying Old Red Sandstone is well seen in the line of the section in the railway-cutting. The Downton Sandstone, about 80 feet thick at Ludlow, has been generally included in the Silurian rocks: it is a yellow micaceous sandstone, very similar in composition to the Caradoc, from the denudation of which it has, most probably, been derived. But few organic remains occur in it at Ludlow, the principal being the Fishes—*Pteraspis* and *Cephalaspis*,—with the Crustaceans—*Eurypterus*, *Pterygotus*, and the small *Beyrichia*. Above this rock is a very hard, greenish, micaceous sandstone containing lime, much resembling an Old Red Cornstone in mineral composition. The Bull Ring is situated upon this rock, and no doubt owes its present relative altitude to the hardness of this sandstone and its capability of resisting denudation. Above it are several thin beds of sandstone, in which nothing organic has been found. Next occurs a greenish micaceous sandstone, containing *Cephalaspis*, *Lingula*, &c. We then come to the "Olive Shales," which are thin argillaceous beds, easily broken, and containing layers and thick masses of fossils. Several species of *Pterygotus* and *Eurypterus*, and spines of *Onchus* have been found. A thin sandstone-band forms a capping to these olive shales, and underlies a bed of Old Red marl about 80 feet in thickness. On the top of this marl, N.E. of Ludlow, is situated the high-level gravel, in a bed about 30 feet in thickness. The rain-water, falling on this gravel-bed, percolates through it, and issues forth as a spring. Very nearly the whole of the sand and gravel here deposited is composed of Old Red Sandstone débris. The inclination of the sand-belts and their thinning-out towards the east, in this drift, indicate the direction of the current which brought this gravel to the lake in which it was deposited to have been from the westward. It is probable, therefore, that, prior to the deposition of this gravel, the Silurian rocks, which now form the entire area of the district west of Ludlow, were masked to some extent by Old Red Sandstone, since removed by denudation.

By subsequent denudation, and an alteration of currents, this "high-level lake" became drained, and a lower lake formed about 100 feet below it. Currents from the north deposited sand, gravel, and other drift in this lower basin, which now forms the site of Corve Street. This gravel-bed is composed chiefly of Cambrian and Silurian débris, water-worn fragments of the well-known Cambrian rocks of Church Stretton being abundant. A very small part of the present site of Ludlow would, during the deposition of this "low-level gravel," appear above water. The south edge of the lake appears to be opposite the Feathers Hotel, in Corve Street. A little lower down that street, opposite the Compasses Inn, large boulders of Old Red Sandstone were discovered, resting amongst sand, gravel, and fine clay. These boulders must have been carried to their present position by floating ice, which became stranded in

Fig. 1.—*Geological Sketch-map of Ludlow.*

Alluvium. | Old Red Sandstone.
Low Level Gravel. | Downton Sandstone.
High Level Gravel. | Upper Ludlow Beds.

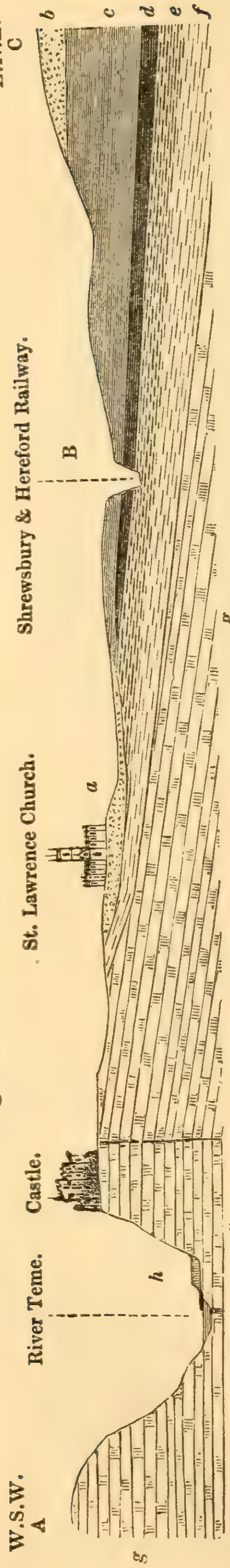
a. 'The Compasses' Inn. *c.* The Bull Ring.
b. 'The Feathers' Hotel, *d.* Ludlow Castle.
A, B, C. The line of Section.

water, eight or ten feet deep, near the edge of the shelving lake. The current which carried down the gravel, &c., passed over the present site of the River Teme; for a bed of fine blue clay lies at the bottom of Old Street, and yellow clay below Frog Lane. The dam which kept back the water of this lower lake was probably opposite to the tanks at the Old Paper Mill.

The average thickness of this low-level gravel is about 25 feet, a thickness of 21 feet of which has been exposed by shafts and tunnelling for the main sewer. During the existence of this water, the site of Ludlow appears to have been covered, save a narrow strip, about 130 yards wide, along the present direction of Castle Street. The water of this lake would be 70 feet deep at the bottom of Corve Street, and 90 feet deep at the bottom of Old Street.

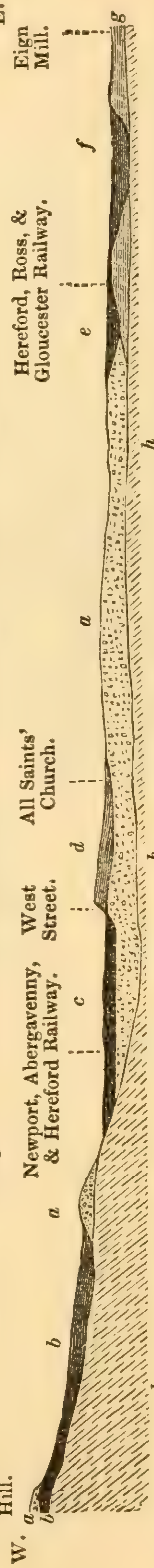
In process of time, the rocks which formed its southern dam having been worn through, the whole of this lake-water seems to

Fig. 2.—*Section across Ludlow, along the line* A, B, C.



a. Yellow gravel and clay with large boulders.
b. Gravel composed of 'Old Red' débris.
c. Old Red marl.
d. Olive shales.
e. Old Red Sandstone.
f. Downton Sandstone.
g. Upper Ludlow Beds.
h. Alluvium.

Fig. 3.—*Section across Hereford, from Broomy Hill to Eign Mill.*



a. Gravel. b. Puddle-clay. c. Vegetable soil. d. Silt. e. Peat. f. Yellow clay. g. Red clay. h. Old Red Sandstone.

Fig. 4.—*Section across Skipton, from Eller Beck to Storem's Lathe.*

a. Soil. b. Alluvium. c. Gravel. d. Shale. e. Blue clay. f. Sand. g. Carboniferous Limestone.

have gradually drained away, the rain-water of the catchment-basin scooping out the beds of the Rivers Teme and Corve,—the courses of which, however, had then dissimilar directions, as is shown by the high terraces behind Burway, leading to Broomfield. Similar changes are now going on, slowly and imperceptibly, though probably not more so than the former ones.

Hereford.—The city of Hereford is 158 feet above the sea-level, and stands upon a gravel-deposit 900 acres in extent. The materials of this bed appear to have been transported from a great distance, being well rounded and water-worn. In addition to pebbles of Old Red Sandstone and Cornstone, it contains Silurian pebbles from the upper part of the Valley of the Wye, and fragments of trap-rocks from Builth. This gravel is seen to be the lowest of three terraces of drift, and has an average thickness of 30 feet. At a level of 30 feet above it we meet with a second deposit, a belt of gravel perfectly level, and evidently forming the edge of an old lake. Forty-two feet above this, a gravel-bed of small extent exists as a capping to Broomy Hill.

I am inclined to consider that the denudation of the Old Red Sandstone over the area of the Hereford valley was comparatively rapid; the present River Wye, which flows through it, discharging, in ordinary dry weather, 1650 million gallons daily. These three gravel-zones are very similar in their appearance and mineral constituents. The quantity in the lowest, or City-of-Hereford bed is 25 million cubic yards—sufficient to gravel a walk, 10 feet wide, round the globe.

Skipton.—The plan and sections of the town of Skipton exhibit a somewhat similar condition of things. The lower portion of the town is situated on a lacustrine deposit, lying in a basin of Mountain-limestone, containing gravel composed of the débris of this rock and the adjacent Millstone-grit.

Under this gravel there occurred, on the south side of the canal, and in the excavations for the main sewer, a black deposit of silt of the consistency of tar, which caused great trouble to the contractor; for straw had to be introduced behind close boarding to keep out this treacherous material, which appeared to be composed of pulverized coal-shale, derived from stratified layers in the neighbourhood. In the sewer-cutting, opposite Christ Church, a thick bed of dark marl was cut through, full of the shells of *Physa fontinalis*. In the cutting of the sewer north of the canal, opposite Victoria Mills, the skull, tibia, and other bones of a species of *Bos* were met with in fine sand, below 8 feet of peat and gravel-drift. Large boulders, about $3\frac{1}{4}$ tons in weight, were found in the gravel opposite the Devonshire Hotel.

The section along the line of the main sewer has been extended to include the contorted stratification of the Carboniferous Limestone on which the Castle stands, and the anticlinal axis of Storem's Lathe.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

On the GEOLOGICAL STRUCTURE *of the* SOUTHERN GRAMPIANS. By JAMES NICOL, F.R.S.E., F.G.S., Professor of Natural History in the University of Aberdeen.

[Read June 18, 1862*.]

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1. Introduction.
2. Object of the Paper.
3. Clay-slate Formation of Bute.
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7. Leny Limestones.
8. Ben Ledi.
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19. Clay-slate of Loch Creran.
20. Loch Leven and Glencoe.
21. Fort William and Ben Nevis.
22. Glen Spean.
23. Geological connexion of the Grampians with other parts of the Highlands.

1. *Introduction.*—The nature and origin of the crystalline or metamorphic strata have recently formed the subject of various memoirs, both in this country and abroad. Living in a region in great part composed of these rocks, and having for many years been engaged in examining them in various parts of Scotland, I have naturally taken much interest in these discussions. I now venture to lay before the Society an account of some sections which I have recently examined (several of them not for the first time), as they appear to me to throw light on some points of high importance both in the history of the earth and the structure of our own country.

Before noticing special sections, it is right to mention that I have long held the view of the metamorphic origin of these so-called pri-

* For the other communications read at this Evening-meeting, see Quart. Journ. Geol. Soc. vol. xviii. p. 378.

mary strata. In my 'Guide to the Geology of Scotland,' in 1844, I pointed out the close resemblance of some parts of these formations to the Silurian strata in the South of Scotland, and indicated that they were merely the metamorphosed representative of the latter. In a paper read before the Geological Society in 1849 I again stated this opinion, and specially noted the "band of clay-slate from Stonehaven to Arran as forming the continuation of the Silurian beds in the south, rising up on the other side of the synclinal valley in which the Carboniferous strata of Scotland have been deposited"*. The same views of the identity of the crystalline strata in the North of Scotland with the Silurian deposits in the South have been expressed by me on many subsequent occasions†, and may thus have in some points influenced the statements given in the following paper.

2. *Object of the Paper.*—My principal object in describing these sections is to examine the relation to each other of the three great formations, the Clay-slate, the Mica-slate, and the Gneiss, which, with some subordinate groups, as the Quartz-rock and Chlorite-series of Macculloch, have hitherto been regarded as composing the chief stratified masses in the Scottish Highlands. These formations, "founded on the great relations which rocks bear to each other and to the general structure of the earth"‡, have been recognized with nearly identical characters in the most distant regions of the globe, thus showing that they are not mere capricious distinctions of local observers, but true constituents of the crust of the earth§. The order originally assigned to these formations by Werner—of Gneiss in the lowest position, followed by Mica-slate, and this by the Clay-slate—has usually been adopted by geologists, though some remarkable exceptions to this order have been long known. To some of these I adverted in 1844, and again in a paper read before the Geological Society in 1855, in which I endeavoured to explain the phenomena on the supposition of a reversal of the beds. The following sections will show how far this view can still be maintained‖.

* Guide to the Geology of Scotland, pp. 128, 139, 249; Quart. Journ. Geol. Soc. vol. vi. (1849) p. 60.

† See especially "On the Geol. of Cantyre," Quart. Journ. Geol. Soc. vol. viii. (1852) pp. 422, 423 (the substance of this paper was read at the Meeting of the British Association at Edinburgh, in August 1850); "On Easdale and Oban," *id.* vol. xv. (1858) pp. 112, 116; Note to Geol. Map of Scotland, Edinb. 1858.

‡ Macculloch, Geological Classification of Rocks (1821), p. 3. In that work the different varieties of rocks composing each formation are fully described, and perhaps undue importance ascribed to them. See also his 'Western Isles,' vol. ii. p. 353, note.

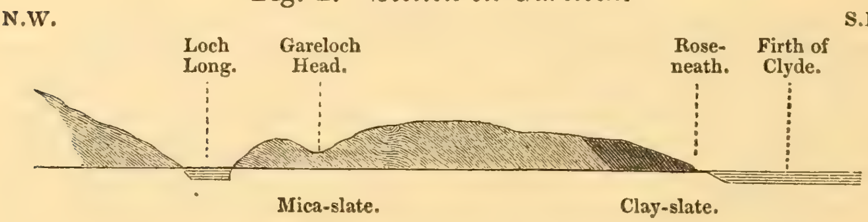
§ It is enough to mention Humboldt's Essai géognostique sur le Gisement de Roches (Paris, 1826) among the older, and Naumann's elaborate 'Lehrbuch der Geognosie' among the newer foreign works, in proof of this universal recognition of these formations. Dr. Ami Boué, from his knowledge of Scottish rocks, is an unexceptional witness to their agreement with those of foreign countries.

‖ See Guide to Geol. of Scotland, p. 169; "Section of the Eastern Grampians," Quart. Journ. Geol. Soc. vol. xi. p. 547. Even in 1821, in his 'Treatise on Rocks,' p. 92, Dr. Macculloch had pointed out this fact, like many others which have been claimed as new discoveries.

3. *Clay-slate Formation of Bute.* — The first formation I shall notice is the clay-slate. This, as shown by Dr. Macculloch and in my own map, forms a narrow band along the southern flank of the Grampians, from Arran to Stonehaven, everywhere presenting very similar and unmistakeable characters. These it is unnecessary to repeat, and some local peculiarities will be noted in the special sections. I shall also pass over its relations in Arran, only remarking, that the granite appears to have risen up nearly in the line of junction between the clay-slate and the mica-slate. In Bute the clay-slate dips to the S.E. at angles ranging from 20° to 60°, and appears to rest on the mica-slate, also dipping in the same direction. Some sections near Rothsay have led me to suspect that in this island there are two formations of the clay-slate, as intimated by Mr. D. Sharpe, the upper green or light-grey slates appearing to rest unconformably on the lower blue slates.

4. *Loch Long and Gareloch.*—On the mainland a similar S.E. dip prevails along the Firth of Clyde, though in some places, as near Dunoon, the outer range of clay-slate can scarcely be said to occur. On the Gareloch a better section of the clay-slate in its relation to the mica-slate is seen, though still in some places concealed by detritus. This section is represented in fig. 1, beginning on the north

Fig. 1.—*Section on Gareloch.*



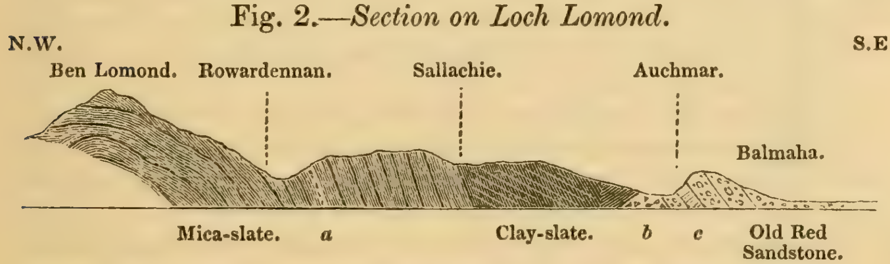
side of Loch Long, near Castle Carrick, and extending to the Clyde, near Roseneath.

On the north side of Loch Long the mica-slate, rising up into the gnarled and rugged mountain-group known as Argyll's Bowling Green, forms an anticlinal axis, apparently oblique to the direction of the loch. On both sides of Loch Long the mica-slate is so twisted and contorted that the dip is almost undeterminable. Occasionally the beds are horizontal, then they dip to the north or south at angles ranging from 15° to 80°, or, again, are, as it were, twisted in both directions in the most complex manner. The average direction is, however, N.E. by E. (or N. 55° E.), and thus nearly parallel to the general range of the strata. Several dykes or veins of greenstone intersect the strata, but do not produce much change either on their direction or character.

The strata, generally a distinct lustrous mica-slate, intersected by quartz-veins, continue to dip S. 35° E. from Loch Long to Gareloch Head. Near the latter place the beds become more regular, with an average dip of 70°. Further down the Gareloch the rocks are more arenaceous or less crystalline, and the dip declines to 55°, 45°, and even to 30°. On the east side of the loch, near Shandon, some beds of clay-slate appear; and the strata, dipping first north at high angles, then south, then again north, and finally regularly south-east, show that in this place there is probably a faulted synclinal. The same irregularity, as shown in the section, occurs on the west side of the loch, but beyond this break the beds have a uniform south-east dip to the clay-slate near Roseneath. These slates dip at 40° to S. 35° E., and appear to consist, as in Bute, of two divisions, the lower micaceous or talcose, and of a deep blue or purplish tint, the upper of a lighter blue or green with a more silvery lustre. Some of the beds resemble a fine-grained greywacke. This section and that of Bute show what may be considered the regular normal order of the formations on the south border of the western Grampians. First, towards the axis of the chain, the more highly crystalline and contorted mica-slate, covered by less crystalline and more even beds of the same rock, and these in turn by talcose or chloritic blue and green clay-slates, with occasional beds of greywacke. The low and regular dip of the beds, and the conformity of the order to the only theory of metamorphic action which seems admissible in the present state of geological science, induce me to regard this as the true normal order of these formations.

5. *Loch Lomond.*—The next section I shall notice (fig. 2) is that

Fig. 2.—*Section on Loch Lomond.*



a. Syenite. *b.* Granite. *c.* Limestone.

seen on the east side of Loch Lomond, from Ben Lomond to the Red Sandstone at Balmaha, about ten miles east of the one just described.

Ben Lomond, at the northern extremity, consists of mica-slate, often quartzose, much contorted, and dipping at low angles, and intersected by veins of felspar-porphyry. Near Rowardennan the strata become more regular, dipping at high angles (80° to 85°) to S. 27° E. The rocks are still chiefly mica-slate, passing occasionally into a light-grey talc-slate. About a mile below the inn some of the beds dip north at high angles, and are intersected by a parallel vein of fine-grained syenite, composed chiefly of red felspar and dark-green hornblende. At Sallachie Wood a coarse greywacke, very hard and full of quartz-veins, appears, dipping at 80° to S. 27° E., and thus conformable to the mica-slates on the north. It contains distinctly rounded grains of quartz, thus leaving no doubt of its mechanical origin. Further on, the clay-slate, well exposed in the quarries, dips at 70° to 75° to S. 27° E., or S. 33° E., and thus still conformable to the mica-slate. The lower beds are compact, glossy, blue slates of uniform texture, and with a few grains of pyrites; the higher beds are a similar rock, but of a light grey or green colour. In his section of this place Mr. Sharpe indicates two planes of division in these slates—one of cleavage or foliation, the other of bedding or deposition, but both nearly coincident. So far as I could make out, the bedding and cleavage coincide, though there are other division-planes dipping about 38° to N. 75° W.

Beyond the clay-slates coarse greywackes again appear, dipping first at 70° to N. 12° W., and soon at 70° to S. 17° E. There is thus in this place probably an anticlinal fold in the beds, and some thin irregular veins of a white granite also mark it out as an axis of disturbance. About a mile further down the lake, beds of reddish greywacke appear to dip at 40° to N. 10° W., but are not very distinctly seen. The cause of this change in the dip is probably the intrusion of a coarse red granite or felspar-rock, which breaks out near the junction with the Red Sandstone, about half a mile from the Old Manse. Some hard, jaspery masses associated with this igneous rock are perhaps altered beds of the Old Red. Near Auchmar an impure yellow limestone has been wrought, also probably a portion of the Old Red, though often conjoined with the Leny limestone in the clay-slate. At the Pass of Balmaha the conglomerate of the Old Red Sandstone, dipping at 60° to S. 45° E., forms a bold projecting hill in front of the primary mountains. The low ground to the south consists of finer-grained red sandstone lying at a low angle, and near Drymen dipping at 12° to E. 15° S.

In this section, though the beds dip at much higher angles, the relation of the formations is still the same as on the Gareloch. The mica-slates, dipping south, are covered by an upper group of blue and green clay-slates and greywackes. The two formations also appear to be conformable, and the direction of the beds varies little from E. and W. by compass (E. 27° N. true), but near the south margin of the clay-slate, probably from the intrusion of the granite, approaches nearer to the true east and west (E. 16° N., to W. 16° S.)*.

6. *Callander and Pass of Leny.*—Passing again to the eastward, over an interval of about fifteen miles, we reach the well-known vicinity of the Trossachs and Callander. To the north of the latter the rocks are very well exposed in the Pass of Leny and on the banks of Loch Lubnaig (fig. 3).

At Callander, the red sandstone and conglomerate, which form the low undulating plain stretching south to the Ochils, rise up into a range of low but rugged hills, immediately behind the village. The rocks are well seen in a fine natural section at Bracklyn Falls, where the Keltie forces its way through the upturned beds in a series of deep pools and whirling caldrons. Higher up the stream there is a thick

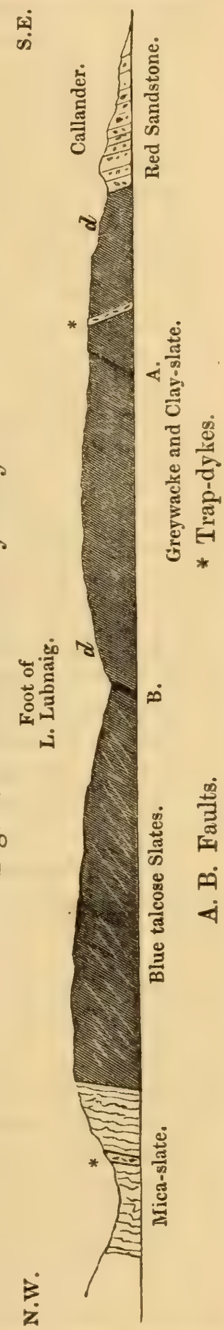
* My observations agree generally with Mr. D. Sharpe's section in Quart. Journ. Geol. Soc. vol. viii. (1852), p. 129. Sir R. I. Murchison and Mr. Geikie, in their new Sketch-map, also give a section of this locality, but differing in some important points.

mass of red and reddish-grey sandstone, with a conglomerate-bed consisting of masses of brown porphyry and white quartz. The strata dip at 75° to S. 45° E., and at the Falls consist of coarse sandstones below, of a quartzose conglomerate in the centre, and of deep-red, fine shaly beds above. They are intersected by "backs" or division-planes, nearly vertical to the bedding, so that the water removing the softer portions has left great square ledges projecting like walls into the ravine. The conglomerate is also well seen near the Railway-station, dipping at 65° to S. 42° E., the whole surface being deeply grooved and smoothed as by glacier-action. Here also it consists especially of vein-quartz, with smaller fragments of the clay-slates on the north, in a reddish-brown basis of decomposed felspar. Beyond the village the lower sandstones, dipping at 70°–77° to S. 37° E., are quarried for building-purposes, and are in part fine-grained and greyish purple, in part deeper brown and more shaly.

The next formation is the clay-slate (*d*), seen in the deep gorge of the Pass of Leny. The lowest beds are light-grey greywacke, weathering brown, and composed of distinct grains of quartz in a basis of decomposed felspar and clay-slate. These strata dip to N. 37° W., at angles of 44° to 50°. Above them are red and yellow slaty beds, some of them almost a pure iron-ochre, others more arenaceous, dipping at 47° to N. 17° W., but with some confusion and uncertainty. Red beds follow, with a distinct cross cleavage; but their dip is disturbed and obscure, probably from a dyke of blue columnar dolerite, 30 to 40 feet wide, which runs N. 25° E. with a slight dip to the south. Beyond it are fine-grained grey slates, dipping at 66° to N. 55° W., but with a cross structure or cleavage inclined at 20° to N. 35° E.

At this point a marked change takes place in the position of the strata. The dip is first 25° to N. 20° E., but soon rises to 40° to N. 5° W. Further on, it rises to 67°, N. 37° W., and then to 75°, N. 45° W., in curved, irregular beds of blue slate, with a cross division or cleavage inclined at 12° to N. 12° E. Grey slates again follow, dipping at 68° to N. 37° W., and are succeeded by coarse greywackes in thick beds, dipping at 60° to N. 5°–10° W. This rock is also intersected by other planes dipping 55° to S. 25° W., and by well-marked fissures, lined on the sides by actinolite, running to W. 62° S.

Fig. 3.—Section in Pass of Leny.



Beyond this point, near the foot of Loch Lubnaig, there is a great mass of chloritic slate and greywacke, full of quartz-veins reticulating in all directions, but with no determinable dip or direction. It contains imbedded fragments of a more siliceous nature. The coarse greywacke also is composed of fragments of quartz and felspar, from one-tenth to one-fourth of an inch in diameter, in a basis of grey chlorite or mica in fine scales. Even the coarser varieties have, however, a distinctly foliated or schistose texture, unlike anything I have seen in the South of Scotland. The grains of quartz and felspar are flattened and drawn out in the direction of the foliation, so that the rock presents, as it were, an incipient tendency to assume the structure of regular gneiss*. As illustrating the metamorphic origin of the crystalline strata, this rock is exceedingly interesting, presenting, as it were, one of the intermediate steps in the process. It is more crystalline than the greywackes of the south, less so than the true gneiss of the north, and, though distinctly foliated, still clearly fragmentary in origin.

Beyond this point the strata become more regular, and less detail is necessary. The first beds are greenish clay-slate, dipping about 40° or 45° to N. 42° W., and interlaminated with parallel veins or layers of quartz with undulating surfaces, as if ripple-marked. Further up Loch Lubnaig the dip rises to 75°, N. 37° W., in blue talcose slates. Near Ardchullarie another vein of dark greenstone, about 50 feet wide, runs nearly E. and W. by compass (E. 30° N.). Soon after the true mica-slate appears, dipping at 73° to N. 15° W., in thin undulating beds. It continues along the whole lake; but further up the strata become more contorted, and dip very irregularly at lower angles. Though not quite conformable to the clay-slate, the mica-slate clearly overlies that rock, seen further down the loch.

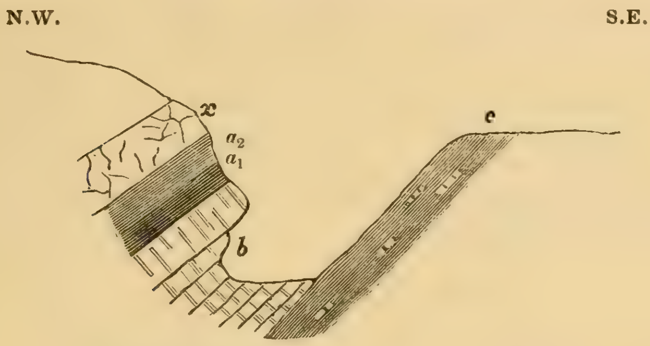
7. *Leny Limestones.*—On the hills to the east of the Pass of Leny, limestone has been quarried for a long period. The excavations follow the outcrop of the rock across the ridge of the hill, and in some places are of considerable depth. In one part of the old quarry there is the section represented in fig. 4.

To the south are black shales (*c*), mixed with contorted beds and masses of limestone. Above the shales is the limestone *b*, blue and reticulated by veins of white calcspar, and now wrought out above. It is covered by grey talcose beds (a_1), and these by red shales (a_2) curved and twisted. At *x* is a bed of red compact felspar-porphyry, with grains of quartz and crystals of mica sparingly distributed through it. The limestone is better seen in the quarry now being wrought, where it is 15 feet thick, and divided into several thin, curved, and irregular beds, dipping at 53° to N. 25° W. It rests on and is covered by black shales, both dipping at 70° to N. 37° W.,—thus, curiously enough, both unconformable to the limestone between them. The shales are covered by a red porphyry, identical with that in the

* Professor Hitchcock, of Amherst College, has recently described a similar appearance in America. See Silliman's Am. Journ. of Science, vol. xxxi. (1861) p. 372, &c.

former quarry. To the south the shales rest on reddish greywacke, intersected by a great dyke of basalt, from twenty-five to thirty yards wide. It dips northwards at about 60° under the limestone, and runs a little north of east by compass (E. 40°–45° N.), and thus approximately parallel to other similar dykes in the southern

Fig. 4.—*Section at Leny Old Lime-quarry.*



x. Felspar-porphyry.
a_2. Red shales.
a_1. Grey talcose shales.
b. Limestone.
c. Black shales.

Grampians. It continues east as far as the Keltie, but seems distinct from the dyke noticed in the Pass. The limestone has also been sought in vain in the low ground, as the quarries opened high on the mountains are very inconvenient. Though of considerable thickness and divided into many beds, this limestone, as is frequently seen in the primary strata, is a very partial formation. The red porphyry, hitherto overlooked, has produced considerable disturbance in the strata, as shown both by the irregular outcrop of the limestone and its relation to the other strata. Both the texture and colour of the limestone, and the black carbonaceous-looking shales associated with it, remind us rather of the Carboniferous formations than of a primary deposit*.

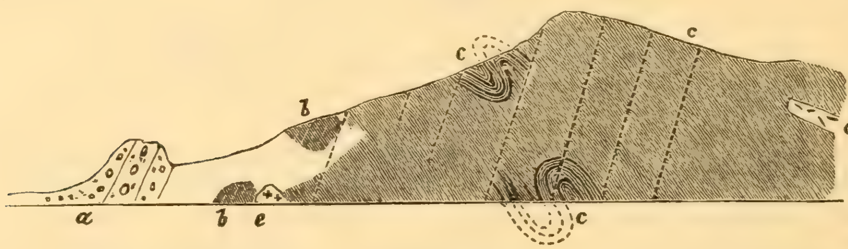
8. *Ben Ledi*—The great mountain of Ben Ledi, on the west side of Loch Lubnaig, also shows an interesting section of these deposits (fig. 5).

At the foot of the hill, immediately north of the road to the Trossachs, a mass of coarse conglomerate rises into a rugged knob. Beyond it the slope of the hill is low, and thickly covered with moss and vegetation concealing the rocks. Where the acclivity becomes steeper, a fine hard greywacke dips at 50° to N. 4° E., followed on the first shoulder of the mountain by a light greyish-green clay-slate, containing grains of quartz and scales of mica, dipping at 40° to N. 2° E. The next shoulder of the hill consists of light-grey mica-slate, dipping at 50° to N. 15° W. along the foliation, but with other very distinct

* Prof. Harkness, in his section of this place, omits both the trap and porphyry. He also states that the limestone rests on quartz-rock, which I could not find either in the quarries or the neighbouring ravines. The only rock at all resembling quartz-rock is the porphyry above the limestone.

division-planes, which dip at 60° to S. 43° W. These rocks generally weather to a dark rusty brown, probably from containing the protoxide of iron. Soon after, the same rocks dip at 60° to N. 27° W., again on the foliation of the slate, but in a few yards fall to 35°, N. 27° W., from a curve in the beds. The next acclivity is a fine-grained mica-slate with a veined aspect, from the folia being arranged in curved layers. The dip here is still low (30° to N. 17° W.), but soon rises to 65°, N. 12° W., in a grey mica-slate full of quartz-veins. This rock continues to the summit of the hill, where the dip is 55° N. 17° W., and a nearly similar dip appears in the rugged precipice along the ridge to the north. Other division-planes, dipping 70°, S. 50° W., are seen in these cliffs; and a series of ridges and hollows, like the outcrop of beds, run N. 50° W. across the top of the hill. The rock there is still a light-grey mica-slate, with small garnets rarely disseminated through it.

Fig. 5.—*Section of Ben Ledi.*



a. Red Conglomerate. *b.* Clay-slate. *c.* Mica-slate. *d.* Greenstone. *e.* Felspar-porphyry.

On descending the mountain on the north-east towards the top of the great corrie that opens up from Loch Lubnaig, the mica-slate passes into a coarse granular rock, full of rounded grains of quartz, and almost like a greywacke, but still distinctly foliated. This is again one of those transition-forms that so clearly illustrate the metamorphic character of these rocks. The dip of these beds is 45° to N. 18° E.; but other planes dip at 67° to S. 38° W., and thus approximately parallel to the second set of division-planes already mentioned. It is, however, curious that these coarse-grained greywacke-like beds, both here and in other places, do not coincide in dip with the slates or finer beds near them. Still lower on the mountain, towards the south, mica-slate again appears, dipping 70° to N. 40° E. Below it there is an irregular vein or mass of light-grey greenstone decomposing in globular concretions, and probably the continuation of the vein near Ardchullarie on the other side of Loch Lubnaig. Still lower, a very quartzose mica-slate, in thin beds, dips at 70° to N. 27° W. The stream continues to flow over irregular beds of mica-slate, in some places much bent and contorted, and dipping E. at 10° to 30°, in other places more regularly at 65° to N. 10° W. Near the foot of the corrie the stream forms a series of picturesque linns over the ledges of the fine-grained mica-slates, which dip at 70°–80° to N. 30°–40° W. At the foot of the hill the dip falls to 60°, and further south to

50° N. 40° W., in fine granular mica-slate. Still lower, I found a thick bed of clay-slate, reticulated with numerous veins of quartz, similar to one mentioned in the section on the east bank of the Lubnaig; and some slate-quarries are wrought high up on the hill, but probably lower in the series. Further south, and quite within the gorge of the river, a concretionary red felspar-porphyry appears, similar to the porphyry at the Leny lime-quarry. Below it there is a red greywacke, followed to the south by other beds, apparently the mere continuation of the first beds in the former section, but much concealed by woods and detritus.

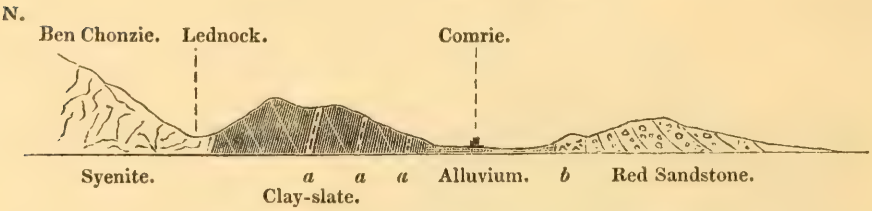
9. *General Remarks on the foregoing Sections.*—I have given fuller, perhaps it may be deemed tedious, details of the changes in character and in dip and direction of these strata than might otherwise have been necessary, from the great theoretical importance of this section. A mere casual walk along the road, with its numerous turnings and windings, and the distraction occasioned by the wild and romantic scenery, is apt to leave on the mind an impression of greater regularity in the sequence than really exists. And so it is when the facts are at once generalized, the numerous exceptions ignored and passed over, and mere averages, deduced or assumed, only stated. In such a method of procedure both author and reader are deceived, and a regularity imagined which has no existence. I have felt this to be the case in reference to these sections. The first general impression is, that there is here a continuous series of beds dipping regularly to the north, one below the other. In that case the greywacke to the south would be the lowest and oldest deposit, followed first by clay-slate, and this by mica-slate, as the upper and newest formation. This is, of course, exactly the opposite order from that noted in the former sections, and cannot therefore be adopted without some consideration. To the general question of order I shall subsequently advert, and would now only direct attention to one or two special points. The first of these is the marks of disturbance in the sections, indicated both by igneous intrusion and by changes in the dip and direction of the beds. This is especially seen in the Leny section, fig. 3, at the points marked A and B. The beds north and south of A seem merely the same group repeated. At B a more decided change takes place, and here Dr. Macculloch has drawn the line of junction between the clay-slate and mica-slate. Clay-slate indeed occurs north on Loch Lubnaig, but more talcose and foliated, or crystalline, than the strata south of B. In Ben Ledi, also, beds containing distinct fragments run far into the interior. The two sets of division-planes seen in Ben Ledi give rise to another important question,—which of these indicates the true bedding or stratification? If the lines of foliation in the slates are not truly lines of bedding or deposition, and we must look for these in the other set of division-planes, then the whole order of the formations is reversed. It would undoubtedly be easier to assume either supposition as true, than to assign a sufficient reason for the choice made.

10. *Comrie and Strath Earn.*—The next locality I have to notice is Upper Strath Earn, near Comrie, again about twelve miles north-

east of the last section. Comrie, though remarkable both for its picturesque beauty and for the frequency of the earthquake-shocks felt there, has met with less attention from geologists than the interesting nature of the phenomena around it might demand; and I am not acquainted with any detailed description of its formations. The village lies in the bottom of a wide, flat valley, shut in on all sides by hills, and traversed by the Earn, Ruchill, and Lednock rivers, which unite at this place. On the north and west the primary mountains rise high and rugged, whilst the trap and Old Red Sandstone form a lower range, separating it from the central plain. Upper Strath Earn is evidently a great valley of denudation, with rounded knobs of slate and trap, smoothed and striated by glacier-action, rising through the level sheet of detritus.

The section, fig. 6, represents the rocks as seen on nearly a north

Fig. 6.—*Section at Comrie.*



a. Trap-dykes. *b.* Greenstone.

and south line passing from the granite, or rather syenite, of Ben Chonzie, through Comrie, to the red sandstone of the central valley. Where it begins in the south, the strata are chiefly fine-grained red sandstones intermixed with grey micaceous beds or dark-red sandy shales covered with bright-green blotches. In the low ground the beds lie at a low angle, but towards the north dip at 70° to S. 15° E., and rest on thick masses of coarse conglomerate. In this rock the strata are nearly vertical, with a direction from E. 28° N. to W. 28° S. It appears to have been elevated by the greenstone on the north, which runs in a series of low, rounded, and interrupted knolls from N.E. to S.W., separating the Red Sandstone from the primary formations. The changes that the igneous rock has effected on the conglomerate are very remarkable. In one place, large, distinctly rounded boulders are imbedded in a basis of porphyritic or amygdaloidal trap, intersected by veins of chalcedony and calc-spar. It looks almost as if, in some period of violent convulsion, a bed of molten lava had forced itself in amidst a heap of water-worn shingle, and kneaded up the loose boulders into its own mass. Probably, however, it is only a true conglomerate with a basis of broken-down or decomposed trap, which has subsequently been semi-fused, thus giving the mass the aspect of an igneous rock.

The boulders in the conglomerate range in size from fine sand or gravel to masses of nearly a foot in diameter. Lying close to the foot of lofty mountains of the primary formations, it might naturally be expected that the conglomerate should be composed of fragments derived from these rocks; this, however, is not the case. I examined a very large number of specimens collected indiscriminately in several localities, and found them, almost without exception, fragments of igneous rocks, and especially of clove-brown felspar-porphyries and claystone-porphyries. They are thus derived from rocks distinct both from the augitic greenstone on which they rest, and from the crystalline rocks forming the mountains on the north and west. This peculiar character of the conglomerates of the Old Red Sandstone in the central valley of Scotland is by no means confined to this locality; it reappears in many other places, both along the foot of the Grampians and on the south side of the valley near the Ochil Range. Thus, in the coarse conglomerates near the Bridge of Allan, similar brown felspar-porphyries and claystones predominate, in many places to the exclusion of almost every other rock. In the Ochils, rocks of this nature, from which these conglomerates may have been derived, are not uncommon; but near Comrie they either do not occur, or are probably concealed by newer deposits. The whole phenomena of these red-sandstone-conglomerates lead to the conclusion that they have been formed along lines of fissure, through which outbursts of igneous matter were taking place,—one of these lines running along the foot of the Grampians, and another marked by the present Sidlaw, Ochil, and Campsie Hills. Along these lines the materials of the conglomerates are chiefly trappean. In some localities, however, as near Callander, fragments of quartz or primary strata predominate, the rocks in these places having probably been formed near the outlet of some ancient river, or where projecting points of the old strata rose high above the waters and were thus exposed to atmospheric and oceanic influences. It is also a curious fact that, mixed with these trappean conglomerates, there are other beds of finer materials, undoubtedly derived from the older crystalline rocks. Thus, some of the Pteraspis-sandstones at the Bridge of Allan consist of angular fragments of quartz, felspar, and mica, and hence like a true granite or gneiss, only with a fragmentary or clastic, not a crystalline structure. The prevailing red colour of the sandstones also seems owing to the ejection of ferruginous matter during these long-continued eruptions*.

The next formation is the clay-slate and greywacke, which probably underlie the flat plain south of Comrie, though concealed by the covering of detritus. They are, however, well seen on the north side of the Earn, especially in the deep gorge of the Lednock, which has cut through them in a series of romantic rapids and cascades. The rocks vary from a moderately coarse greywacke, composed of rounded grains of quartz in a basis of clay-slate, to a fine-grained clay-slate with a fibrous or silky lustre. The greywackes are of a

* Whilst these facts show that part of the igneous formations in the Ochils preceded, and that part accompanied the formation of the Old Red Sandstone, there is full evidence that other portions are younger than the Red Sandstone, and indeed even than the Coal. It is also right to mention that some observers consider the trappean conglomerates as marking an older, the quartzose conglomerates a newer stage in the Red Sandstone. (See Page's Advanced Text-book, p. 174.)

blue colour; the slates often bluish or greenish grey, weathering brown on exposure. Both rocks contain iron-pyrites in cubical crystals or disseminated in small grains, and also scales of mica. The slates show very distinct division-planes, or foliation, with a very predominant dip at 70° to N. 10° W., but the inclination ranging from 55° near Comrie to 85° on the north near the syenite, and the direction of the dip from N. 15° E. to N. 55° W.

Before noticing some other peculiarities in the slates, it is better to complete the section by describing the granite, or rather syenite, in the north. This rock rises high up on the declivities of Ben Chonzie (2922 feet high), and occupies a great part of the valley of the Lednock. Generally it is a fine-grained syenite, composed of abundant felspar and hornblende, with scales of black mica and a little quartz. In some varieties, as that used in building the Melville Monument, the hornblende is in great measure replaced by mica, and the stone has then a white or grey colour. It has been compared to the grey granite of Aberdeen, but the resemblance is merely superficial. In the Comrie syenite the felspar is more predominant, and often forms distinct porphyritic crystals; hornblende seems always more or less present, and the quartz is far more subordinate than in the grey Aberdeenshire granite. In truth, it seems more closely related to the felspar-porphyry or trap group, than to the true granites of the central Grampians. Its peculiar character is better seen in other varieties, which are fine-grained mixtures of red felspar and green hornblende, with very little quartz or mica. A vein or mass of this kind occurs in Dunmore Hill, near the Monument, chiefly composed of red crystalline felspar*.

Some of the effects of the syenite on the slate near it are very interesting. It appears occasionally to send veins of considerable extent far into the midst of the slate mountains, and finer veins are seen ramifying through the slate irregularly in various directions. On the position of the slate it does not appear to have produced much change, as the beds near it are on the whole conformable in dip and strike to those more remote from it. More marked is the change in the mineral character of the rocks as seen in tracing them along the Lednock from Comrie to the vicinity of the syenite. As they approach the igneous rock the slates gradually become harder and more crystalline. Then lenticular masses of red felspar and quartz, like a binary gneiss, become intermixed with layers, more or less continuous, of the blue slate, till at length the whole rock is converted into a fine-grained gneiss. Even the coarser greywackes are so altered in aspect as, in many places, to be readily mistaken for the syenite.

11. *Bedding or Cleavage* (?).—In examining the section just described, and other sections in the slates, considerable difficulty is often felt as to the true character of the division-planes seen in them.

* See, for the position of this syenite, Dr. Macculloch's Geological Map of Scotland, or my own Map. It is omitted, along with the other igneous rocks in this vicinity, in the "Sketch of a New Geol. Map," &c., by Sir R. I. Murchison and Mr. Geikie.

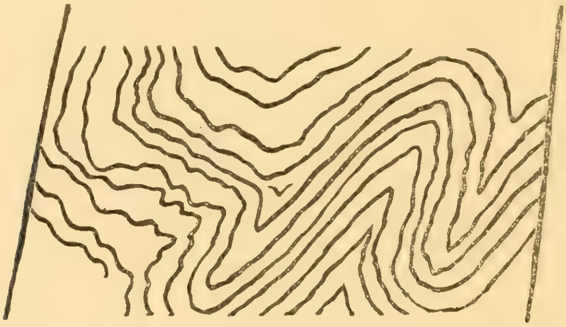
Are these planes of deposition and bedding, or a true slaty cleavage * distinct from, and independent of the stratification? Or are these two structures here coincident? This question is of very considerable interest in relation to the true structure of this locality, and of the Highlands generally. It has too often been assumed, without proof, that all the marked division-lines in the metamorphic strata of the Scottish Highlands are lines of deposition, and much error and confusion has thus been produced. Near Comrie, this question is not easily decided, as the rocks, chiefly exposed in natural sections, or quarries of small extent, furnish few precise data for its determination. Still even there the great regularity in these planes, and the intimate manner in which they pervade the entire mass of the rock, correspond more to cleavage than bedding. Other planes of structure, too, may be observed in these rocks. One set of these show a very predominant dip west by compass, or W. 25° to 30° S., and thus with a strike to N. 30° W., almost at right angles to the direction usually assigned to the strata in this region. This dip is very clearly seen in the coarse greywackes at the foot of Loch Earn, and also in the contorted mica-slate at St. Fillans Church. The latter rock consists of thin, undulating laminæ, dipping N. 27° W., but intersected by other planes dipping W. 27° S. parallel to the bedding of the slates. Similar planes dipping generally W.S.W. are observable in the whole valley from Loch Earn to Comrie, but near the latter place the dip is more nearly west. In the valley of the Lednock a second set of division-planes also occur, but far less regular in position.

The slate-quarries wrought in the Aberuchil Hills, in Glen Artney, to the south-west of Comrie, offer better evidence on this question. These slates are of a light bluish-grey colour, with a fine granular, almost compact texture, occasionally becoming fibrous or minutely crystalline. The cleavage is very distinct, so that the slates appear scaly, or as if made up of very flat and thin lenticular plates. The cleavage is cut obliquely by other planes, some very distinct, others little more than mere striæ, or lighter and darker lines. Where very numerous and close, these give the slates a glossy, fibrous aspect. The more distinct lines are readily traced in hand-specimens, and appear as great curves on the exposed faces of rock in the quarry. They do not intersect the cleavage at any fixed angle, but range from 15° to 45°, and 60° in some instances which I measured. These curved lines seem to me to represent the planes of deposition, whilst the slates are wrought on the true slaty cleavage. The dip of the cleavage is N. 12° to 27° W., thus parallel to the foliation of the

* It has been affirmed that true slaty cleavage does not exist in these metamorphic strata. Mr. D. Sharpe had great merit in directing attention to its occurrence in many parts of the slates, though in some points going further than I can find good reason for following. (See Quart. Journ. Geol. Soc. vol. viii. p. 126, and Phil. Trans. 1852, p. 445.) In the Quart. Journ. Geol. Soc. vol. xv. p. 113, I described this structure in the slates of Easdale and Oban, where a marked parallelism in the cleavage is combined with remarkable convolutions in the beds. Compare, for cleavage in the Aberdeenshire slates, Rep. Brit. Assoc. for 1859, p. 118.

slates at Comrie, and proving that it too is cleavage and not stratification. The position of the other planes is less definite from their curvature, but they seem on the whole to dip S.E., and the large rock-masses in some of the neighbouring hills appear also to dip in that direction. The subjoined figure (fig. 7) may give some imperfect idea of the contortions in the beds in one part of these quarries. The borders, represented as seen in the quarry, are nearly in the line of cleavage.

Fig. 7.—*Contortions in Slate, Aberuchil Quarry.*



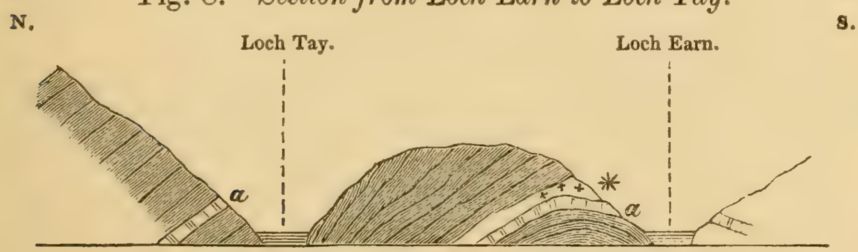
On the whole, therefore, I conclude that the chief division-planes seen in the slates near Comrie are those of cleavage, and not of deposition. The dip of this cleavage is predominantly N. 10° W., and the direction W. 10° S. to E. 10° N., and thus oblique to the general course of the slate on the south flank of the Grampians. The strike of the beds, as marked by the other division-planes, N. 30° W., with a S.W., or more rarely N.E. dip, is still less conformable to the usual course of the slates. This deviation may perhaps be caused by the intrusion of the Glen Lednock syenite, though, as stated, it appears to have exercised no very marked influence on the position of the slates *.

12. *Mica-slate of Loch Earn.*—The relation of the clay-slate to the mica-slate formation is not very clearly shown in any of the sections I examined in Strath Earn. Mica-slate appears near St. Fillans Church, but soon again gives place, higher in the valley, to clay-slate and greywacke. This mica-slate, as already noted, besides a very distinct foliation, much twisted and contorted, as is common in mica-slate, shows also other division-planes parallel to the bedding of the clay-slates. Mica-slate predominates along the north bank of Loch Earn, but the rocks are much concealed by wood and vegetation, and the strata greatly disturbed, probably by intrusive greenstones. So irregular are the beds, that at first it seems almost impossible to discover any dominant dip or direction. On further examination, however, the direction E. 22° N. comes out as the average result of the whole; or, excluding a few dips nearly at right angles to the others, a mean direction of E. 40° N., with a

* The strike of these beds is thus parallel to that of the gneiss on the N.W. coast of Ross and Sutherland, which it has been supposed to characterize as an older group; but see my paper, Quart. Journ. Geol. Soc. vol. xvii. p. 110.

preponderance of dips to the south, but nearly balanced by dips to the north. The dips are frequently at low angles; and, on the whole, I have no doubt that on the north side of Loch Earn the mica-slate forms a marked anticlinal axis, probably the continuation of the axis of highly contorted beds noted above on Loch Long, Loch Lomond, and Loch Lubnaig. The limestone, formerly quarried on the upper part of Loch Earn, appears to lie deep in this series, and is probably overlain by the greater part of the mica-slate, both higher and lower on the loch. This limestone is large-grained, crystalline, and of a grey, or rather mixed white and black colour. It is wholly unlike the Leny limestone near Callander, but closely resembles some of the limestones in the mica-slate of Cantyre. The limestone is also wrought at Edinample, on the south side of Loch Earn, and also runs N.N.E. for some miles up Glen Vech. The dip, generally at low angles, varies, however, even in the main quarry, from N. 57° W. to S. 67° W. The limestone seen on the south side of Loch Tay, also in the mica-slate, is probably the continuation of this deposit, whilst the beds on the north side of that lake, dipping below Ben Lawers, are the same series brought up by a fault*. This view is represented in the diagram, fig. 8.

Fig. 8.—*Section from Loch Earn to Loch Tay.*



a. Limestone. * Trap.

As already stated, the relation of the clay-slate to the mica-slate is not clearly exhibited in any single section. At the foot of Loch Earn, near St. Fillans, the clay-slate and greywacke have a very constant dip W. 32° S., and consequently a strike N. 32° W. This, as formerly noted, is the general direction of the stratification in the slates, and nearly at right angles to the direction just deduced for the mica-slate (E. 22° N. or, better, E. 40° N.). This strike of the mica-slate more nearly corresponds with the strike of the other set of planes, or the foliation of the clay-slate, which we found E. 10° N., but still deviates from it, on what I consider the better determination, by 30°. Besides, whilst the dip of the mica-slate is predominantly to the south, that of the clay-slates is very constantly to the north. We must therefore conclude that in Strath Earn the mica-

* In my Guide to the Geology of Scotland, p. 170, I stated that "Loch Tay lies in a valley of elevation;" and Sir R. I. Murchison says that it "lies on an anticlinal fold" (Note to New Sketch-map, p. 17). In the section on my Geological Map of Scotland, the strata on both sides of the loch are represented as dipping N.W. This is the result of my observations round Killin, where that section crosses the valley of Loch Tay.

slate is a distinct formation from the clay-slate, separated from it both by its lithological and physical characters and its geological position and relations.

Before leaving this vicinity, some notice must be taken of the veins of trap which form a most striking feature in its geology. Several of them are seen near Comrie, as in the bed of the Lednock and on the road to the Melville Monument. In this line three, or, probably, four of these dykes occur, generally consisting of black, columnar basalt, decomposing in globular concretions. Their direction is E. and W. by compass, or a little to the south of east (E. 17° N. true), and they often show an inclination (60° to 90°) to the north. Their breadth varies from 20 to 30 yards, but they run for great distances nearly in the same direction; some of those in the Lednock, near Comrie, crossing the valley of the Earn two miles further up, and then running into the Aberuchil Hills beyond. On Loch Earn similar dykes, chiefly of grey greenstone, are common with a parallel direction, and probably pass by Loch Rattachan into the upper valley of the Lednoch, where similar E. and W. trap-dykes again occur. We might be disposed to connect these dykes with the earthquake-phenomena so common at one time near Comrie*, were it not that similar and nearly parallel dykes traverse the whole chain of the southern Grampians from the east coast, near Aberdeen, to the west coast of Bute and Cantyre.

13. *Dunkeld and Blairgowrie.*—Further to the north-east, near Birnam and Dunkeld, the clay-slate and greywacke also dip towards, and apparently under, the mica-slate. It was this curious appearance which induced me many years ago to state that "the strata seem in some places to have been completely reversed†." I again drew attention to this relation of the strata in 1858, observing, however, that "The very distinct cleavage of the [clay-] slate, obscuring the stratification and often mistaken for it, makes it very difficult in many places to determine the true position of this rock"‡. A similar section is seen on the Ericht, above Blairgowrie, in the lower part of Glen Shee. Here the Old Red Conglomerate, broken through by trap-rocks, is beautifully exposed in the precipitous gorges in the pleasure-grounds of Craighall. Further up, the river traverses the clay-slate, quarried near Cally Bridge, and dipping north-west towards the mica-slate. Probably a fault intervenes between the two formations, but I have not examined the district so as to speak with confidence.

* A register of the time of occurrence and the direction of these earthquake-shocks was kept by Mr. Patrick Macfarlane, of Comrie, whose kindness in showing me the very ingenious apparatus for marking the intensity and direction of their motion (some of it his own invention) I take this opportunity of acknowledging. The fullest account of them is given in some valuable papers by Mr. Milne-Home, in the Edin. New Phil. Journ. vol. xxxi., &c. Compare Geol. of Scotland, pp. 257, 258. They have recently become rare, or, rather, have ceased, to the great relief of the natives, who found that they repelled strangers from visiting one of the most picturesque localities on the outskirts of the Grampians.

† Guide to Geol. of Scotland (1844), p. 169.

‡ Note on Geol. Map of Scotland, p. 3.

A similar relation occurs at the extreme north-east termination of the chain between Stonehaven and Aberdeen, in the section on the sea-coast described by me in a paper formerly read to the Society*. Referring to it for further details, I shall now make a few general remarks on the sections described.

14. *Relation of the Old Red Sandstone.*—The first point I would notice is the relation of the Old Red Sandstone to the primary or metamorphic strata. Some years ago I showed that in Cantyre the Red Sandstone rests conformably on the mica-slate †, and has, in part at least, been elevated along with it. It is therefore not improbable that these deposits are among the oldest unaltered red conglomerates, and distinct from other red sandstones that rest on them. On the mainland from Loch Lomond to Stonehaven the sandstones are separated from the slates by a great line of fault; and I do not remember any place where the sandstones are seen resting immediately on the older rocks. Very often, as in the Comrie section, a great intrusion of trap intervenes, and, though less marked in other localities, a band of igneous rock might probably be traced almost continuously from sea to sea. Near the line of junction the sandstone has been forced up at a high angle, and dips away from the primary strata. It is often a hard, coarse conglomerate, but mixed with finer beds, and in many places forms a range of lower hills skirting the great Grampian chain. The position of the sandstone implies that the strata forming the primary mountains on the north have not merely been elevated, but have undergone a great lateral expansion, or pushing out to the south-east‡.

15. *Clay-slate and Mica-slate.*—The relation of the clay-slate to the mica-slate is more complex and difficult of explanation. In Cantyre clay-slate does not appear, having, as it were, been split off from the mica-slate by the granite-eruption of Goatfell, in Arran. Further north-east, as formerly stated, the two formations run side by side along the whole southern base of the Grampians. But in Bute and on the Gareloch both formations dip S.E., and the clay-slate rests on the mica-slate almost or altogether conformably, and at low or moderate angles. On Loch Lomond the two formations are nearly vertical, but both have still a southerly inclination, so that the clay-slate continues to rest on the mica-slate. At Callander both formations dip north, and now the clay-slate apparently below the mica-slate. At Comrie the two formations are unconformable, and both, perhaps from the intrusion of the syenite, have a strike oblique to their ordinary course. At Dunkeld, Blairgowrie, and other places, to Stonehaven, the clay-slate again dips north, towards, and apparently under, the mica-slate. There is thus a most remarkable anomaly in the two portions of the chain. The clay-slate, which at the western extremity covers the mica-slate, and is thus the newer formation, is at the eastern end covered by it, and is there apparently

* Quart. Journ. Geol. Soc. vol. xi. (1855) p. 544.

† Nicol, on Geology of Cantyre, Quart. Journ. Geol. Soc. vol. viii. (1852) p. 410.

‡ Nicol, on Eastern Grampians, Quart. Journ. Geol. Soc. (1858) vol. xi. p. 549.

the older. It seems a ready solution of the difficulty to declare both formations identical, and to affirm that there is no normal order or arrangement in them. This, however, is a mere evasion, not a solution, of the question. The mica-slate and clay-slate are too distinct to be thus conjoined; and Dr. Macculloch, who first pointed out (more strongly, I suspect, than facts will warrant) their alternations and transitions, fully admits their claims to be considered distinct geological formations. Besides, the difficulty, evaded in words, really recurs in another form. How is it that the more metamorphic portion of the series, which is lowest in one place, is highest in the other? Still more, the bed of clay-slate is known and quarried at so many points along the line from Bute to Stonehaven, that its physical continuity can scarcely be doubted; and the question recurs, how is it that this bed, which in the west forms the highest part of the series, appears in the east as the lowest?

In further considering this curious phenomenon, the first point for inquiry is, what is the normal order of the two formations? Is the clay-slate regularly the upper or the lower deposit? The analogy of other localities leads us to believe that the clay-slate is the higher and newer formation; and the lower inclination and more regular dip of the beds in Bute and on the Gareloch confirm the view that the strata there are in their normal position. The reversed position, therefore, seen at Callander and other points to the north-east must be abnormal. We thus again return to the second question, How has this peculiar position of the clay-slate been effected? Now I am inclined to regard this infraposition of the clay-slate as, in part, only apparent. Besides the great fault intervening between the red sandstone and the clay-slate, other faults, approximately parallel to it, run through the clay-slate, along which the dykes of trap and other igneous rocks have found their way to the surface. The primary strata have thus been divided into longitudinal sections, and each section having been tilted up from the south, the rocks all dip north, towards, and apparently under, the centre of the chain. But at other places, and especially at Callander, a real infraposition of a portion of the clay-slate takes place, caused I believe by a complete folding over or reversal of the beds. The first portion of the strata in the Pass of Leny has been raised up from the south, and dips normally to the north-west. Near the foot of Loch Lubnaig there is a fault, and immediately beyond it the whole strata have been folded over, so that the clay-slate comes to dip under, or rather to be folded up in, the mica-slate. This change has taken place in the country to the south-west, and, it would appear, in a gradual manner, the strata rising from a dip of 40° or 50° on the Gareloch to 80° or 90° on Loch Lomond, and at Callander being turned completely over to the south.

There are two subsidiary facts supporting this view of these relations. First, the highly inclined position of the conglomerate and red sandstone proves, as stated above, that they have been acted on by a force from the north-west, not merely raising up the beds, but pushing them in a south-east direction,—that is, such a force as the reversal of the beds on the north-west supposes. Second, the mica-slate also shows that it has undergone an action conformable to this supposition. The enormous twisting and contortion of the mica-slate has long been considered as one of its most characteristic features; but it has been seldom observed that there is within these beds a similar twisting and contortion of the minuter laminæ or folia. Not only are the beds, as such, bent and curved, but within these beds a second set of contortions—convolutions, as it were, of another order—have taken place. Now any force acting from below would evidently merely bend or curve the strata, and thus pull out or lengthen their mass, and could not thus convolute or fold up the beds on themselves. Such folds or convolutions imply a force acting on the beds laterally, not vertically; and not raising them up, but forcing the ends or sides together*. Such a force, however, is exactly the one required to fold the mica-slate over on itself and on the clay-slate, and to raise up the red sandstone as seen on the south-east. Were it necessary to assign an agent for this compression, I should point, partly, to the great outbursts of granite in the central region to the north-west, and, as even more influential, to the great compression which the strata must have undergone when taken down into those interior regions of the earth's crust where the chief laboratories of metamorphic action are situated †.

16. *Central Gneiss and Quartzite.*—The next formation we have to notice is the great central formation of gneiss. In this I include most of the quartzite on its margin, as, although distinct in mineral character, these two rocks in this region do not appear to me sufficiently separate in other respects to be regarded as two independent geological formations. This view was stated by me in the note to my Geological Map of Scotland, and this central gneiss, with its associated quartzite and limestone, referred to a newer formation, "not older than the Lower Silurian period"‡. At the Leeds Meeting of the British Association in 1858, I also brought forward sections proving that "in the central region of Scotland, from Aberdeenshire to Argyllshire, the great formation of gneiss, with limestone and quartz-rock, overlies the mica-slate, and does not dip under it as usually represented. In particular, the gneiss of the Black Mount and Breadalbane Highlands appears to form a wide synclinal trough resting on both sides on mica-slate, and thus to be an overlying and younger formation"§. Although these views differed widely from

* This was long ago proved by Sir James Hall's simple experiment—all the more demonstrative from its simplicity.

† A similar view was proposed in reference to the section at the S.E. extremity of the Grampians in my paper in Quart. Journ. Geol. Soc. vol. xi. p. 547. Subsequently (Paper at Leeds Meeting of Brit. Assoc., Proceedings for 1858, p. 96. and Note on Geol. Map of Scotland) I was inclined to regard the clay-slate as normally the lowest bed; but the difficulties in the way of this supposition, and further examination of the localities have caused me to revert to my former view.

‡ Note on Geol. Map of Scotland, pp. 2 and 4.

§ See Report of the Twenty-eighth Meeting of the British Association, held at Leeds, 1858, Transactions of the Sections, p. 96; also Report of the Twenty-ninth Meeting, held at Aberdeen, 1859, Transactions of the Sections, p. 119.

those then entertained by the highest authorities in Scottish geology, I have as yet seen no reason to recede from them, and shall now bring forward some of the facts on which they are based. I must, however, pass over several sections which, though I regard them as favouring my views, I have not yet been able to examine thoroughly.

17. *Tyndrum and Black Mount.*—The relation of this gneiss to the mica-slate is well seen between Tyndrum and the Black Mount. Near Killin, at the head of Loch Tay, the strata, principally mica-slate, mixed with hornblende-slate and limestone (the latter, as already stated, probably the continuation of the beds seen on Loch Earn), dip at low angles (30°–40°) to N. 25° W. The same dips, though more irregular, continue along Glen Dochart to the limestone near Crianlarich, where there is probably a synclinal fold. From this place to Tyndrum the general dip of the strata is to the S.E. Round Tyndrum the rocks are true mica-slate, intersected near the mines by a vein of quartzose hornstone or felspar-porphyry running about E. 30° N. Following the road to the north-west, the mica-slate is well seen, intermixed with a few beds of quartzite, and still dipping at 30° or 40° to S. 40° E. A little beyond the village there is a dyke of greenstone running about E. 10° S. At the top of the ridge the dip becomes first easterly, and then gradually folds over to the north and north-west*. In passing down the glen to Urchay Bridge the rock changes to gneiss, and is seen distinctly resting on the mica-slate on both sides of the valley. No true quartzite intermediate between the gneiss and the mica-slate, as represented by Dr. Macculloch, was seen in this line of section. On the hills to the south-west great protruding veins of quartz occur, which Mr. Thost informed me range for great distances across the country. Beyond the Urchay, the gneiss continues by Inveroran and King's House to the top of Glencoe, and, though often concealed in the low moors, has its position well marked in the mountains on the west. This section left no doubt on my mind that the gneiss forming the great central region of the Black Mount overlies the mica-slate of Tyndrum and Loch Tay, and thus, as stated, is a newer formation†.

18. *Glen Shee and Braemar.*—The same relation of these two formations appears to me to exist in the valley of the Tay and its tributaries; but as I have not been able recently to re-examine some of the sections there, I shall pass to the valley of Glen Shee (fig. 9), where the connexion of the mica-slate of the southern Grampians to the gneiss of the central mountains is well seen.

The greater part of this glen lies in the mica-slate, the beds showing a general inclination to the north, though much concealed

* Thus, my observations at intervals to beyond Urchay Bridge gave 30° to E. 17° N.; 22° to E. 27° N; 37° to E. 37° N.; 10° to E. 52° N.; 20° to E. 77° N.; and 30° to N. 27° W.

† It is right, however, to mention that, in their "Sketch of a New Geol. Map of Scotland," Sir R. I. Murchison and Mr. Geikie make it an older formation. It will be seen that the tract of country coloured by them as *b*′ 1+ in this place nearly corresponds with the outline of the gneiss and quartzite as drawn by Dr. Macculloch and myself. The continuous limestone-zone, laid down in their map as overlying the gneiss, was not observed by me.

in the lower valleys by detritus and occasional convolutions. North of the Inn at the Spittal I found a black carbonaceous shale, in highly contorted beds, but dipping 60° to N. 12° W. This rock closely resembles the black shales of Oban and Easdale, described by me in 1858*. It appears to overlie the mica-slate, and thus confirms the view that the clay-slates are the higher and newer formation†. The part of the section, however, to which I wish specially to refer lies further up the glen, and on to the Braemar Mountains. The slates continue up Glen Beg to the foot of the steep pass over the Craig Well. Here a bed of bluish-grey limestone, with numerous veins of calc-spar, crops out, dipping at a high angle to the north-west. This is overlain by beds of gneiss passing up into quartzite, which forms the higher portion of the mountains. Near the summit-level of the ridge veins of red felspar-porphyry are seen, running from E. 30° to 35° N. to W. 30° to 35° S. Further down, near Ben Turk Bridge, a grey micaceous limestone appears, dipping at 70° to S. 45° E. From this place to Braemar the lower part of the valley consists of gneiss, with veins of granite, but overlain by beds of blue or grey compact limestone, and this in turn by a white quartzite or altered sandstone, often much iron-tinged. The whole of the formations seem to be conformable, and though occasional high angles occur, yet taken generally they dip at low angles to the south-east. The gneiss appears merely the more metamorphic lower portion, and the quartzite the less metamorphic and higher portion of one great formation. Further north, beyond the River Dee, as shown in the section, it rests, still at very low angles of from 5° to 10° or 15°, on the granite of the Ben-Mac-

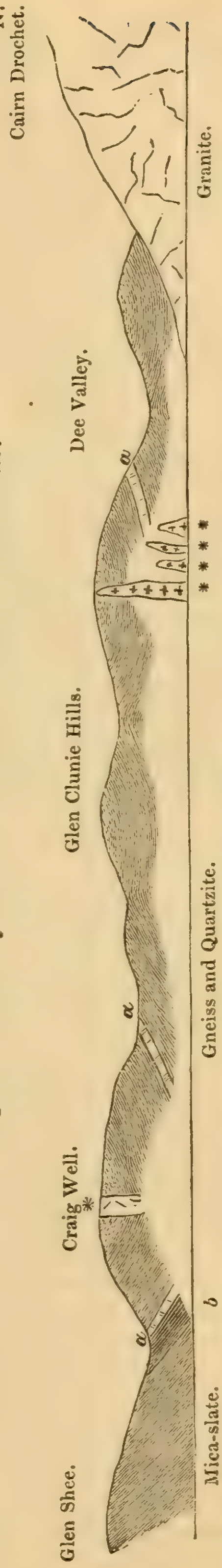


Fig. 9.—*Section from Glen Shee to Braemar Mountains.*

a. Limestone. *b.* Black carbonaceous shales. * Dykes of porphyry and trap.

* Quart. Journ. Geol. Soc. vol. xv. (1858) p. 111.

† I described this rock at the Meeting of the British Association in Aberdeen in 1859 (see Report of that Meeting, Transactions of the Sections, p. 118), and exhibited some fine specimens presented by Mrs. Farquharson of Invercauld. It has since formed the subject of a paper by Sir R. I. Murchison and Mr. Geikie, Quart. Journ. Geol. Soc. vol. xvii. (1861) pp. 226 & 232.

dhui and Cairn Gorum Mountains. So little does it appear to have been affected by these great igneous masses, that I have been almost disposed to believe that it may have been deposited on the granite at a period subsequent to its consolidation. Be this as it may, there is no doubt that this great formation of gneiss, limestone, and quartzite rests on the mica-slate of the southern Grampians, and is thus a newer formation. I have also no doubt that it is a continuous portion of the same great gneiss and quartzite formation which we have seen in the Breadalbane Highlands overlies the mica-slate of Loch Tay and Glen Dochart.

19. *Clay-slate of Loch Creran.*—I shall not at present follow this series of deposits north into Aberdeenshire and Banffshire, but turn now to its relation to the slate-rocks of the south-west. These are by no means so clearly seen as might be wished, probably in consequence of the great eruptions of igneous rocks of diverse kinds and of very different ages. In the south-west it abuts against the granitic mass of Ben Cruachan. Near Dalmally and Loch Awe, this mountain is skirted by schistose rocks, but these I regard as belonging to the mica-slate formation more probably than to the gneiss. Beyond this granite mountain-group, in the angle between Loch Creran and Loch Leven, there is a great development of schistose beds, classed partly as clay-slate, partly as mica-slate. A fine section of these beds is exposed near Appin and along the shores of Loch Creran. At Port Appin quartzite appears on the shore and extends north-east along the Linnhe Loch. Generally it is composed of distinct grains of quartz in a finer quartz basis, with a few crystals of iron-pyrites or felspar, the latter well marked by weathering to an opaque, white colour. In some places, however, the quartzite is a mere mass of quartz-veins with no marks of stratification, and in many cases may almost be regarded as a binary granite composed of abundant quartz with a little felspar. Where most distinctly stratified it dips 60° or 70° to W. 20° S., and thus runs in a direction N. 20° W. Proceeding east towards Loch Creran, mica-slate, often talcose, begins, and forms the great mass of the country with very little diversity of character. It first dips E. 35° to 40° S., but, about two miles east from Appin, forms a synclinal, beyond which the dip is very predominantly W. 30° N. at angles ranging from 45° to 60°. The beds are strongly undulated, and in many places show a transverse cleavage or grain. This peculiar character is beautifully seen on the weathered surface of the rock near Creigan Ferry, where it approaches in mineral aracter to gneiss. The two sets of planes dip nearly in opposite directions,—the one at 55° towards N. 52° W., the other 43° towards S. 52° E.; and in another place, the first at 56° towards N. 64° W., the second at 20° towards S. 64° E. The first is probably the true dip, as it is the more continuous, and also as it is parallel to the change in the mineral character of the beds. Great veins of quartz also run along these divisions or bedding. In either case the mica-slate in this locality is unconformable to the quartzite, as clearly shown by the direction of the beds. This is—

In the Quartzite	N. 20° W.	
In the Mica-slate ..	N. 30° E.	
Difference	50°	

The position of the mica-slate has probably been determined by the eruption of the granite of Ben Malugage, one of the northern outliers of the Ben Cruachan Mountains. Round this granite a zone of gneiss is laid down; but I had not an opportunity of examining this wild region so as to speak confidently of its position.

The most remarkable feature in the rocks of this region is the double foliation or structure which they exhibit. Nowhere have I seen this peculiarity more strongly marked in the crystalline strata. In some specimens, layers of a more quartzy nature alternate with others that are more micaceous. In the quartzose layers only one set of lines is seen, which may be regarded as the true bedding. In the more micaceous layers, which on the whole are parallel to the former, there is a second set of lines oblique to the first, and produced by the alternation of folia of mica and quartz. Both sets of lines are of the same nature, produced by the alternation of different mineral substances, and the chief distinction is that the first is more continuous than the second, which is cut off by the quartz-layers even where very thin. In this respect they resemble the bedding and false bedding in ordinary strata. These lines differ essentially from cleavage, either in a rock or simple mineral, inasmuch as their number and position are definite, whereas in cleavage (marking only a minimum of coherence in a certain direction) the mass separates along parallel planes indefinite (or rather infinite) in number and position. This peculiar double structure is not confined to the mica-slate of this locality, but is well seen also in the similar beds near Loch Leven on the north, and Loch Craignish on the south. It must form an element of much importance in all speculations on the origin and history of the rock. The two structures so closely correspond, that we can scarcely doubt that the cause producing the foliation of the rock on the great scale has also produced this cross foliation on the small scale. If the one be an effect of crystallization, or of mechanical action, subsequent to the deposition of the beds, so must also be the other. It is also of consequence as proving that the foliation of the mica-slate may not in all cases coincide with the bedding, but be more or less oblique to it. So much is this the case, that occasionally the inner foliation is highly convoluted or twisted, whilst the outer planes of stratification remain more nearly even or plain. From not observing this fact, many inaccurate determinations of dip and direction have been given.

20. *Loch Leven and Glencoe.*—North of Loch Creran lie the valleys of Loch Leven and Glencoe, so well known for their wild and magnificent scenery, and so interesting to the geologist from the variety of their igneous rocks. To a superficial observer, merely walking along the roads, the sections may seem simple enough; but on following them out into the upper parts of the mountains, where the rocks are more fully exposed, many anomalies appear. Therefore, though

I have examined this neighbourhood repeatedly, returning to it again and again in different years, many points in its structure still appear very obscure. In the slate-quarries on the south shore of Loch Leven, the principal division-planes dip at 65° to W. 28° S., and a corresponding dip is seen in some of the other rocks in the vicinity. This plane, however, I am inclined to believe, is, in the slates, that of the cleavage, whilst the true bedding, though very obscure, dips nearly east. Further up the loch, limestone is quarried, but the dip is very obscure; and beyond it, towards the foot of Glencoe, mica-slate is seen very highly undulated, but probably dipping S.W. towards and below the clay-slate. The mountains west of the slate-quarries consist of quartzite intermixed with gneiss, mica-slate, and limestone, but I found the dips so variable that no fair average could be deduced. This is not wonderful when account is taken of the enormous protrusions, in this region, of igneous rocks —granites, porphyries, and greenstones, of almost endless diversity in mineral character and age. On the north side of Loch Leven the clay-slate dips to S. 40°–50° E., but again probably on the cleavage. Taken as a whole, this region seems too highly disturbed to throw much light on the relations of the formations. This is specially true of the quartzites, of which some portions at least appear rather a binary granite of quartz with a little red orthoclase, than a stratified rock. It prevails especially in the higher parts of the mountains, where the narrow ridges, much steeper and scarcely broader than the roof of a house, covered with the small loose angular fragments among which no vegetation takes root, shine in the sun almost like drifted snow.

21. *Fort William and Ben Nevis.*—The vicinity of Fort William and Ben Nevis also presents some interesting sections. The lowest rock seen on the east side of the Great Glen is probably the gneiss near Nevis Bridge, which dips at 60° to S. 10°–15° E., and runs apparently under the granite of the mountain. The shore of Loch Eil, south from Fort William, consists of mica-slate alternating with clay-slate and talc-slate, and dipping generally at 60° or 70° to S. 50°–55° E. In a few places the beds dip N.W., probably near a fault or anticlinal axis, running nearly in the direction of the loch. These beds pass north towards Ben Nevis, where, at the foot of the mountain, similar slates dip 65° towards S. 57° E. below the granite, but separated from it by veins of the black porphyry which forms the centre prism of the mountain. This porphyry, as has long been known, is the newer eruptive rock, not merely piercing the granite in mass, but forming irregular branched veins through it * as in fig. 10. Generally, however, the strata do not extend far north of the Nevis River, the slope of the hill consisting of granite intermixed with numerous veins of red and black porphyry. The south

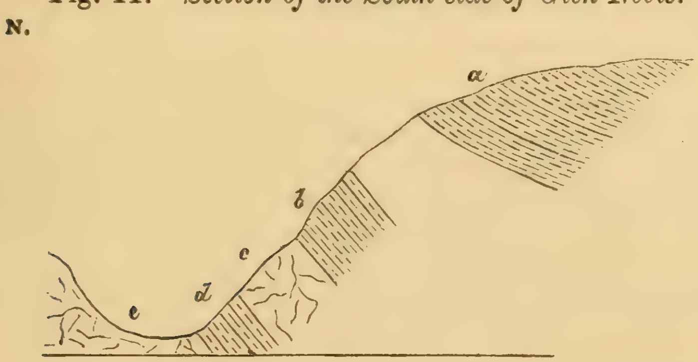
* Nicol's Geology of Scotland, p. 164. Here also I described the singular brecciated character of this porphyry as shown on the weathered surface. So marked is this character, that one is almost induced to speculate on the possibility of this rock being a huge fragment of some old stratified deposit caught up in, and metamorphosed by, the granite.

side of the glen consists of gneiss dipping 50° or 70° to S. 40°–50° E. Further up, the red granite, still full of veins of porphyry, crosses the stream, and is well exposed at a small fall in the river. Still higher the valley contracts, and gneiss forms the lower portion on both sides; the beds much contorted, but dipping on the whole about 70° to S. 42° E.

Fig. 10.—*Porphyry Vein in Granite, Ben Nevis.*
(Length about 30 feet.)

The lower portion of Glen Nevis thus consists essentially of gneiss, dipping, more regularly than might have been expected in the vicinity of such a mass of granite, to the S.E. The mountains on that (the south-east) side of the glen appear generally to be capped by quartzite, which ought thus to overlie the gneiss. A great part of this region, however, is now a mere desolate deer-forest, without house or path, so that even in the finest seasons—and these too rarely occur for the geologist—it is difficult of examination. In one of the ravines on the south side of the Glen the following section was observed (fig. 11).

Fig. 11.—*Section of the South side of Glen Nevis.*

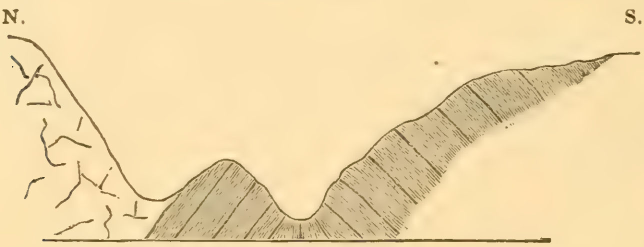


a. Quartzite. *c.* Red Granite *e.* Red Granite.
b. Gneiss. *d.* Mica-slate and Gneiss.

The bottom of the valley is red granite—a branch of that in Ben Nevis. It is covered by a fine-grained gneiss or hornstone, probably altered by the igneous rock, which dips at 60° to S. 27° E., and above passes into chloritous mica-slates, some dark, others light grey, and also dipping at 65° to S. 27° E. These slates are in turn covered by a bed of red granite, perhaps from 100 to 150 yards wide, which runs along the face of the southern hills, and in another ravine is traversed by a vein of the dark Ben Nevis porphyry. The granite is again succeeded by fine-grained, grey gneiss much contorted, but dipping south-east, probably at a high angle. Still higher, beds of quartzite appear, dipping at 10° to S. 47° E., and thus, though the immediate junction is not seen, apparently unconformable to the gneiss. In others of the surrounding hills the quartzite, readily recognized by its white colour, also appeared to rest unconformably on the grey gneiss, but I was prevented from determining this point by further examination.

About ten miles from Fort William, Glen Nevis is crossed by a great ridge of rock, through which the river forces its way in a series of narrow gorges and rugged cascades. This ridge must have been cut through by the river in some very different condition of the country, as the valley beyond it lies at a much lower level than its summit, and opens out to the upper part of Glen Treig, by what would be its natural drainage. Above this ridge a large branch of the river enters from the south, forming a fine waterfall over an overhanging cliff. In this place there is another interesting section, represented generally in fig. 12, though from the incessant rain and mist I was again prevented following out all its details.

Fig. 12.—*Section of the upper part of Glen Nevis.*



On the north-west is the granite dome of Ben Nevis, pierced by the porphyry prism that forms the summit of the mountain. To this succeeds a ridge of mica-slate, dipping at 70° to N. 47° W., and thus apparently below Ben Nevis. Both in mineral character and dip these beds correspond with the mica-slate seen in Glen Spean, above the opening of Glen Roy. The valley forms an anticlinal, as the strata on the other side dip about 45° to the south, and in the higher part of the mountains appear to be again covered by the quartzite.

22. *Glen Spean.*—In Glen Spean, on the north side of Ben Nevis, a similar series of rocks is seen, but with some diversity in the details. In the lower part of this glen the mica-slate dips generally to S. 50° E., and contains one or more beds of limestone, which are quarried in some places, and is also intersected by veins of red felspar-porphyry and granite. Near the mouth of Glen Roy the dip changes, and the mica-slate further up dips 55° or 60° to N. 50°–55° W. These beds appear to correspond to the mica-slate seen in the upper part of Glen Nevis. Some of the lofty mountains, however, on the south, towards Loch Treig, consist of gneiss, which I

am inclined to regard as, in this locality, a lower formation than the mica-slate, and thus not connected with that in the central region.

The whole of this western region, however, is so much disturbed by igneous intrusive rocks, and the wild nature of the country, with the uncertainty of the climate, renders continuous geological investigation so difficult, that few certain conclusions can be drawn from the sections as to the relations of the stratified masses. Still, on the whole, I adhere to the view stated by me in 1858, that the quartzite and gneiss of the Black Mount and Breadalbane Highlands form a wide synclinal trough resting on both sides on mica-slate, and thus is an overlying and younger formation. On the other hand, the gneiss near Ben Nevis, and probably also that towards Loch Treig, appears to me an older formation. So also the great gneiss-formation on the west side of the Great Glen. This singular depression is evidently the line of a great fault, so that the connexion of the strata on its two sides is very uncertain. On the upper Loch Eil beyond Corpach the gneiss dips to the west, but this is clearly connected with the granite which forms the hills along the west side of the Lochy.

The mica-slate of Loch Creran, with some similar strata seen in other parts of the western Highlands, is probably also a peculiar formation, distinct both from the ordinary mica-slate and also from the clay-slate. In regard to age, I conjecture—for with so few certain facts little more is possible—that it is younger than the mica-slate, and older than the clay-slate.

The clay-slate, limestone, and quartzites of Appin and Balahulish are, we have seen, unconformable to the mica-slate, and probably an overlying formation. I still conjoin them with the slates of Easdale and Islay, though the black carbonaceous beds so common at Easdale and Oban are not seen at Balahulish, and the deposits also differ in other respects. As in 1858, I am still inclined to regard these rocks as the newest deposits in this region. I then stated that these slates were the equivalents of the Lower Silurian (Skiddaw Slates)*, and Sir Roderick I. Murchison has since expressed his concurrence in this view. These slates and limestones thin out north of Loch Leven, and do not seem to be represented near Ben Nevis or further north. The partial beds of limestone quarried in Glen Spean belong to the mica-slate, and thus to an older group.

23. *Geological connexion of the Grampians with other parts of the Highlands.*—Before concluding this paper, I may be allowed to say a few words on the connexion of these beds with the strata in other parts of Scotland. In such comparisons we are deprived of one great means of identification of distant formations by the entire want of organic remains. Except some obscure indications noticed by me in a former communication, no traces of organic beings have ever been mentioned from these beds. We are thus thrown entirely on the mineral character of the rocks and their geological relations for any conclusions we may form in reference to these points. There is no doubt that ultimately all Geology of the primary rocks must depend on these characters as the basis of its classifications; but as there is reason

* Quart. Journ. Geol. Soc. vol. xv. (1858) pp. 112, 116.

to believe that rocks with nearly identical mineral characters may occur in more than one period, and as the geological connexion of the strata is often obscure, many difficulties have still to be encountered in such investigations.

There seems little doubt that the gneiss of Ben Nevis and the Great Glen forms a continuous formation with the great mass of this rock represented, in Dr. Macculloch's Geological Map and my own, as running from Inverness-shire through Ross and Sutherland to the northern extremity of Scotland. In a former paper I have shown that there is no reason for separating this gneiss from that of the north-west coast of the mainland or of the Long Island. The chief distinctions arise merely from the greater predominance of intrusive igneous rocks, granites and syenites, in the latter, and recur in the eastern gneiss wherever these igneous masses appear. The mica-slates of the south have also their representatives in these north-western regions, where some of the mica-slates, like the thin, even-bedded varieties on the Kyle of Tongue, contain garnets. Others, like those of Ben Hope and Strath Oykell, have more resemblance to the talcose varieties on Loch Creran. As the mica-slates in the south are a distinct formation from the gneiss, it is probable that this may also be true of those in the north, where their relations have been less studied*.

The overlying red sandstones and conglomerates of the west coast ("Cambrian" of Murchison) have no representative, so far as yet ascertained, in the South-west, unless some portions of the red sandstones in Cantyre belong to the same formation. The quartzites and limestones that rest on them are Lower Silurian, according to Mr. Salter's determination of the fossils found in them by Mr. Peach and others. As I have ascribed the same age to the slates of Easdale and Oban, it would follow that the connected quartzites in the south-west are, to a certain extent, of the same age with those in the north-west. This view of the identity of these quartzites, embodied in Dr. Macculloch's Geological Map and my own, has also been adopted in the recent map of Murchison and Geikie. As both formations are the uppermost in the series, there is, of course, no improbability in this view; and as this Lower Silurian Period was evidently of very long duration, and in other regions contains a great diversity of deposits, the marked difference in some of the phenomena cannot be held as invalidating it. The most remarkable of these diversities are, first, the entire absence in the south of the great underlying red sandstone and conglomerate group of the north. But, as I pointed out in 1856, this red sandstone is even in the north a very limited formation, not extending far to the east, where the quartzite in many places appears resting immediately on the gneiss,

* It is necessary to mention this diversity, as Sir R. I. Murchison appears to have overlooked the statements to this effect in my former papers, and consequently represents me as maintaining the identity of the gneiss of the west coast with certain mica- or chlorite-slates. They are identical only so far as both belong to the great series of metamorphic formations inferior to the red sandstone and quartzite; but, both in my papers and map, they are represented as distinct formations, each with its own peculiar features, and, it may be, of widely different age.

without its interposition. The diversity in mineral character is of less importance, though still very considerable. It may in some measure have arisen from the far less extent of metamorphic action to which the sandstones (quartzites) in the north have been exposed, many portions of them being not more altered or more crystalline than the ordinary sandstones of the Coal-formation. To this more powerful metamorphic action we may also ascribe the more marked diversity of, and the entire absence of organic remains in, the southern limestones and quartzites,—a want which prevents us from feeling perfectly assured of the identity of these two formations. Whatever view we may take of this question, it is, however, certain that the quartzites and slates of the south-west cannot be of more recent date than the lower portion of the Silurian. As the gneiss and mica-slate are inferior and older formations, we are thus compelled to carry them back into a still more ancient period in the history of the earth. There is indeed nothing in the mere thickness of these deposits to prevent us regarding them, as I was formerly inclined to do, as the altered representatives of the lower portion of the Silurians of the south, as the clay-slates were of the upper portion,—but the break in the conformity of the formations, seen in many places, is opposed to this view. The analogy of nature too in other regions, where the lowest Primordial zone of life rests unconformably on upturned, and evidently far more ancient, crystalline or metamorphic strata, strengthens this view of the great antiquity of the gneiss and mica-slate of the Scottish Highlands. This is especially true of Scandinavia, in which we find a great gneiss-formation identical in many respects with that of Scotland, and probably at one time even in geographical connexion with it. The conviction has thus been forced on me, that in the north of Scotland there is a much longer series of formations—deposits dating from a far more early period in the history of the earth—than might at first be imagined. Thus, as our knowledge of the geological structure of Scotland becomes more precise, we find that, as in every other field of geological science, the duration of the earth, as measured by successive phenomena, irresistibly expands, and we are more and more taught to feel how impossible it is to comprise, in the narrow framework of our partial and merely temporary systems, the majestic series of evolving events that have filled up the untold ages which have left their traces inscribed even on the crust of this little globe of earth.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

JANUARY 21, 1863.

Edward Brooke, Jun., Esq., Oakley House, Edjerton, Huddersfield; John Brunton, Esq., C.E., Engineer of the Scinde Railway; Alfred Hewlett, Esq., Mining Engineer, Haigh, Wigan; Thomas Wardle, Esq., Leek Brook, Leek, Staffordshire; and George Worms, Esq., 17 Park Crescent, Portland Place, were elected Fellows.

The following communications were read:—

1. *On the* UPPER SILURIAN PASSAGE-BEDS *at* LINLEY, SALOP. By GEORGE E. ROBERTS, Esq., and JOHN RANDALL, Esq.

[Communicated by the President.]

A ZONE of thin-bedded, often conglomeratic, sandstones, forming the passage-bed between two great formations, is frequently found to include within its series of deposits one or more bands of shell- or bone-breccia. Perhaps the most important of these zones is the one which lies between the mudstones of the Upper Silurian series and the lowest Old Red Cornstone, the most northerly extension of which forms the subject of this paper. This, from the number and variety of its organic contents, may almost be called a formation by itself. The continuance of Silurian forms of life is, however, too strongly marked to permit any division of it from that great series of deposits. On the other hand, its uppermost layers are allied, by physical constitution and fossil contents, so nearly with the overlying

Old Red, that, although this new exposure at Linley adds to our knowledge of the series, it does not, in our opinion, enable us to draw a more definite boundary-line between the Silurian deposits and the Old Red Sandstone.

In commenting generally upon these passage-beds, we cannot choose a more fitting preface than the following passage from 'Siluria':—

"During the accumulation of nearly all the Silurian deposits of Britain, which were characterized by a certain fauna, the bottom of the sea was, to a wide extent, occupied by dark- and grey-coloured sediments. At the close of that period a great change occurred, over large areas, in the nature and colour of the submarine detritus. In and around the Silurian region, for example, the dark-grey mud was succeeded by red silt and sand, the colour being chiefly caused by the diffusion of iron-oxides in the waters" (2nd edit. p. 270).

The characters of this more or less iron-tinged zone have had the careful attention of many geologists, more especially as regards the fossil contents of the lowest and, hitherto, best-known layers, in which the bone-bed of the Upper Ludlow shales is so noticeable a feature.

The important exposures of the uppermost division, in which the rocks described in this paper occur, at and near Ludlow, and at Ledbury, have revealed enough to show it to be by far the more important series of the two, whether we consider it with regard to its greater thickness, variety of mineral composition—indicating an era of more frequent physical changes,—or for containing the remains of more highly organized animals. At Ledbury, Cephalaspid Fishes seem to have been the chief inhabitants of the water; while at Ludlow, remains of *Pterygotus* and other Crustaceans occur plentifully in and near this "upper bone-bed." At Linley, remains of those Fishes known as *Plectrodus, Onchus, Ctenacanthus*, &c., characterize the zone, and no Crustacean remains have yet occurred.

The position of the beds at Linley is shown by sections along the course of Linley Brook, a stream which falls into the Severn at Apley, four miles north of Bridgnorth. Opposite Linley Hall the Upper Ludlow rock is exposed in the sides of a little gorge formed by the stream, the dip being S.S.W. Here it is traversed by two sets of joints, one N.E. to S.W., the other W.S.W. to E.N.E. Lower down the brook, near the "Holly Bush," a more extended section may be obtained. The dip is here 15° to the S.E.

The series exposed in this sinuous gorge ranges from the true Aymestry rock, which forms, in places, the bed of the brook, to the Upper Coal-measures, capped with northern drift and scratched boulders. The coal-seams are but two in number, and of poor quality. One or more beds of jointed freshwater limestone lie among the clays. The exact junction of these coal-measures with the Old Red we failed to discover, though at a point high up the north bank, near the "Holly Bush," the line of fault marked down by the Geological Survey, as dividing the two systems, is traceable in the steeper inclination of the Coal-measure clays.

Fig. 1.—*Sketch of the Upper Ludlow Rocks and the Passage-beds at Linley Brook.*

The numbers refer to those attached to the beds in fig. 2.

In connecting the higher beds of this series with the true Old Red Sandstone, it is worth remarking that the lowest Cornstone of the Old Red at present known occurs interstratified with the plant-bearing grits (*d* in the Linley series) at Trimpley, two miles north-west of Kidderminster. If, therefore, these bands of inorganic breccia have any value as dividers of the series, we have here the proved position of one, relatively to underlying deposits, hitherto most difficult of arrangement.

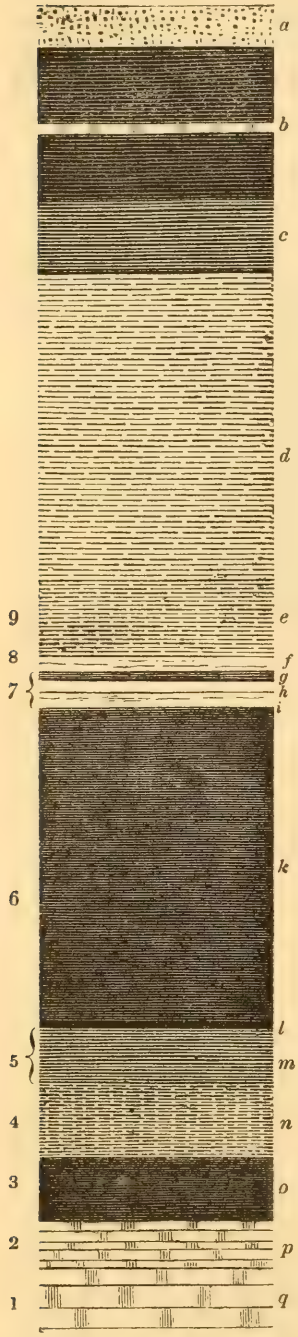
On the fossil contents of the series three observations may be made:—firstly, the abundance of *Lingulæ*, occurring in two conditions—as well-preserved shells upon the surfaces of the shales, and as layers of triturated shells; secondly, the importance of the Fish-fauna of the upper bone-bed, which has yielded the largest spines, yet discovered, of the forms figured by Sir P. G. Egerton from the corresponding bed at the Paper Mill, Ludlow*, together with some fragments of solid bone (ribs?) two inches in length; and, thirdly, the entire absence, so far as we have been able to make out, of Crustacean remains. Even the lower "bone-bed," which has furnished, from its outcrop at Ludlow and all other exposures, such numbers of *Astacoderma*, does not appear to contain a trace of these bodies; for, though subjected to careful scrutiny by Dr. Harley and ourselves, it

* Quart. Journ. Geol. Soc. vol. xiii. Pl. X. p. 289.

yielded little else beside the dermal studs of *Thelodus*, fragments of *Lingulæ*, and a large percentage of ferruginous inorganic grains.

A section of about 80 feet, through the Old Red to the lowest Silurian bed exposed, gives us the following series of deposits*:—

Fig. 2.—*Vertical Section of the Beds exposed at Linley Brook.*



	ft.	in.
a. Northern drift with boulders.		
b. Upper coal-measures, containing a band of limestone.		
c. Red clays, unfossiliferous	6	0
d. Light-coloured grits, with Plant-remains—*Juncites*?, *Lycopodites*, &c. .	20	0
e. Hard micaceous grits, somewhat flaggy, and charged with Fish-remains. (The Upper Bone-bed.)	7	0
f. Flagstones bearing current-markings .	1	9
g. Micaceous sandy grits with *Lingulæ* .	0	11
h. Greenish, irregularly laminated rock with conglomerate	1	0
i. Hard calcareous grit with thickly disseminated greenish grains and many broken *Lingulæ*	1	0
k. Laminated light-grey micaceous and sandy shales	20	0
l. Grey micaceous grit	0	6
m. Micaceous sandy clays, coloured by peroxide of iron	6	0
n. Yellowish sandstones (Downton series) with *Beyrichiæ* and *Lingulæ*, and including two or more ferruginous bands containing large quantities of the dermal studs of *Thelodus*, fragments of *Lingulæ*, and minute crystals of quartz. (The Lower or Ludlow Bone-bed.) Clusters of *Modiolopsis complanata* occur at the base of this rock . . .	8	0
o. Hard calcareous shales with Fish-remains, *Lingulæ*, &c.	6	0
p. Flaggy beds of impure limestones, with *Serpulites longissimus*. (True Upper Ludlow.)	4	0
q. Hard, impure limestone. (Aymestry series.)		
	82	2

* In these sections, *Lingula cornea* ranges up to the summit of the bed *c*.

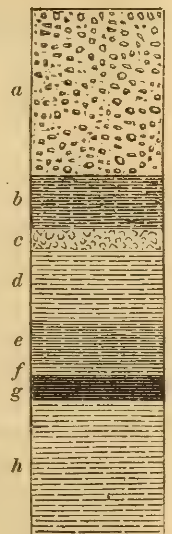
2. *On some* Crustacean Tracks *from the* Old Red Sandstone *near* Ludlow. By George E. Roberts, Esq.

[Communicated by the President.]

I lately received some sandstone-slabs from the Lower Old Red Cornstones, obtained by Mr. Alfred Marston, of Ludlow, which exhibit more clearly than is usual tracks and trails of *Crustacea*. They were obtained from a somewhat noted quarry at Bouldon, a village seven miles north of Ludlow. Mr. Marston has furnished me with the following details of the Bouldon section:—

Fig. 1.—*Vertical Section of the Beds exposed at Bouldon Quarry, near Ludlow.*

	ft.	in.
a. Rough coarse conglomerate; a few Fish-remains (*Pteraspis*, *Cephalaspis*)	5	0
b. Fine-grained sandstone with *Pteraspides*	1	3
c. Rubbly beds	0	6
d. Fine-grained sandstones with *Pteraspides*	1	6
e. Micaceous sandstones	1	0
f. Thin-bedded fine sandstone with tracks of Crustaceans	0	4
g. Fine-grained shales	0	8
h. Lowest Cornstone; remains of Fish and Crustaceans; *Pteraspis* and *Cephalaspis* abundant, *Pterygotus* scarce.		



A zone of fine-grained and thin-bedded deposits, indicating quiescent conditions and shallow water, is thus seen dividing two conglomeratic beds, the lower of which I am inclined to regard as the rock wanting above the plant-bearing bed at Linley, but which is seen to accompany that deposit at Trimpley, in Worcestershire, and elsewhere.

The Crustacean tracks occur as casts abundantly upon the under surface of the thin sandstone-layer, *f*, of the above section.

Of the three or more varieties, the most important in size and distinctness (fig. 2) is a slightly curved trail about $1\frac{1}{2}$ inch in width, formed by two series of oval or, rather, flask-shaped prints, $\frac{1}{4}$ of an inch long, each bearing a number of transverse wrinkles parallel to the direction of the trail. The prints taper inwardly, and have a slight upward curve at the same end. Their distance from each other varies, as also does the height of the cast, but these inequalities may be regarded as results of peculiarities of the condition of the surface which received them.

The indentations made by another Crustacean (?) upon the slabs (see fig. 3) are longer and more sharply ended, and show a nearer

Figs. 2–4.—*Crustacean Tracks from the Old Red Sandstone of Bouldon.* (Natural size.)


SKETCH-MAP OF A PART OF LOCHABER.
Parallel Roads.
Old Deltas.
Glacier-moraines and Moraine-deltas.
Syenite of Glen Spean.
Direction of the glacial striæ.
Outlets of the old Lakes.
BRITISH MILES
0 1 2 3 4 5 6 7 8 9
Lochan
River Spey
Loch Laggan
The Rough Burn

resemblance to those described and figured by Mr. Salter, from the Lingula-flags, as the trail of *Hymenocaris vermicauda*?*

The track of an apparently smaller Crustacean (?) (fig. 4) consists of ovate prints, stamped in a more regular serial order. In none of these is there any evidence of tail-markings, in the existence of any central rib or ridge, like that which appears in the trail of the *Climactichnites* of the Potsdam Sandstone, or in that of recent *Limuli*. Long, slender impressions also appear upon the sandstone-surfaces, having coriaceous interiors, and being probably the casts of Sertularian zoophytes.

The Bouldon quarry is certainly the richest exposure of these track-bearing sandstones, and should therefore be carefully worked; for in the absence or, at least, paucity of organic evidence as to the Crustacean fauna of the Old Red Sandstone, we are forced to content ourselves with the examination of secondary and indirect witnesses.

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3. *On the* PARALLEL ROADS *of* GLEN ROY, *and their* PLACE *in the* HISTORY *of the* GLACIAL PERIOD. By THOMAS F. JAMIESON, Esq., F.G.S., Fordyce Lecturer on Agriculture in the University of Aberdeen.

[PLATE X.]

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2. The different theories.
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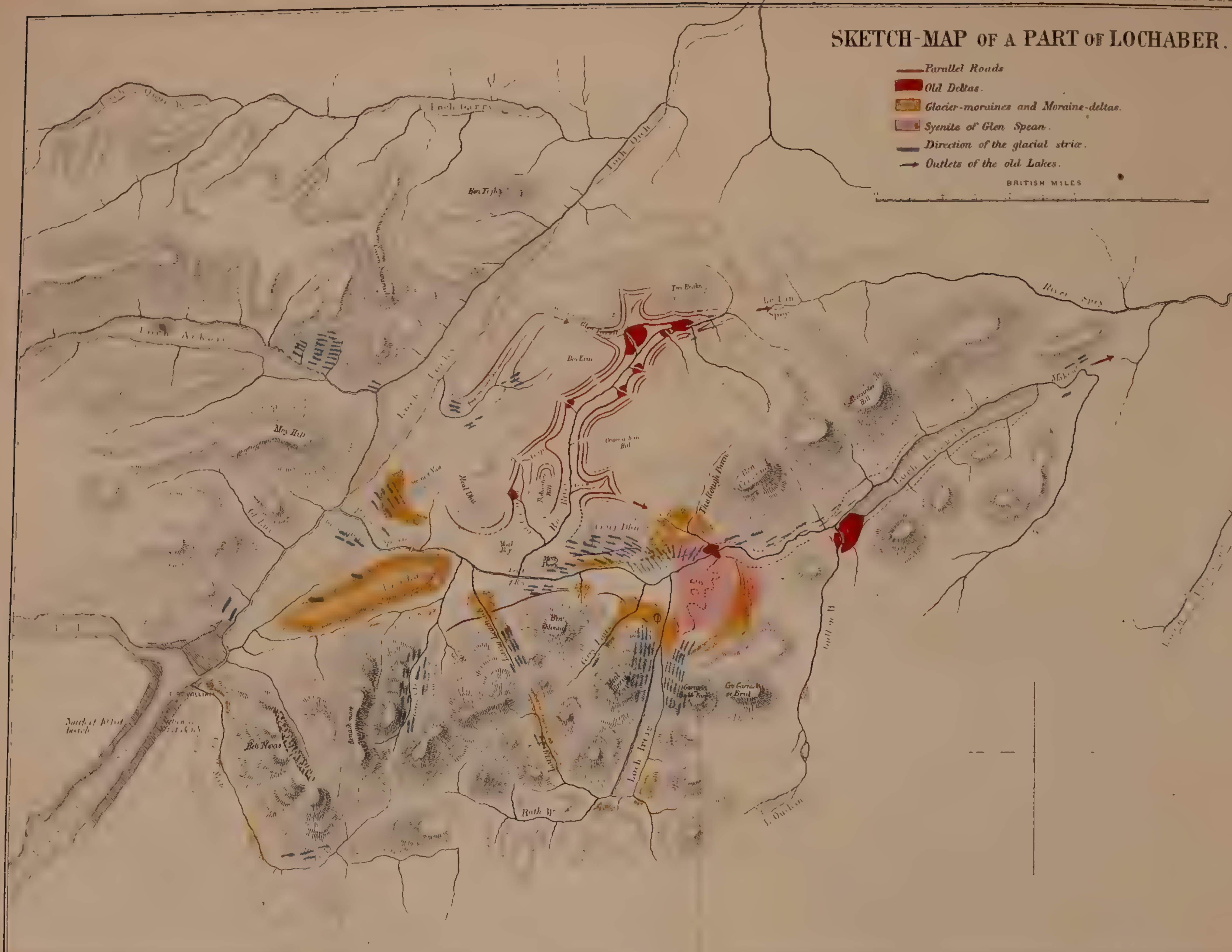
   a. Relation to the period of chief submergence—Eskers and Osar.
   b. Relation to the 40-feet Raised Beach of Argyleshire and to the 'Raised Beaches' of Norway.
4. Height and horizontality of the Parallel Roads.
5. Difficulty as to a dam of ice.
6. Central Asia during the Glacial period. Its glacial lakes and inland seas.
7. Intensity of glacial action in the West Highlands
8. Recapitulation.

§ 1. *General appearance of the Roads.*

IN the Highlands of Scotland there is a district called Lochaber, embracing a range of bare hilly country in the south-west of Inverness-shire. In this district lies the little valley of Glen Roy, famous for certain curious features in its scenery.

High up on both sides of this glen three lines appear, one above another, and some distance apart. They are perfectly level, strictly parallel, and run along the bare mountain-sides as neatly as if drawn with a ruler and pen. They sweep round the shoulders of the hills, wind into their side-recesses, and encircle all the upper part of the valley, everywhere preserving the same rigid parallelism and the same undeviating horizontality. A sight so curious and unusual

* Quart. Journ. Geol. Soc. vol. x. p. 208.


SKETCH-MAP OF A PART OF LOCHABER.
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BRITISH MILES
Loch Arkaig
Loch Oich
Loch Lochy
River Spey
Loch Laggan
Loch Treig
The Rough Burn
Ben Nevis

W West, imp.

strongly arrests the attention of the spectator. These lines look all too mathematically regular for the work of nature, and yet they seem on too grand a scale to have been traced by mere mortal hands. One might fancy he had wandered into fairy-land, and caught the *genius loci* practising geometry on the hill-sides. No wonder then that the imaginative Highlanders ascribed them to the ancient heroes of their race, and saw in these lines the hunting-roads of Fingal and his companions, that they had made for chasing the deer. In their native language they call them '*Casan*,' or 'the footpaths'; for, on climbing up to them, they are each found to consist of a green ledge, or narrow terrace, jutting out from the face of the hill; so that they actually serve as convenient tracks for walking on.

Pennant, I believe, was the first to draw attention to these singular appearances, and, before they were well known, various conjectures were started to account for them; but an attentive examination of the district by Dr. Macculloch* and Sir Thomas Lauder-Dick† at once showed that these "Parallel Roads" must have been formed by water that had once filled the glen to the height of the uppermost line, and had subsided step by step till it reached the lowermost, leaving its water-mark in these shelves as the traces of its ancient shore. But then arose the difficulty, how to account for the water. As you walk down the glen and draw near its lower extremity the two upper lines vanish, and no sign of them again appears; in like manner the lowest line, which now becomes more faint, after being traced into the larger valley called Glen Spean, of which Glen Roy is a branch, also vanishes before reaching the mouth of the Spean valley, leaving no trace of any barrier to account for the retention of a lake to the necessary height; and so deep and wide is the gap that would have to be filled up, that any attempt to account for the gradual wearing down, or wasting away, of any mass of earth or rock that could have occupied the void strikes one at once as utterly hopeless. Another little valley, called Glen Gluoy, in the immediate neighbourhood, and branching off from the Great Valley of the Caledonian Canal, is also marked in a somewhat similar though less striking manner. Here only one decided line is seen, although there are likewise some faint traces of a lower one. This Glen Gluoy line is a little higher than any of those in Glen Roy, and towards the mouth of the long narrow valley, which resembles a profound trench cut among the hills, it seems to reach the very brow of the ridge, and then ceases; but the flanks of the hills on either side show not a vestige of any protruding mass that could have filled up the deep gulf between. There is no narrow rocky gorge, no mound of earth, nothing, in short, but the smooth slopes of grass and heather, with the sheep nibbling quietly on the hill-side. Had any barrier of earth or rock existed here in times so recent as these shelves would appear to indicate, it is incredible it could have been so completely cut away as to leave no trace whatever of its former existence. The question then occurs, If these are the marks of old lakes, what could have retained them?

* Geol. Trans. ser. 1, vol. iv. p. 314.

† Edin. Roy. Soc. Trans. vol. ix.

§ 2. *The different Theories.*

a. *General review of the theories.*—It was scarcely possible in the first examination of such a subject to escape errors, and some of those Dr. Macculloch fell into greatly enhanced the difficulty attending it, so that although both an able geologist and an acute reasoner, and believing a lake to be the cause, yet he found himself quite baffled to account for either its existence or disappearance. Sir Thomas Lauder-Dick, himself a very excellent observer, and aided by the local knowledge of Mr. Macdonell of Insch, had made a nearer approach to the true conditions of the problem, but was unable to offer any more probable explanation as to how the lakes were retained or emptied, than was to be got by supposing some great displacements or dislocations of the adjoining district. But there is not a jot of evidence that any such have taken place since the period of these lakes. No fault has anywhere been detected in the lines; and they are so horizontal and undisturbed that, even apart from many other objections, these circumstances alone are incompatible with the notion of great convulsions having rent the surrounding district.

Another theory is that which appeals to diluvial agency. A great inundation, it has been said, flowing over the country from the west, might have left these marks as it gradually subsided. This was Sir George Mackenzie's idea*; and very recently Mr. H.D. Rogers†, Professor of Natural History in the University of Glasgow, has suggested something similar, only that he thinks it was during the rise of this great inundation that the thing was done. A great heave of the Atlantic's bed might have sent a volume of water across Scotland, and as it poured through the glens it might, it is said, have grooved these lines on their sides. In support of this, Professor Rogers states that the lines consist of deep grooves in the earthy covering of the hills, and are most distinctly and deeply indented in the sides that look down the valley, disappearing altogether in the recesses or deeper corries that scollop the flanks of the mountains; and, further, that certain traces of what is called false bedding, or oblique lamination, in the gravel-beds indicate a current flowing in the required direction.

So far, however, from the lines being faintest on the N.E. faces of the hills, or being absent in the side recesses, it so happens that these are often the places where they are most beautifully seen. This is remarkably the case on the hill of Bohuntine, in the lower part of Glen Roy, where all the three lines are strongly marked on the N.E. face of the hill, the two upper vanishing entirely round the other side, which looks down the valley. And in the side recesses of Glen Turrit the shelves are as clearly seen as anywhere else. Indeed, Professor Rogers seems to have overlooked the fact that, in regard to the two lower lines, there is no outlet for this current at the head of Glen Roy; for, owing to the rise of the ground, they

* Edin. Phil. Journ. January 1848.

† Lecture before the Royal Institution, March 22, 1861.

meet the bottom of the valley long before reaching its extremity. Glen Roy itself is thus a long recess, forming a complete *cul-de-sac* in respect of these two lines, so that no current rushing up the glen from its mouth to its head, it seems to me, could account for them even on the Professor's own theory. Moreover the lines are not, properly speaking, *grooves*. They are not due to matter cut out of the hill, but to matter deposited. They consist, wherever I have been on them, of buttresses, or small narrow terraces, formed by the check which the waters of the old lake gave to the descent of the débris washed into it by the rains and streams, as Macculloch long ago pointed out. They are, if I might use the expression, the continuous deltas formed by the rains and other atmospheric agents.

The false bedding in Glen Roy, of which Professor Rogers speaks, I did not see, nor in the sections of gravelly matter that I examined did I find anything to indicate a current up the glen. During the time of the highest line, however, the surface-water of the lake would have had a determination towards the *col* beside Lochan Spey. But, apart from all these objections to the facts brought forward in favour of this diluvial theory, there is abundant evidence that no such transitory action can account for the phenomenon in the numerous large deltas that exist, chiefly along the lowest line, where the side streams had poured their débris into the old lake. These furnish sufficient evidence, as has been often pointed out, that the water occupied the glen for a very considerable time. Other facts will be adduced in the course of this paper, all pointing to the same conclusion. And if this be not enough, another strong objection rests in the horizontality of the lines, which is so complete that none of the engineers who have been employed to test it have been able to allege any deviation from a dead water-level. Sir Thomas Lauder-Dick, Mr. Milne-Home, and Mr. Chambers all had surveyors with them, all of whom came to the same conclusion. Mr. D. Stevenson made a section along the middle road for a distance of nearly $3\frac{1}{2}$ miles, from Glen Turrit downwards, and throughout that extent the road was found to be perfectly horizontal. He and his assistants were there for a week, at Mr. Milne-Home's request, on purpose to test this very matter.

That any flood, or diluvial body of water set in motion by an earthquake, and rushing up a rugged inclined plane, could have traced lines so neat and so level as these, is to me quite incredible.

Another mode of explanation presented itself in supposing the sea to have been the agent. Sink the country to the level of the highest line, and we should have a sea-margin corresponding to it; and then as the land gradually emerged, successive coast-lines might be traced corresponding to all those we find. On the mountains of Wales sea-shells of existing species had actually been obtained, imbedded in sandy layers, at a height greater than would be necessary even for the most elevated of these parallel roads, and had been allowed by many geologists as evidence of a recent submergence to the required extent; so that there was nothing objectionable in the idea so far, while the mode in which it accounted for the absence of all barriers told strongly in its favour. This was the theory of Mr. Darwin *, who urged it so forcibly, and handled so well the difficulties that arose on every side when it was attempted to place barriers of earth or rock in any of the required positions, that his explanation met with general acceptance, and appears to be still the one most in favour.

A Swiss visitor, however, came and offered quite a new suggestion. This was Agassiz †, who, living in sight of the snow-clad Alps, and awakened by the teaching of Venetz and Charpentier to a perception of the former vast extension of their glaciers, had much enlarged our acquaintance with the ice-world, and had come over to Britain to see whether he could find any trace of glaciers in a country where none now occur. These traces he met with in abundance, and nowhere more clearly than in Lochaber, which he visited in company with Dr. Buckland in 1840. Perceiving that the lines occupy certain glens where the hills are comparatively low, and that ranges of higher mountains encircle them on the W. and S. ‡, fronting the opening of the valleys where the lines terminate, and that Ben Nevis, the loftiest of them all (where the snow still lingers even in the hottest summers), guards the entrance of the main valley, the idea struck Agassiz that this curious phenomenon, that had puzzled so many able heads, must be due to glacier-lakes, instances of which were known to him in the Alps. Ice, in short, had been the barrier that no one could find, and which, on the approach of a more genial climate, had melted before the heat of the sun, and vanishing left "not a wreck behind."

Here was an explanation no one had thought of. The visit of its author, however, was too hurried to enable him to work it out. He merely pointed to the evidence of a former glacier having protruded from Glen Treig across the valley of the Spean as one element in the solution of the problem, suggesting that the ravines of Ben Nevis would probably account for the rest.

Admirably as this seemed to meet the difficulties of the case, yet few were prepared to admit such a development of ice in this country. Had the lines been in the Alps or the Himalaya, the explanation might have been at once accepted; but to suppose that our little hills could have given birth to so large ice-streams seemed to exceed all probability. Accordingly, though the parallel roads have since been repeatedly examined by Messrs. Robert Chambers § and Milne-Home ||, and Professor Rogers, and although all three came away differing with one another as to how they originated, yet they agreed upon this point, that the theory of Agassiz was quite inadmissible,—the two latter even declaring that no evidence whatever existed of the supposed glaciers, at all events not in the places where their presence had to be assumed. And it was pointed out that the glacier from Ben Nevis, which Agassiz had laid down in his

* Phil. Trans. 1839. † Edin. New Phil. Journ. vol. xxxiii. p. 217.

‡ In the map accompanying this paper, the engraver has failed to bring out this feature so distinctly as in the MS. sketch.

§ Ancient Sea Margins, 1848. || Edin. Roy. Soc. Trans. vol. xvi. p. 395.

little map, would not serve his purpose, inasmuch as the lowermost line extended beyond it.

Here then was no approach to agreement; and Sir Charles Lyell, in summing up his lucid sketch of the controversy, correctly expressed the state of the case when he said, "This problem, like many others in geology, is as yet only solved in part; a large number of facts must be collected and reasoned upon before the question can be finally settled."*

These words will serve as an excuse for reopening the discussion. The matter is one of interest, not merely as a local curiosity. It is so connected with the history of the last great geological changes that to leave it unsettled is not only an opprobrium to our geologists, but is also a confession of our inability to give any clear account of these events. Unsolved it is a source of perplexity and confusion, whereas, if once fairly understood, it would help us much in unravelling the history of the great ice-period.

Accordingly Sir Charles Lyell suggested to me, when in London in 1861, to visit the district in order to get more evidence on the subject; and this was further urged by Mr. Darwin, who candidly admitted that, not having glacier-action in view when he was there, he had since, to some extent, doubted his own observations. He furnished me with some useful maps and memoirs bearing upon the problem, and likewise indicated several points worthy of particular attention.

Having myself been long desirous of seeing these curious lines, I took the first opportunity I had of carrying out these suggestions; and to that intent devoted a holiday ramble to Glen Roy in August 1861, and another in July of the following year.

b. *The marine theory.*—The first good sight I had of the parallel roads was from the shoulder of Bohuntine Hill, in the lower part of Glen Roy, near a place known as "the Gap." Looking up Glen Roy from this station, the three lines are beautifully seen, running along both sides of the glen with unbroken regularity. Here I was much impressed with the extreme neatness and precision of the markings. These clear narrow lines seemed to me altogether too fine and neat for the effect of a sea-margin, subject as it is to a continual rise and fall of tide. On the west of Argyleshire there is a fine old coast-line, about 40 feet above the present, which every one admits to be due to the sea, but it has a very different character from these Roads of Glen Roy.

Here are no cliffs, no caves, no banks of well-rolled shingle, no rude notching of the rock. Wherever the lines pass across a rocky face of gneiss, they die out or become so faint that they can scarcely be traced. This fact has been allowed by all the visitors who have attended to it, by Macculloch, Lauder-Dick, and Darwin. In the narrower land-locked parts, where the water had been least ruffled by the prevailing south-west wind, the little terraces, of which these lines consist, jut sharply out from the hill, almost perfectly flat and

* Manual of Geology, 3rd edit. p. 89.

level, as is well seen along the western side of the valley, from the Gap up to Glen Turrit; where, however, the valley is wide, and has been exposed to the westerly gales, the terraces are broader, ruder, and more shelving. This is seen on Tom Brahn, and in the Spean valley above Tiendrish, for example.

The general appearance then of the Roads did not, at first sight, exhibit that erosion which I should have expected from a coast-line. There is a marked absence of well-rounded shingle, less of it indeed than I have observed along the margin of existing fresh-water lakes. This absence of any strong erosion has been generally admitted; but there is at one place a certain amount of rounded rock, upon which the author of the marine theory built a good deal, as evincing an amount of abrasion that no mere freshwater lake could have accomplished. This is near the entrance to Loch Treig, where the lower line only occurs; and this was one of the points Mr. Darwin wished me particularly to attend to.

But the rounding of the rocks here I found to be clearly due to glacier-action. This, indeed, Mr. Darwin himself had begun to suspect. It extends, as I have shown in another paper, for many hundred feet up the hill on both sides of the entrance; the line here, and around Tom-na-fersit, being formed by a thick terrace of gravelly débris abutting against the ice-worn rocks. Until, however, the contingency of ice-action in Britain was thought of, it was, of course, almost unavoidable to attribute this effect to water. Some rounded rocks occur also at the gorge near the head of Glen Roy, owing to the same cause, the scoring being in many places quite visible. On the flank of Craig Dhu the glacial markings are often very finely displayed close above and below, and even *on the very line itself.* But I nowhere found any decided notching or cliff that I could assign to the action of the old lake.

There was another feature that seemed to bear against the presence of the sea. This was the state of the deltas in the upper part of Glen Roy. The fine preservation of these is very remarkable. One upon the east side of the glen, below the shooting-lodge of Dalriach, is especially worth notice. Its surface comes up to the level of the lowest line, and it protrudes from the little ravine that gave it birth nearly halfway across Glen Roy, bulging out like an artificial mound, compact and clear in outline as when first formed, save that the stream from which it was originally deposited has now cut a great gash through its midst. The fan-shaped margin shows that the water it dropped into had no strong set or current, either up or down the glen. If it had, the débris would have curved more or less up or down the valley; whereas it has disposed itself almost equally all round the mouth of the little stream, the tendency being, if any way, down the glen. Now it seems to me that the continual swaying up and down of a sea-loch subject to the tides, is incompatible with all this. So far as I have observed, delta-matter carried into the sea, or into a salt-water lake, is levelled and spread out to a much greater degree. Its bearing upon the notion of a deluge sweeping up the glen is still more obvious. There is a fine little delta of the same kind in Glen Collarig, and also a large one at the mouth of the Rough Burn in Glen Spean.

A further way of testing the matter presented itself.

Had the lakes been freshwater, they should each have had an outlet for the discharge of their excess, and we ought to be able to point out the channels along which the streams descended to a lower level. Now this can be done for all the three Glen Roy lines, and likewise for that of Glen Gluoy. It has been ascertained that the latter, which is the highest of all, coincides in level with the watershed at the top of its glen*; so that were Glen Gluoy filled to the height of its line, the water would pour over this *col* or summit-level down a hollow, called Glen Turrit, into the upper part of Glen Roy. The fall from this *col* to the highest line in Glen Roy is, according to Messrs. Milne-Home and Chambers, nearly thirty feet. The overplus of the Glen Gluoy lake would, therefore, run into that of Glen Roy. That this was actually the case is well confirmed by a huge old delta at the mouth of Glen Turrit, coinciding in its upper surface with the lowest of the Parallel Roads. This delta is out of all proportion to the size of the stream. Standing at the junction of the Turrit and the Roy, I estimated the water in the latter at fully three times as much as that of the Turrit. Seeing then that the channels of the two streams are similar in character, the Roy should have had much the larger delta. Instead of that, the delta of the Turrit is more than twice as big as that of the Roy. It is a considerable mass, some furlongs wide, with a flat surface, and a front rising at its centre ninety feet above the bottom of the valley—a striking proof how long the lake must have existed. Deep terraces of delta-matter fill the glen here at all the lateral openings, and the scene strongly reminds one of Dr. Hooker's sketch of the terraces in the Yangma valley (Himalayan Journal, vol. i. p. 242).

With regard to the uppermost Glen Roy line, it was ascertained by Sir T. Lauder-Dick, and the fact has been further verified by Mr. Darwin, that it coincides with the watershed at the head of Glen Roy. So that were Glen Roy filled with water to the level of its uppermost 'road,' the lake would have discharged its excess over this *col* into Lochan Spey.

Again, the middle line of Glen Roy coincides (as was first pointed out by Mr. Milne-Home) with the *col* at the head of Glen Glaster, a little valley which branches off to the eastward from the lower end of Glen Roy. This point I verified myself, and found the line to be just on a level with the watershed, or, more accurately, a foot or two above it. The parting of the waters is in a flat swampy hollow, over which peat is now growing. Here a small stream rises, and flows eastward down a hollow into the Rough Burn, which enters Glen Spean opposite Loch Treig. The fall, or descent, of the stream from this Glen Glaster *col* to its junction with the Rough Burn is, by an aneroid observation, about seventy feet. The trace of an old channel is here visible, that looks to have belonged to a

* More accurately, it is a foot or two above it; see Darwin, Phil. Trans. 1839, p. 42.

good-sized stream. It is now overgrown with swampy turf, which hides the nature of the bottom. It is interesting to observe that a large old delta occurs at the mouth of the Rough Burn at a level corresponding with the lowest of the Parallel Roads; the top of the delta rising, however, above the line which marks the west side of it.

This third or lowest of the Parallel Roads of Glen Roy extends into the valley of the Spean, and, passing the old delta just mentioned, seems to have stretched eastward beyond Loch Laggan to a place called Makoul, where the watershed occurs that divides the basin of the Spean from that of the Spey. Sir Thomas Lauder-Dick first showed the connexion of the line with this watershed, pointing out that here must have been the outfall for the water of the old lake, when it stood at the height of the lowest Parallel Road. This conjecture appears to be perfectly correct. Owing to the broken, rocky nature of the ground, the line can only be traced faintly here and there. Nevertheless we have this large delta at the mouth of the Rough Burn. There is also another of far greater size at the west end of Loch Laggan, where the entrance of the Gulban River had formerly been. This is the largest of all the deltas. It is a wide-spreading mass of silt and gravel, the front of it rising about twenty feet above the surface of Loch Laggan, but it slopes gradually backwards to a height of about fifty feet. These two deltas, together with other traces, afford good evidence that a lake had filled all this part of the Spean valley to the height of the lowest Glen Roy line. It further appears, from levellings executed for other purposes by the Ordnance Survey, that the altitude of the watershed near Makoul corresponds with that of this line. There is no reason then to doubt that this was the outlet of the lake when it stood at the lowest Parallel Road. Now, when we come to examine this spot, we find evidence of a large stream having flowed out there. Some low rocks of gneiss, sprinkled with birches, occupy the hollow bordered by a steep hill on the north side. These crags have been ice-worn at a former period, as can still be perceived, but the traces of subsequent water-action are unmistakeable at a level corresponding with what had been the old outlet of the lake. The glacial markings are effaced, and the rock worn into smooth, sinuous curves, with something like incipient pot-holes. These water-worn ledges are strewed with well-rounded balls of stone, as large as cocoa-nuts —the mullers that had ground the rocky surface—lying just where the eddy had left them; and, in the recesses and sheltered bends to the east or lee side of the crags, large heaps of pebbles, intensely water-rolled, afford good proof that a strong brawling current had long gone out here. On ascending the knolls of gneiss above the level of the old outflow, these appearances vanish. No water-rolled pebbles are to be seen, no washed gravel, no water-worn rocks, no tendency to pot-holing, but merely a thin covering here and there of coarse earth with angular bits of stone. Had this watery action been due to the sea, it would not have been confined to the level I have mentioned, but would have extended, at least during the period of the two higher lines, to a greater elevation.

On going eastward the features of a deserted river-valley increase. The rocky banks recede on either side, and a flat level space occupies the centre, now covered by peat. Beds of water-worn pebbles occupy the bays and curves at the sides, and, further on, old river-meadows present themselves, with alluvial flats running close up to the rocky masses that rise abruptly from their margin, and all the signs of a river-course are seen but the river itself, which has disappeared. I quite agree, therefore, with Mr. Milne-Home, who has likewise described this spot, that the evidence of a deserted water-course is here very plain.

But it will be seen, on referring to the map, that a stream called the Pattag enters the head of Loch Laggan, and turns round close by this watershed. It may therefore be said, admitting all this evidence of a current flowing out here, might it not be merely the old channel of the Pattag, that might easily be supposed, by a slight diversion of its course, to have here turned eastward into the Spey, instead of wheeling round, as it now does, into the head of Loch Laggan?

The answer to this is that the deserted channel is far too large to be due to a small stream like the Pattag, for it is such as a river like the Spean or the Lochy might have produced. But perhaps a better answer may be derived from a consideration of the old delta of the Gulban already mentioned, for the height of it proves that a lake must have formerly extended to Makoul, and consequently had its outfall there.

We have evidence, then, in regard to each of the Parallel Roads, that it coincides with an outlet where the water might have escaped to a lower level. And, where the point has been attended to, it appears that the lines *just exceed the height of these outfalls sufficiently to admit of a certain depth of water passing out.* This fourfold proof tells very strongly, I think, in favour of the view that the lakes were freshwater. A short line which Mr. Darwin discovered in a gully near Kilfinnan coincides in like manner with the watershed between it and another valley.

The fact of the drop, or descent, of 20 or 30 feet from the Glen Gluoy line to the highest one in Glen Roy has always been felt as a difficulty, if we suppose the Roads to be sea-beaches; for why should there be no coincidence between the lines in these two glens, both having been so favourable for the preservation of the beaches? And why, indeed, should these four lines be absent in all the other glens of Scotland?

But Glen Roy presents an exceptional character to our other mountain glens, not only in respect of its parallel roads, but also on account of its great beds of silt and gravel, and, still more, the wonderfully fine deltas at the mouths of its lateral ravines. All these local peculiarities—the lines, the deltas, and the heavy banks of silt and gravel—bespeak a local cause, such as a freshwater lake, and not a universally present one like the sea. It has further been pointed out, as another formidable objection to the marine theory, how improbable it is that this region should have been heaved up some 1200 feet or so, and yet have preserved its horizontality so perfect that all the observations hitherto made have failed to detect any fault in the lines, or any deviation from a dead water-level.

The absence, therefore, of any good positive evidence in favour of the marine theory, and so many considerations urging themselves against it, seemed to me to render it untenable.

c. *Agassiz's theory*.—Let us now see what help is to be got from the glaciers; and first as regards Glen Gluoy. This glen opens into the great valley of the Caledonian Canal (or '*the Great Glen*,' as it is called in pre-eminence), right opposite Loch Arkaig. A glacier, then, issuing out there might have blocked up Glen Gluoy; or we may conceive the Great Glen itself to have been the bed of a large ice-stream, fed by the lateral valleys.

I therefore went to Glen Arkaig, and at its very mouth, close to Loch Lochy, found the gneiss much ground down, as if by ice coming from the west. From this to the Lake is known as 'the dark mile,' the road winding along the bottom of the glen beneath the shade of oak, birch, alder, and ash. On reaching Loch Arkaig I ascended the hill on its north side, and found the gneiss much ice-worn as far up as I went, which was about 700 feet above the lake. The crystalline schist is here highly mineralized and of a very metamorphic nature. The bedding seems nearly vertical, and the layers often twisted and gnarled. These rocky masses show an evident *Stos Seite*, as Sefström would have called it, the west faces being smoothed down, and the eastern more rugged and unworn. The scores and striæ have mostly weathered out, but I succeeded in finding some well-marked instances, the direction being up and down the valley. This was nearly 400 feet above the Loch; and, judging from the appearance of the ridge as far up as I could see, the glacial action had extended to a great height. There was an absence of any superficial detritus, and also of large boulders. Glen Arkaig shows a wide basin encompassed with large, broad-flanked hills. The ridge between it and Glen Garry is very high, three of the peaks reaching about 3000 feet, and the highest exceeding that a little. Glen Arkaig, therefore, would seem to possess the qualities suited for turning out one of the largest glaciers in the district. This, then, was so far favourable.

On coming to examine the mouth of Glen Gluoy, I found on the north side, upon the angle of the ridge between it and Loch Lochy, glacial scores pointing W. 25° N., as if caused by a pressure of ice from Loch Arkaig. This was at a height of about 260 feet above the bridge, the markings being discovered by tearing off the peel of turf that covered the rock, so as to expose a fresh surface. On walking up the glen to the point where Glen Fintaig branches off, I found scores here and there, generally parallel to the valley; but on the spur of the hill that divides Glen Gluoy from Glen Fintaig, the scoring runs right up and down the slope that faces down the valley. This had been previously noticed by Mr. Milne-Home, who attributed it to diluvial action.

I now examined the shoulder of the hill between the mouths of

Glen Gluoy and Glen Spean, and on the angle of the ridge, between Loch Lochy and the Spean (known, I believe, as Strone-y-Vaa), I found the rock much worn in many places, as if by the pressure of ice from the west. The surface, however, of these masses has yielded to the influence of the weather, so that it required much search to discover any reliable markings. Several clear instances I did at length find. At an elevation of probably 800 or 900 feet glacial scoring occurred, pointing W. 5° N., a little lower W. 20° N., running not horizontally, but up and down the slope, as if by ice mounting over it from Loch Lochy. Again, W. 26° N., W. 45° N., and W. 12° N., pointing generally towards the mouth of Glen Arkaig. Further round the angle of the hill towards Glen Spean and lower down, W. 15° N. and W. 45° N., or due N.W.; and the western sides of the rock being most worn showed that the action had come from that side, and not down the Spean Valley. The rocks were also most bared where the pressure of a glacier, wheeling round from the Great Caledonian Valley into the mouth of Glen Spean, would have applied most strongly. All this seemed to show that the Glen Arkaig glacier not only blocked up Glen Gluoy, but also largely contributed to close the mouth of Glen Spean.

At a place called Brackletter, on the south side of the Spean, near its junction with the Lochy, I observed glacial scores pointing more nearly due west, but still inclining a little to north, as if caused by the pressure of ice from Glen Lui, a valley lying to the south of Glen Arkaig, and opening in front of Glen Spean.

The south side of the Spean, from its mouth eastward to Loch Treig, is bounded by a range of lofty hills, which may be looked upon as an extension of the Ben Nevis ridge. The highest peaks exceed 3000 feet in height, but they are not disposed around a basin that could collect their snows into one ice-stream. The most extensive, however, of the numerous gullies that intersect their flanks is "Corry N'Eoin" (the "Bird-Corry"), a grand place to the east of a large mountain called the Aonach More. This ravine presents a series of rocky amphitheatres, or great caldrons, whose walls have been ground down by the long-continued action of the ice. The quartz-veins are all shorn to the level of the rounded gneiss, and streaked with fine scratches pointing up and down the hollow. These signs of glacial action extend far up the rocks on either side. I should have therefore considered it a good objection to Agassiz's theory, had any of the parallel roads been visible in this gully. But it is interesting to remark, that although the lowest line can be traced from Loch Treig all along to here, yet it stops short just as it approaches the entrance of this ravine, and further west I could not trace it. The conclusion, therefore, seems reasonable, that the extension of the lake was cut off here by a glacier issuing from Corry N'Eoin, and on the opposite side by the ice of Glen Arkaig and the Great Glen flowing over the shoulder of Strone-y-Vaa to near Tiendrish, where the line on the north side of Glen Spean vanishes.

Probably all the Great Caledonian Valley was at this time filled with ice, from its summit-level at Loch Oich to Fort William; the glaciers I have indicated forming a large proportion of the main stream. This then would close up the mouths of Glen Gluoy and Glen Spean; and so long as the ice exceeded sufficiently the height of the watersheds at the top of the glens, these cols would determine the level of the water in the lakes.

But in Glen Roy there are three lines, and this barrier across the mouth of Glen Spean, although it might serve for the lowest, leaves the two higher ones unaccounted for. In order that a lake could exist in Glen Roy at the height of the upper lines, something must have prevented the water escaping by Makoul, and also by the Glen Glaster Col.

In order to explain this we must go to Loch Treig. Let us suppose a glacier issuing from the mouth of Glen Treig, and let it protrude across Glen Spean until it rests on the hills upon the north side of that valley. This would cut off all outlet to the eastward, both by Glen Glaster and Makoul; and, so long as the icy barriers maintained a sufficient height, the water filling Glen Roy would have to escape by the col at the top of that Glen into the head of Strathspey. This col, therefore, would determine the level of the lake, and keep it at the upper line as long as this state of things lasted.

Now let the Glen Treig glacier shrink a little. This would open the Glen Glaster Col, and let out all the water above its level. That watershed would now determine the height of the lake, and therefore keep its surface at the middle line so long as this second state of matters lasted.

Then let the Glen Treig glacier shrink again, until it withdrew out of Glen Spean. That valley being now clear, the water would escape by the outlet at Makoul, which would then determine the level of the lake, and keep it at the lowest line so long as the ice-stream across the mouth of Glen Spean maintained itself of sufficient height. When this latter finally gave way, Glen Roy would at length be emptied.

Grant then these two ice-streams, one in the Great Caledonian Valley and the other at Glen Treig, and the problem of the Parallel Roads can be solved, provided we allow that glaciers have the power to dam such deep bodies of water as must have occupied Glen Gluoy and Glen Roy.

Now there is good reason to believe that both of these glaciers existed. Indeed the evidence for that of Glen Treig is probably more complete than for any other glacier in the kingdom. I have in a former paper detailed part of that evidence*; I have shown how the rocks at the entrance are intensely worn for many hundred feet up the hills on either side, presenting in their rounded outlines, scored surfaces, and perched boulders, all the marks of glacier-action. The profound pool of Loch Treig, lying in a deep rock-basin, is, adopting the views of Professor Ramsay, a still further proof. But it was not until my last visit that I was aware of some remarkably fine moraines that demonstrate still more forcibly the former presence of the ice, and which I shall now describe. I am the more

* Quart. Journ. Geol. Soc. vol. xviii. p. 170.

induced to do so, because some foreign *savants* have said on visiting Scotland, "You have the glacier-mud, the transported boulders, the *roches moutonnées*, and the striated pebbles; and your ice-scored and polished rocks differ in no respect from those of the Alps. All these we have seen and admit; but where are your moraines?"

The glacier on issuing from the narrow gorge at the end of Loch Treig dilated immensely, and, in doing so, the right flank of it had to pass over a rough expanse of syenite forming a bit of low, rocky ground in the middle of Glen Spean; but the surrounding hills are of mica-schist with veins of porphyry. This syenite has the property of breaking up into large cubical blocks, often of immense size. These have been swept before the advancing mass of ice, and have, along with other débris, been disposed into long mounds, forming a sort of semicircular arch, or great horse-shoe, with a sweep of some miles. These concentric bands mark out most distinctly the former edges of the glacier, as it shrunk from time to time with the return of a milder climate. And it is instructive to observe how, in some places, the ice has pushed this zone of blocks before it, uphill, off the parent rock, and left them upon the mica-schist on the north side of Glen Spean.

The best view of these moraines is to be got by walking along the footpath, or pony-road, that goes eastward from the entrance to Loch Treig, along the base of the hill towards Badenoch. Having proceeded about a mile or more along this tract, you will find yourself at the summit-level of the road, where it crosses these moraines. Here they start out from the hill into the wide low moor that occupies the bottom of the valley, and from this point they may also be traced slanting upwards across the slope of the hill towards the gorge of Loch Treig; showing how vastly the pent-up ice had dilated on issuing from the narrow pass. Here the stuff consists of the débris of the mica-schist with bits of porphyry, but blocks of syenite soon mingle with it, and become more and more plentiful. Two chief lines of moraine now appear, stretching far out into the plain with a gentle curve, and hold on with surprising regularity for a long way. Outside of these, older hillocks of similar origin may be traced for a considerable distance, showing that the glacier had at one time been of much greater extent. But these two are so perfect and well-defined as to indicate a long abiding of the ice at their margin. The outer one is the largest, rising in some places sixty or seventy feet above its base, and forming a narrow steep-sided mound. Blocks of all sizes, up to fourteen feet in length, stick out of its surface, mixed with lesser débris of mica-schist and gneiss. The inner moraine runs alongside of this one, in some places approaching so closely as to mingle with it, in others receding 200 yards or more. It contains less small débris, and is often composed *wholly of large blocks of syenite*, many of them from five to ten feet, some of them fifteen to twenty-five feet in length, which give it a very striking appearance, forming a long pile of blocks like a ruined breakwater. The biggest piece I saw was twenty-six feet in length; it lay on the top of some smaller fragments, and a little wounded lamb had taken refuge in the recess beneath it. Within this moraine there is a wide smooth space, like a bay, almost destitute of boulders for a considerable distance, and overgrown with a green swampy turf; showing that the glacier had made a considerable retreat without halting long enough anywhere to leave much débris.

These two moraines, after being traced for a mile or so out into the moor, become less regular, and gradually merge into the boulder-covered surface. Their curve seems to indicate that the glacier had crossed the Spean near a place called Gorstan. On the north side of the valley two crescent-like zones, evidently a continuation of those I have been describing, stretch eastward from the spur of Craig Dhu to near Ben Caoran (pronounced Ben Hourin, meaning the Rowantree Hill). We might liken the two curving mounds to a double rainbow, and the outer hillocks to the supernumerary bows.

It seems to me that these moraines, together with the ice-worn gorge, afford about as good evidence of the former existence of the Glen Treig glacier as a fossil skeleton does of the former existence of the living animal.

The position of the outer hillocks shows that the ice must have pressed against the hills on the north side of Glen Spean, so as to have blocked up the outlet for the water by the Glen Glaster Col, and boulders of the syenite are numerous in the hollow beside it. The inner ones in like manner demonstrate that gradual shrinking of the ice which the theory requires.

These parallel moraines are as fine a sight to a geologist as the Parallel Roads themselves, and no one who goes there should omit seeing them. Those at the mouth of the Larig Leachach Glen are also well worth a visit.

There are no such fine moraines at the mouth of Glen Spean; but the greater part of the extensive moor called Unichan, or Aonachan, is overspread with what appears to be glacial débris, partly modified by falling into the water of the old lake. The same is the case high up on the shoulder of the ridge all round from Tiendrish towards Loch Lochy. Large boulders are scanty, although one is met with here and there; the stuff being mostly a rubbish of mica-schist—a rock which furnishes a smaller débris with few great blocks.

The character of a moraine depends, of course, upon the rocks that furnish it, and the striking features of those I have described are in a great measure due to the accident of the glacier having to pass over the rough tract of syenite. Much also depends upon the moraine being formed (to borrow a chemical phrase) in the dry way; for when the stuff from the glacier falls into a lake or pool, its features assimilate to those of an aqueous deposit—a circumstance that has misled many good geologists.

The immense accumulations of gravel about Inverlaire and the mouth of Loch Treig seem to partake of this mixed character, being probably the terminal moraine-matter of the glaciers of Glen Treig and Corry Laire when they protruded into the margin of the lake.

At Inverlaire, and around the large rocky knoll called Tom-na-fersit, they have been finely terraced by the action of the water when at the level of the lowest Glen Roy line. But I ascertained that the terraces close by the end of Loch Treig do not correspond in height; they do not, in fact, form part of this Parallel Road, but are about 30 feet above it. This seems difficult to account for except by supposing these heaps of débris to have been piled up by the glacier to such a height as to dam Loch Treig, after the ice withdrew, to a level exceeding the height of this line. The outpour of the lake would then wear through them; but it has not even yet cut its way to the very bottom, for the lake is still partly retained by these banks of gravel.

On tracing the gravelly accumulations up the Laire Glen, I found that they became terraced or flattened at the level of the lowest Parallel Road (which is the only one seen in Glen Spean), but extended up the glen continuously above the level of this line, assuming an irregular hillocky outline, and becoming gradually coarser and of a less water-worn character—assuming, in short, the natural aspect of old moraines. It is interesting to note that none of the syenitic boulders occur here. At a deep section of one of these banks at the mouth of Corry Laire, below the level of the line, I noticed that the stuff was heaped together in a highly inclined sloping manner; the mass consisted of coarse water-worn gravel, very pebbly, and the pebbles indicated a considerable amount of water-rolling. This want of horizontal stratification, and the somewhat earthy character of much of the sand, were the chief differences I could perceive between it and ordinary water-bedded gravel.

The melting of the ice from time to time, aided by heavy rains, would send floods of water over the old moraines, and might thus produce great quantities of rolled gravel in the neighbourhood.

The meeting of the moraines with the lowest Parallel Road at the mouth of the Larig Leachach is also well worth studying. The ice of this short glen seems to have protruded in much the same way, for the outer mounds are fringed with the gravelly terrace of the Road. Something of the same kind is also seen at the next corry to the west, called Corry Vaddie. But at the time of the two uppermost lines, which mark a period of severer cold, all these glaciers must have advanced far out, and perhaps filled the whole of the lower part of Glen Spean, and hence the absence of the two upper lines there. Glen Gluoy, even, and the basin of Loch Laggan may have been then filled with snow and ice, and some of the higher side ravines of Glen Roy may have had their sheets of ice, or glaciers of the second order. This, it seemed to me, might have been the case with a corry on the west side of Glen Collarig, near which the two upper lines cease, one of them quite suddenly; the terrace of which it consists bulging out at its termination as if it had there met the ice. The watershed at the head of Glen Collarig seems also to be formed partly by old moraines from an adjoining corry, but these belong probably to a period antecedent to any of the Glen Roy lines.

Seeing the many fine deltas along the lowest of the Glen Roy lines, I was struck with the remarkable absence of these accumulations along the two upper ones. I do not think the shorter course of the rivulets sufficient to account for this. As far as I remember, there is an absence of delta-matter in Glen Turrit at the level of the two upper lines. Perhaps this may be explained by remembering that the two upper lines mark severer glacial conditions, when the hills would be more covered with snow, and perhaps abound less in running water. Glen Gluoy, as I have said, might then be filled with snow and ice; consequently there would be no lake discharging into Glen Turrit, and hence no delta-matter. Hence also the fainter mark of the Glen Gluoy line.

Glen Gluoy and Glen Roy are both very narrow glens, not having basins fitted for feeding glaciers; it is probable, however, that, at the upper extremity of the latter, traces of glaciers may be found interrupting the mark of the highest line, but circumstances prevented me from examining that locality properly.

Mr. Darwin, in his memoir, alludes to some horizontal mounds or patches of earthy matter near the cols, and at a higher level. Mr. Robert Chambers also lays much stress on certain horizontal markings in Glen Spean, above any of the Parallel Roads. Some of these I observed. An instance of such is distinctly seen high up on the front of Ben Chlinaig when viewed from Bohuntine. I, however, ascertained that these short lines on Ben Chlinaig were neither quite horizontal nor perfectly parallel. I therefore think they have arisen from some other cause than what formed the roads of Glen Roy. I am of opinion that many of these cases are connected with that former great extension of the ice which preceded the period of the Roads. They may mark the edge of those great ice-fields that formerly filled the valleys, being either lines of moraine matter or stuff accumulated in lateral pools between the ice and the hill-sides. These glacier-pools occur in various situations, and their geological effects have been well pointed out by Charpentier *.

A large glacier must have issued from Glen Nevis, and, owing to the great height of the hills there, must, I should think, have protruded across the mouth of the great valley of the Caledonian Canal, after the ice had shrunk out of the mouth of Glen Spean. This would continue to dam the water to a certain height, and may afford the explanation of those broad terraces in the lower part of Glen Spean, some of which are very noticeable. They differ in character from the Parallel Roads, and few of them exceed an altitude of 400 feet above the sea. There is a fine fragment of one about that height at Brackletter, and also at Auchnaderry, near Bridge of Roy, and several at lower levels. It is worthy of remark that these terraced accumulations all cease on approaching the mouth of Glen Nevis. They are also absent in Glen Gluoy, and in the lower part of Glen Arkaig. If they are of marine origin, why do they vanish at these places?

§ 3. *Place of the Parallel Roads in the history of the Glacial Period.*

a. *Relation to the period of chief submergence.*—Believing the Parallel

* Essai sur les Glaciers, pp. 64 & 257. See also Agassiz, Etudes sur les Glaciers, pp. 217–288.

Roads to have been formed by freshwater lakes, I was now anxious to ascertain what relation in time these lakes bore to the great submergence that seems to have overspread so much of Britain and Ireland during what has been called the Drift-period. The preservation of the deltas in the upper part of Glen Roy, and the way in which the pebbles lie on the water-worn ledges of the outlet east from Makoul, just where the eddying outflow of the lake seems to have left them, appeared to me to show that neither the sea nor any diluvial catastrophe had, since the time of these lakes, approached the level of the lower line, which, in round numbers, we may call 850 feet above the present tide-mark.

Seeing that Glen Nevis opens upon the head of Loch Eil, which is now an arm of the sea, I thought an examination of it would afford some further light upon this question. If Lochaber partook in the submergence, and if this submergence occurred after the glaciers had finally disappeared, then some trace of the sea's presence should be found in Glen Nevis, either in the shape of marine strata, or in the moraine-hillocks being levelled by the inroad of the waters. Even supposing no shell-beds could be detected, yet some shingle beaches or stratified beds of clay and sand might be looked for.

It was, therefore, with a good deal of curiosity that I walked up the Glen some five or six miles to try this point. The result was that I found nothing to show that the sea had ever occupied the glen since the glacier left it. The moraine-hillocks, even near the mouth of the glen, have all their original roughness, and are dotted with boulders just as they are in the Larig Leachach. There are no high terraces of silt or gravel, no beds of brick-clay; but there are irregular mounds of débris covered with big stones, and the torrents that scar the steep sides of Ben Nevis are still pouring down their shoals of gravel. The stream in the bottom has likewise accumulated a slight depth of alluvial loam in the flatter parts of the valley; but of the sea's presence I saw no trace.

The same remarks will, I think, apply to the lower part of Glen Arkaig, judging from what I saw during my hasty visit to that locality.

Both Mr. Darwin and Professor Ramsay have expressed their opinion that in Wales the glaciers made a considerable advance after the great submergence which left the shells on Moel Tryfan, and these later glaciers, they maintain, have swept the marine drift out of many of the valleys there. Adopting this opinion, we might suppose some such re-extension of the glaciers to have swept all trace of the sea out of Glen Nevis.

If the glacier-lakes of Lochaber were not formed during the shrinking of the great ice-covering which preceded the submergence, we may suppose them also to belong to this later period. The undisturbed horizontality of the Parallel Roads is in favour of this view, for we should hardly have expected them to be so perfect had they shared in all the ups and downs of the later Pliocene period. This second advance of the ice would also account well for the absence of all high-lying beds of marine shells in the more mountainous parts of Scotland. If, therefore, the Parallel Roads are the beaches of glacier-lakes belonging to this later period, some beds of marine drift with sea-shells may yet be discovered underneath the lacustrine silt and gravel of Glen Roy.

A considerable amount of glacier-action after the chief submergence of the drift-period would also explain a circumstance that has always seemed to me remarkable, namely, the absence of any clear trace of the upper limit of this submergence. One would think that, however indistinct the intermediate halting-places might be, yet the uppermost shore-line ought to be more clearly marked. But if we suppose the ice to have made a decided advance after the emergence of the land, it is clear that it would blot out all trace of the old shores, so far as it extended. I believe we owe the first suggestion of this explanation to the fertile mind of Mr. Darwin.

This re-extension of the glaciers would also enable us to account for much of the valley-gravel without the aid of marine action. I have pointed out in a former paper some features of this upper rolled gravel that mere river-action, however prolonged, does not account for. But if we can call in the agency of glaciers for these features, we might explain the superficial accumulations of our Highland valleys (I am not now speaking of our lower grounds) simply by glaciers followed by a very long period of river-action. Extensive effects might have arisen from the occasional bursting of glacier-lakes, and also from the melting of the ice, if it thawed rapidly. Pools and lakes would be formed by the moraine-mounds left along the valleys on the shrinking of the ice, and these would obstruct the drainage to some extent, but would be afterwards modified by the rivers gradually cutting through them.

Might not some of those curious accumulations known as *eskers, osar,* and *kaims* have been formed by this re-extension of the ice ploughing into the old marine beds, and forcing them up into long narrow mounds? In some regions these may have arisen from the glaciers terminating in the sea, forming a kind of marine moraine; and, if the end of the glacier floated, fine mud and sea-shells might gather beneath it.

b. *Relation to the* 40-*feet beach of the West Coast.*—Another question presented itself. It is well known that a fine old coast-line occurs along the border of Argyleshire, about 40 feet above the present beach, marking a long pause of the sea at that level. What, then, is the relation of this old beach to the time of the Parallel Roads, and the glaciers connected therewith?

I observed that this 40-feet beach fringes the head of Loch Eil distinctly on both sides up to Fort William, and can be traced on to the entrance of Glen Nevis. It is well marked close beside the bridge at the mouth of the Glen, and appears to extend quite across it on towards Bannavie, forming a broad shingly margin along the base of the moraine hillocks. These, however, above that level, preserve their original irregular surface dotted with boulders.

This 40-feet beach is therefore later than the Glen Roy lakes, and later than those large glaciers whose moraines I have described as so remarkable in Glen Spean.

On the east side of Loch Eil, just half a mile to the south of Fort William, I came upon a section of this 40-feet beach, laid open by a small stream cutting through it, which seemed to me especially interesting on account of a bed of marine shells it contained.

These shells are at a height of about 11 feet above present high-water-mark, and about 50 yards or so from the shore. They are imbedded in the lower part of a stratum of greyish stony clay, resting immediately upon the solid schistose rock.

This clayey stratum is about 5 feet thick, and is covered by some sand and gravel which are not well exposed. At the bottom are the shells, which are very numerous, many of them broken and decayed, especially the larger kinds, but many of the smaller perfect. They appear to have been mostly empty or 'dead' shells, being filled with shelly mud, and many of them have been pierced by boring mollusks. They lie in a gravelly matrix of small schistose fragments and clayey sand. In the upper part of the bed the clay is purer, with few stones and no shells.

The following is a list of the species I collected. For the identification of some of them I am indebted to Mr. J. Gwyn Jeffreys, F.R.S., F.G.S., &c.

1.	Astarte elliptica, *Brown*	Numerous.
2.	—— compressa, *Mont.*	Four specimens, mostly perfect.
3.	Pecten Islandicus, *Müller*	Numerous; all small young shells.
4.	Anomia ephippium, *Linn.*	Several.
5.	Modiola modiolus, *Linn.*	Plentiful.
6.	Nucula	One valve, like *N. nucleus.*
7.	Chiton	One fragment of a large species, apparently *C. marmoreus.*
8.	Acmæa virginea, *Müller*	Several.
9.	Puncturella Noachina, *Linn.*	Two specimens.
10.	Trochus cinerarius, *Linn.*	Several, both old and young.
11.	—— tumidus, *Mont.*	Two or three.
12.	Lacuna vincta, *Mont.*	Numerous.
13.	Littorina littorea, *Linn.*	One full-sized specimen.
14.	—— rudis, *Don.*	A few.
15.	Turbo expansus, *Brown*	Several. Mr. Jeffreys informs me this is the same as *Littorina squalida* of Brod. and Sow.
16.	Natica clausa, *Sow.*	Several.
17.	Bela pyramidalis, *Strem*	One specimen.
18.	Mangelia Holbellii, *Möller*	Seven specimens.
19.	Rissoa striata, *Mont.*	One.
20.	Buccinum undatum, *Linn.*	A few.
21.	Trophon clathratum, *Linn.*	Numerous.
22.	—— scalariforme, *Gould*	One fragment. Mr. Jeffreys thinks it may be an aged specimen of *Trophon Gunneri*, Lovén.
23.	Echinus	Some spines and plates.

The prevalence of the *Littorinæ* and *Lacuna*, together with the general character of the group, afford fair evidence of a shore-line, while the fact that the most common *Littorina* is the Arctic variety, or *Turbo expansus* of Brown, together with the number of *Pecten Islandicus, Natica clausa, Mangelia Holboellii,* and the presence of other shells not ranging now so far south as Britain, show the assemblage to be of a decidedly more northern character than what now haunts our coast.

As the assemblage is a littoral one, I see no reason for doubting that it belongs to the period represented by this 40-feet old coast-line, probably the earlier part of that period. It is just the sort of collection that might be expected at the depth of a few fathoms along such a line of shore, were the sea somewhat colder than it is now.

This bed of shells, I should think, must at all events be of later date than the time when those large moraines were formed in Glen Spean, which I have described in a former part of this paper; for the glacier of Glen Nevis, when at a corresponding state of development (and probably the ice of the Great Glen itself), could not but have extended past this spot, and would have consequently destroyed this shell-bed, seeing that there was nothing to shelter it.

The Scandinavian peninsula ought at that time to have had a development of glaciers corresponding to its higher latitude and elevation. Are we therefore to suppose that the elevated beds of arctic shells and raised beaches described by Keilhau, Bravais, Lyell, and others, occurring along many of the fiords from the Naze to the North Cape—are we to suppose these to be posterior to the time of our latest glaciers? How otherwise could so many of them have escaped destruction by the ice, those, for example, near Trondheim and on the coast of Finmark? If the glaciers that formed the large moraines in Glen Spean were later than the chief submergence which covered so much of Ireland and Britain, and left its arctic shells hundreds of feet above our present coast-line, then surely an equivalent extension of the ice in Scandinavia would have swept these Norwegian beaches and shell-beds out of the positions where many of them occur. Might we therefore synchronize some of these with our old 40-feet coast-line of Argyleshire and its northern shells? This would indicate a greater elevation of the land to the eastward since the time of that old beach.

§ 4. *Height and Horizontality of the Parallel Roads.*

We are indebted to Mr. Robert Chambers for the first good measurement of the height of the lowest line. Mr. Joseph Mitchell, C.E., of Inverness, at his request sent Mr. William Paterson, one of his surveyors, to carry a series of levellings up to it from Loch Lochy. The result gave 847 feet above the sea for the height of the lowest of the Parallel Roads of Glen Roy. The measurement seems to have been taken at the western extremity of the line, and, so far as I can learn, would seem to refer to high-water-mark, although this is perhaps uncertain. The space between the lowest and the middle line of Glen Roy was levelled by Dr. Macculloch and by Mr. D. Stevenson and found by both to be 212 feet, thus giving (847+212) 1059 for the height of the middle line. The distance between the middle and the uppermost line is, according to Macculloch, 82 feet, and according to Mr. Stevenson, 80. Taking the mean of these, we get (1059+81) 1140 feet above the sea for the highest Glen Roy line.

The space between the highest Glen Roy line and the one in Glen Gluoy does not appear to have been so carefully ascertained. Sir Thos. Lauder-Dick states it at 12 feet. Dr. Macculloch, who in this case used a barometer, also makes it 12 feet; but Messrs. Chambers and Milne-Home found it to be fully 29 feet. There is a fainter trace of a lower line in Glen Gluoy, which, according to Mr. Easton, C.E., is 200 feet below the upper one. I find that a rough aneroid observation of my own made the distance between them a few yards more. Professor Rogers also made some measurements of the Glen Gluoy lines, and found that neither of them corresponds with those in Glen Roy, but I have not seen any detail of his results.

The shelf in the gully near Kilfinnan is, according to the barometrical measurement of Mr. Darwin, 40 feet above the highest Glen Roy line.

The Ordnance Survey having carried a line of spirit-levelling along the Loch Laggan road from Dalwhinnie to Spean Bridge in 1858, I availed myself of their bench-marks to test the height and horizontality of the lowest line, which extends into Glen Spean. The bench-mark on Roy Bridge is 308·97 feet above the mean sea-level at Liverpool, or say, in round numbers, 309 feet. From this point I carried a line of spirit-levelling up to the inner angle, or upper border, of the terrace of the lowest Parallel Road on the west side of an adjoining eminence called Meal Derry, and found it to be 545 feet above the Ordnance-mark on Roy Bridge. The terrace here is rudely marked, and so obscure when one is upon it, that its upper outline could not be ascertained within a foot or two; I therefore took sights to various parts of the line in the immediate neighbourhood where it was best defined, namely, on Ben Chlinaig and on Bohuntine Hill, and found that I could not anywhere safely make the upper rim of the marking exceed the height I have mentioned. This then gives (545 + 309) 854 feet above the mean level of the sea for the height of the line in the neighbourhood of Roy Bridge. If Mr. Chambers's height is above high water, this would just about correspond with his statement.

I next went to the delta at the mouth of the Rough Burn, which is about six miles east from Roy Bridge, and found the upper border of the same line there (which is distinctly marked on the west side of that delta) to be fully 10 feet higher than an Ordnance bench-mark on the road near it. This bench-mark is 851 feet above the mean sea-level, which gives 861 feet for the height of the line. The trace of the same line at Inverlaire, which is clearly seen from this spot, seemed to be equally high. But the top of the terraces at the end of Loch Treig was distinctly higher; as nearly as I could ascertain, they are about 885 or 888 feet. This fact I have mentioned in a former part of this paper.

The breadth or vertical height of the line on the delta of the Rough Burn is about 6 feet, so that its lower border is higher than the upper border of the same line in the neighbourhood of Roy Bridge.

Assuming then the Ordnance-levellings to be perfectly trustworthy, this would seem to show that the lowest of the Parallel Roads rises slightly—or about 1 foot in a mile—as we trace it eastward. I was unfortunately unaware of the Ordnance-levellings when at Loch Laggan and Makoul, otherwise I should have tested this point there, but hope to be able to do so at some future time. Mr. Milne-Home, however, says that, by barometrical measurement, the height of the line is 21 feet above the highest point of the channel at Makoul, and as the Ordnance-levelling indicates 851 feet for the height of the watershed there, this would give (851+21) 872 feet for the altitude of the line at Makoul. There is therefore some ground for suspecting that this rise to the eastward extends to Makoul, and in a similar proportion to the horizontal distance. The verification of this interesting question, however, requires further investigation. Should a rise to the eastward be actually established, one might speculate upon its connexion with what I have hinted concerning the raised beaches and shell-beds of Norway.

§ 5. *Objections to a Dam of Ice.*

The greatest difficulty that I find in supposing the Parallel Roads to have been formed by glacier-dammed lakes arises from a consideration of the depth of water the ice had to retain; for it is evident the moraines were too insignificant to have done much of the duty. One might think the hydrostatic pressure of a column of water some hundreds of feet high would have forced an escape beneath the ice. If, however, the height or thickness of the glacier were sufficiently in excess of the depth of water, I imagine there would be pressure enough to keep it in. The difficulty may also be lessened by supposing the grinding of the ice to have considerably deepened the bottom of the Great Glen since the time of at least the higher lines.

Some low rocky eminences stretch across the mouth of Glen Spean and Glen Gluoy, and may have blocked them up to some extent before the gaps around them were ground out by the ice. Our knowledge of glacier-action is but recently acquired, and has been derived chiefly from a study of one region, namely Switzerland. Until a country like Greenland or Spitzbergen has been examined, our acquaintance with the geological effects of land-ice will be very imperfect. I, therefore, do not think the objection I have stated is sufficient to counterbalance the amount of evidence in favour of the theory.

§ 6. *Central Asia during the Glacial Period.*

If I am right in my explanation of these Glen Roy lines, it is clear that many stratified accumulations, presenting all the features of aqueous deposits, might be heaped up in pools or lakes confined by the ice in situations where, without this agency, we could not fancy any body of fresh water to have existed. I have no doubt this has been a fertile source of delusion in countries formerly overspread with glaciers. In such regions many of the supposed proofs of the former presence of the sea far inland, and at great heights, whether drawn from parallel roads, perched boulders, gravel terraces, or stratified beds of earthy matter, are inconclusive. And I think Dr. Hooker, in his valuable 'Himalayan Journal,' has rightly explained, by glacier-action, many such phenomena in the Sikkim valleys. From the disposition of the rivers and the mountains in Northern India and Thibet, it seems to me that there may have arisen some glacier-lakes in those countries on a very large scale. The great alluvial plain of the Upper Sutlej, for example, which Col. Strachey has described and referred to marine action, may have been accumulated in a great lake dammed up by glaciers and moraine-matter from the high mountains below Bekhar*. The upper reach of the Bramahpootra and many other valleys may have been blocked up in a similar way.

More important effects, however, than these must have flowed from the refrigeration of the climate of Central Asia during the glacial period, and which I have not seen noticed. The great basin of the continental streams, larger than the area of Europe, is remarkable for its inland lakes from whence no streams ever reach the ocean, owing to the great heat drying up the water. Now this heat and dryness being much lessened during the glacial period, there must have resulted a much smaller evaporation, which would no longer balance the inflow. These lakes therefore would swell and rise in level, and thus the Caspian, the Aral, and the Balkash might have spread until they became more or less connected into a wide inland sea, discharging its overplus into the Euxine, or along that depression skirting the east flank of the Ural noticed by Humboldt. This rise of the Caspian, damming back the waters of the Volga and other streams, would occasion large deposits of alluvial matter over the surrounding flat regions, and account for many of the freshwater beds that occur there. The other great Asiatic depression to the north of the Kuenlun Mountains would likewise be filled up with water, and it is somewhat curious to find that the Chinese have a tradition that Lake Lhop once drained into the Hoang Ho.

The sandy deserts of Central Asia are probably the dried-up beds of these inland seas.

§ 7. *Intensity of Glacial Action on the West side of Scotland.*

So far as I have observed, the traces of glacier-action are much more striking in the West Highlands than in the east of Scotland. It has occurred to me that as the amount of rain along the west coast far exceeds that on the east, so in former times the precipitation of snow may have been in like excess. Hence larger glaciers would be the result. The volume of the streams in Lochaber in relation

* Quart. Journ. Geol. Soc. vol. vii. pp. 306–308. Since writing the above, I have read Dr. Thomson's description of this locality in his 'Travels in W. Himalaya and Tibet,' and his account confirms me in the opinion above expressed. The ice of the Piti and Parang valleys has been probably instrumental in damming the Sutlej near Lio. The lacustrine clays of the Upper Indus may likewise be explained by supposing that valley to have been blocked up below Rondu by the ice of the Gilgit valley, whose glacier seems still to descend lower than any other in the W. Himalaya. (See Thomson's Travels, 1852, p. 482.)

to the areas they drain often drew my attention, and the wetness of the climate is (*experto crede*) something remarkable. During the glacial period the west side of Scotland may have also had a greater relative elevation, which would further increase the size of the glaciers.

The clearness of the evidence in Lochaber leads me to think that those accumulations in the glens of Braemar which I examined and described in 1859, and of whose origin I then felt doubtful, cannot be marine, but must be attributed to freshwater action and the agency of glaciers*.

§ 8. *Recapitulation.*

To recapitulate, then, the following are the conclusions I have been led to by my examination of Lochaber:—

1st. That the Parallel Roads are the beaches of freshwater lakes.

2nd. That these lakes seem to have arisen from glaciers damming the mouths of the valleys and reversing their drainage.

3rd. That the date of these lakes is posterior to the great land-glaciation of Scotland.

4th. That neither the sea nor any diluvial catastrophe has, since the time of the lakes, approached the 850-feet line. Therefore the chief submergence of the glacial period must have preceded the formation of the roads, or else not have been so extensive as to reach them.

5th. The glens of Ben Nevis do not appear to have been occupied by the sea since the glaciers finally left them.

6th. The 40-feet raised beach of Argyleshire extends to Fort William, and is later than the large glaciers.

7th. The Mollusca of this old 40-feet coast-line were of a more northern character than those now inhabiting our shores.

I hope some geologists who have studied glacier-action may be induced to visit this most interesting tract, and either confirm or disprove the above conclusions.

For the information of intending visitors, I may mention that there is an inn at Spean Bridge, and another at the east end of Loch Laggan; also one of smaller size at Bridge of Roy. The locality can be best approached by leaving the Caledonian Canal steamer at Gairlochy, near the mouth of the Spean, and walking or driving up to Spean Bridge, a distance of three miles. There are good hotels at Bannavie and Fort William.

* Even the deep mass of stratified matter on the flank of Meal Uin, near Killiecrankie, described by me in the Quart. Journ. Geol. Soc. vol. xvi. p. 359, and which I thought a good evidence of marine action, from the insuperable difficulties of supposing any ordinary freshwater lake to have existed in that locality capable of explaining it, may possibly be accounted for by supposing it to have been lodged in a deep pool filling the gully, and confined between the mountain and the side of a large glacier occupying the valley of the Tummel.—See Charpentier's Essai sur les Glaciers, p. 64, for an explanation of similar occurrences in the Alps; also Lyell's Antiquity of Man, p. 245; and Agassiz, Etudes sur les Glaciers, pp. 217–288.

February 4, 1863.

William Babington, Esq., and Clement Le Neve Foster, Esq., Geological Survey of Great Britain, 28 Jermyn Street, S.W., were elected Fellows.

The following communications were read :—

1. *On a* Hyæna-den *at* Wookey Hole, *near* Wells. No. II. By W. Boyd Dawkins, Esq., B.A. Oxon., F.G.S., of the Geological Survey of Great Britain.

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§ I. *Introduction.*

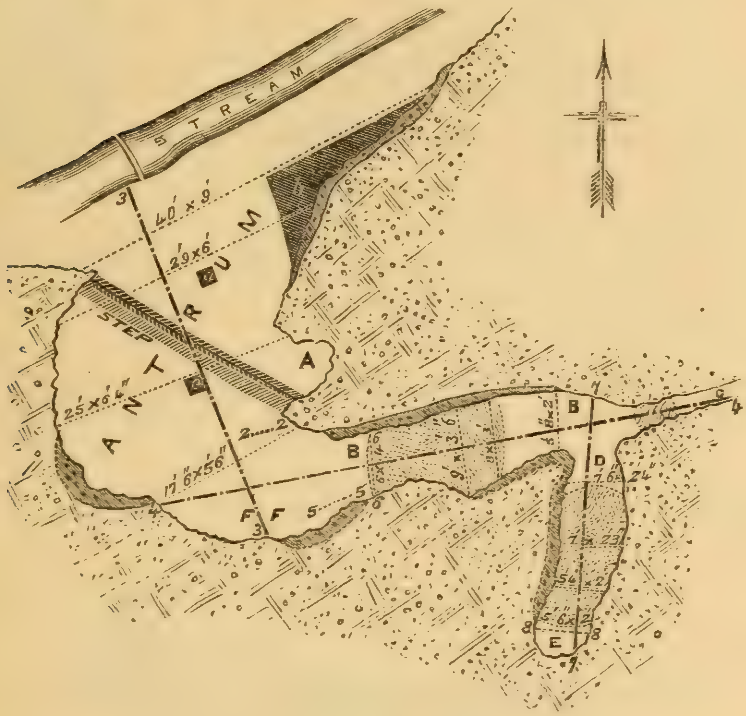
Feeling certain that the results of my former imperfect excavation of the Wookey Hole Hyæna-den, already brought before the Society*, were but the earnest of further discoveries, I, together with Mr. James Parker, of Oxford, and Mr. Henry Catt, of Brighton, determined to explore the cave thoroughly, and to convey its contents completely out. This we were enabled to do in April and May last, by the courtesy of its owner, Mr. Hodgekinson.

§ II. *Excavation of the Cave.*

1. *The Antrum.*—We commenced by completely clearing out the large antrum or entrance-hall (see fig. 1). On the left-hand side, and near the entrance, we discovered teeth of *Ursus spelæus*, Mammoth, *Hyæna spelæa*, and especially of *Rhinoceros tichorhinus*, which greatly predominated over the rest. Associated with these were numerous implements and a few ashes of bone. The area where these were found is represented in the ground-plan (*a*, fig. 1). As we dug our way towards the vertical passage F (see figs. 1 and 3), we found that the cave extended between it and the left lateral branch A. Here a tusk of *Elephas primigenius* was discovered, about 2 feet 5 inches in length, and greatly incurved. Its position is shown by the transverse section (fig. 2).

* Quart. Journ. Geol. Soc. vol. xviii. p. 115.

Fig. 1.—*Ground-plan of the Hyæna-den at Wookey Hole.*



Dolomitic conglomerate. Position of the traces of man.

Undisturbed red earth. Bone-bed *.

A. Upward-tending Branch.
B. Left lateral Passage.
C. Upward-tending Branch.
D. Right-hand Branch of B.
E. Vertical Passage.
F. Vertical Fissure.

——-——-——. The numbers attached to these lines of section correspond with those of the figures in which the sections are given.

-------------. The figures attached to these lines give the breadth and height of the cave in feet and inches.

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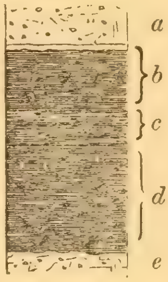
* These explanations also refer to the same symbols, where they occur, in the following figures.

Fig. 2.—*Transverse Section in the Antrum of Wookey Hole.*

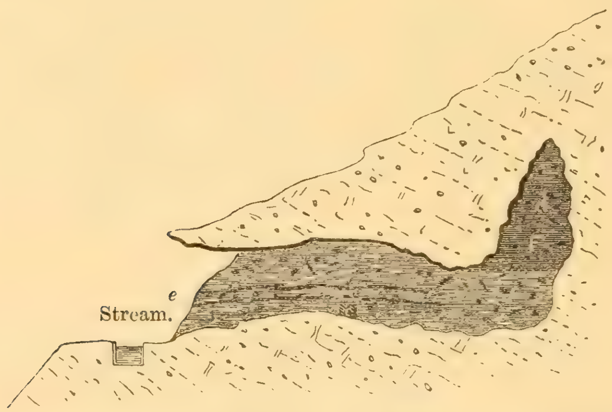


a. Roof.
b. Red earth, containing a large quantity of stones, and but few organic remains, 2 feet in thickness, and extending within 1 or 2 inches of the roof.
c. Red earth, with irregular layers of album græcum and peroxide of manganese, and containing the Elephant's tusk, together with teeth, and numerous splinters of bone; 7 to 8 inches.
d. Red earth, containing stones and a few organic remains; 4 feet.
e. Floor, worn by water and corroded by carbonic acid.

On the right-hand side of the cave we found some more implements, at the spot marked *c* in fig. 1, underlying layers of peroxide of manganese and comminuted bone, as in the case of those which I described in my former paper.

Fig. 3.—*Longitudinal Section in the Antrum of Wookey Hole.*

N.N.W. S.S.E.



d. Grey clay, containing stones, but no bones *. *e.* Red earth, containing stones and bones.

The longitudinal section (fig. 3), taken along the line marked 3—3 in the ground-plan (fig. 1), shows the relation which the flints of area *c* held to the contents of the cave—the scattered bones and stones,—the complete filling-up of the cave to its roof, and the change in the colour of the sediment in, and the absence of organic remains from, the vertical passage F, described in my former paper.

We had now cleared out every portion of the antrum except that between A and F, and had found that the contents extended up to the roof everywhere except in this latter locality, where there was an interval of from three to four inches. This interval was traversed by stalactites, which formed in some places a smooth undulating drapery with stony tassels, in others miniature pillars extending down to the débris and, as it were, propping up the roof. Their pedestals, as they gradually expanded upon the débris, formed round plates of stalagmite, and, where they met, became a continuous

* These explanations also refer to the same symbols in the following figures.

crust—the "pie-crust" of Dr. Buckland. In this interval were hazel-nuts, bearing tooth-marks of Rodents, together with the bones of recent Frogs. With this exception, the section was the same as the transverse section, fig. 2. The layers of album græcum contained round balls, as at Kirkdale. The splinters of bone at this point began to increase in size, and became also, proportionately, more numerous than the teeth. In places an infiltration of carbonate of lime had cemented organic remains, stones, and matrix into one hard mass. In one fragment of this breccia, now in the Brighton Museum, are a tusk and a carpal of *Elephas primigenius*, the coronoid process of the right ulna of *Rhinoceros tichorhinus*, and the base of the antler of *Cervus Guettardi* *; in another, the shaft of the radius of a *Rhinoceros*, side by side with the antler of *Cervus Bucklandi*—a second variety of Reindeer; in a third, two scapulæ, an ilium, and ischium of *Rhinoceros tichorhinus*, together with a coprolite and the lower jaw of *Hyœna spelœa*. The vertical passage F now took the form of an oblique fissure, which presented every appearance of being connected with some rabbit-burrows vertically above it.

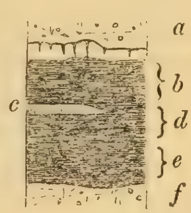
2. *The Passage* B.—We were now at the entrance of the small constricted passage B (see figs. 1 and 4), which branches off almost

Fig. 4.—*Longitudinal Section of the Passage* B.

a. Dark-red earth.
b. Bone-bed.
e. Red earth, containing stones and a few bones.

at right angles to the antrum. A spot a little to its right gave the following section, fig. 5.

Fig. 5.—*Transverse Section of the Passage* B.



a. Roof.
b. Red earth, containing stones and but few bones, 1 foot 8 inches in thickness, at a distance of from 4 to 5 inches from the roof, and under a crust of stalagmite.
c. A mass of conglomerate fallen from the roof.
d. Red earth, with irregular layers of album græcum and large stones, which are a continuation of those mentioned in the previous section.
e. Red earth, full of stones, and containing but few bones.
f. Floor.

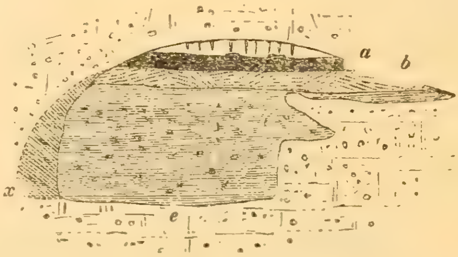
As we dug our way deeper inwards, the stalagmitic crusts became

* I have retained this term for a variety of *C. tarandus*, as sanctioned by the usage of Dr. Falconer, in his paper on the Gower Caves, Quart. Journ. Geol. Soc. vol. vi. p. 489.

more and more intermittent, until they were reduced to a few rounded pedestals. At this point began the bone-bed, a layer of matted bones, teeth, and coprolites, in all stages of decay; some perfectly sound, others too much decomposed to be handled (see figs. 1 and 4). Its relation to the other members of the same section is as follows:—Immediately upon the water-worn and acid-worn conglomerate-floor was red earth (*e*, figs. 4 and 6), 2 feet in thickness, and, as usual, containing few organic remains, but numerous stones; upon this lay the bone-bed (*b*), from 3 to 4 inches thick, with the junction-line rather irregular, and containing a few stones in its lower part; next came a layer of dark-red earth (*a*), from 3 to 4 inches thick, very loose and friable, and having upon the surface a few rounded stalagmites, and a few stalactitic pillars extending through the interval of from 3 to 4 inches, which separated it from the roof.

The bone-bed extended horizontally across the passage, with an average width of 7 feet and a length of 14 feet, affording, therefore, a square area of 98 feet. The enormous quantity of organic remains present cannot be estimated even by the large number we have preserved. The 243 bones, the 64 jaws, and 240 teeth obtained from it are to be looked upon merely as a small fraction of the whole.

Fig. 6.—*Transverse Section across the Passage* B.



a. Dark-red earth. *e*. Red earth with stones, &c.
b. Bone-bed.
x. Undisturbed red earth.

3. *The Passage* C.—Having now exhausted the bone-bed, as we worked onwards we found that the passage B bifurcated, the smaller branch, C (see fig. 1), going onwards and gently upwards, the larger branch, D, stretching at right angles from it, and having a gentle dip of 6° to the south. In the former we met with a second bone-bed (see figs. 1 and 4), which continued undiminished in thickness until it rested upon the floor, and thinned out at a distance of 5 feet from the bifurcation. At the entrance of C the section was identical with that in B, the red earth (rather more clayey, and containing more stones) resting upon the acid-worn and water-worn floor, and supporting the bone-bed, immediately above which was a thin layer of dark friable earth. This, at the further end, owing to the thinning out of the beds underneath, was superimposed directly upon the floor, until it likewise thinned out. The bone-bed extended through the whole width of C, affording a square area of about 15 feet. Besides bones, it yielded 8 jaws of *Hyæna*, and 46 teeth and 41 bones of various animals. The passage was but 15 or 16 inches high, and about 3 feet in width; it gradually narrowed until, at a distance of 12 feet from the bifurcation, a stalactite, about 6 inches

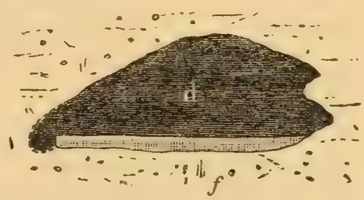
long, had reached the floor and formed a vertical bar, as if to forbid further ingress. The last portion of this branch, for a distance of about 6 feet, was perfectly free from sediment, and was covered here and there with stalagmitic crusts.

4. *The Passage* D.—Having explored C as far as we could crawl, we commenced clearing out D, and discovered a third layer of organic remains presenting the same section as the former bone-beds, except that the dark layer was absent in places, and the bone-bed was in immediate contact with the roof. Besides an enormous quantity of bones, it yielded 45 jaws and 120 teeth. It occupied the whole of the width of D, and its edge rested on the floor of the eastern side. Its average width was 6 feet, its length 14 feet; and its square area was, therefore, 84 feet (see figs. 1 and 7).

Fig. 7.—*Longitudinal Section of the Passage* D.

f. Sand.

Fig. 8.—*Transverse Section in the Vertical Passage* E.



d. Grey clay.

For the explanation of the other symbols see Figs. 2–6.

As we approached the further end of the bone-bed, the red earth became of a paler hue and of greater tenacity; the stones also became larger, and the organic remains more rare. At its further edge was a layer of fine sand (*f*, fig. 7), 4 inches in thickness, underlying grey clay (*d*), full of large stones, and containing a few large bones. This latter extended completely up to the roof (see fig. 7), and was 20 inches in thickness.

5. *The Vertical Passage* E.—From this point up to the vertical passage E (see fig. 7), a distance of 4 feet, there was not the slightest vestige of bones or teeth. The stiff grey clay (*d*, fig. 8) rested upon the horizontal layer of sand on the floor of the cave (*f*). In the former a most beautifully polished piece of chert from the Mountain-limestone was found, which, as its surface is very irregular, appears to owe its polish to friction upon some soft substance. Dr. Buckland would have called it a rubbing-stone *. In the latter, also, there were numerous angular pieces of chert from the Mountain-limestone, associated with peroxide of manganese. The vertical passage took the form of a vault (fig. 7), 6 feet in height and 4 in width, and was represented overhead by an opening, 1 square foot in extent. Here our exploration ended.

* In the bears' dens of Zahnloch and Gailenreuth similar traces of polishing were found, which Dr. Buckland assigns, without hesitation, "to the skin and paws of antediluvian bears" (Reliq. Diluv., second edition, pp. 132, 137).

6. *The Physical Features of the Cave.*—The ground-plan * and sections exhibit the more important features of the cave, namely, the horizontal antrum traversed by a fissure filled with calc-spar, side by side with the "step" of conglomerate; the oblique and but partially filled passage C, similar in these respects also to A; the vertical and completely filled passages E and F, totally devoid of organic remains and full of grey clay; the places where the contents have not been disturbed, and many other phenomena which brevity compels me to pass over.

§ III. *Organic Remains.*

A. General Review.

1. *Table showing the Distribution of the Bones in the Cave.*

	Antrum.	Passage B.	Passage C.	Passage D.	Total.
Carnivora.					
Hyæna spelæa	4	4	1	5	14
Felis	1	2	...	3	6
Ursus	...	1	...	...	1
Meles taxus	1	...	...	...	1
Canis lupus	2	...	...	4	6
C. vulpes	3	...	...	...	3
Proboscidea.					
Elephas primigenius...	4	2	1	3	10
Perissodactyla.					
Rhinoceros tichorhinus	32	144	22	38	236
Equus.....................	6	33	3	3	45
Artiodactyla.					
Bos †	12	27	10	17	66
Cervus tarandus ‡	...	...	...	...	...
C. elaphus §	...	...	...	...	..
Cervus†, sp.	8	20	4	9	41
Total...............	73	233	41	82	429

* For many of the measurements in the ground-plan I am indebted to my partner in the work, Mr. James Parker.

† The absolute accuracy of these numbers is not to be depended upon, on account of the great difficulty in discriminating between the carpals and tarsals of the larger Deer and those of the smaller Oxen.

‡ The skull of a Reindeer bearing an antler of *Cervus Guettardi*, in the Taunton Museum, proves that the latter is a variety of the former. *Cervus Bucklandi*, Owen, a species based upon a small fragment of antler, and characterized by the brow-antler being "3½ inches from the lower extremity or base" of the beam [Owen, Foss. Mamm. fig. 200, p. 485], is by no means satisfactorily separated from *C. tarandus*, in which the brow-antler varies greatly even in the same individual (see Coll. Surgeons' Hunt. Cat. 3512). *C. Guettardi* is probably founded on a young, and *C. Bucklandi* on an old antler of the Reindeer.

§ There is no evidence that *Strongyloceros spelæus* is a distinct species from *Cervus elaphus*.

2. *Table showing the Distribution of Jaws and Teeth in the Cave.*

	Antrum.		Passage B.		Passage C.		Passage D.		Total.	
CARNIVORA.	Jaws.	Teeth.	Jaws.	Teeth.	Jaws.	Teeth.	Jaws.	Teeth.	Jaws.	Teeth.
Hyæna spelæa	26	229	46	67	8	7	41	39	121	342
Felis spelæa	...	5	...	2	...	...	...	2	...	9
Felis.........	...	...	...	...	...	...	...	1	...	1
Ursus spelæus	1	13	...	...	...	3	...	8	1	24
Ursus arctos	...	1	...	...	...	...	...	...	...	1
Ursus	1	2	...	...	...	...	...	...	1	2
Canis lupus	1	3	3	...	...	...	...	...	4	3
C. vulpes	3	2	...	...	...	...	...	...	3	2
PROBOSCIDEA.										
Elephas primigenius...	...	13	...	4	...	...	...	13	...	30
PERISSODACTYLA.										
Rhinoceros tichorhinus	3	88	4	63	...	10	...	29	7	190
R. hemitœchus, *Falc*...	...	1	...	...	...	...	...	...	...	1
Equus.....................	...	215	4	95	...	24	...	28	4	362
ARTIODACTYLA.										
Bos primigenius	...	14	...	1	...	1	...	...	...	16
Bos	...	1	...	...	...	...	...	...	...	1
Megaceros hibernicus	2	18	7	4	...	1	3	...	12	23
Cervus tarandus*	2	...	...	...	...	...	...	...	2	...
C. elaphus	...	...	...	...	...	...	...	...	...	...
Cervus, sp................	...	7	...	...	...	...	...	...	...	7
Total..................	39	612	64	236	8	46	44	120	155	1014

3. *Introduction of the Organic Remains into the Cave.*—I shall now briefly consider the method by which the contents of the cave were introduced; and first the organic remains.

The 800 or 1000 bones, including splinters, which we obtained, form no index to the vast quantity that crumbled to pieces on exposure to the air. Table No. 1 shows the distribution of the 429 which I have catalogued; and Table No. 2 shows the distribution of the teeth and jaws in the cave. A glance at them will show that, on the whole, the remains of any given animal, if abundant, are not confined to one spot in the cave, but are pretty evenly distributed, and lie large with small, the more with the less dense, not in the least degree sorted by water. There is no evidence of the Bear succeeding to the Hyæna, or the *Felis* to the Bear, in the occupation of the cave; or that the latter retired hither to die, as in some of the caves of Germany; or that any of the Herbivores fell into the open swallow-holes, and so left their remains, as in the Hutton and Plymouth caves †. On the contrary, the numerous jaws and teeth of *Hyæna*, the marks of those teeth upon every one of the 800 to 1000 bones, upon the 155 jaws, and even upon the great

* *C. Guettardi* and *C. Bucklandi* are merely varieties of *C. tarandus*, under which they are here classed.

† See Buckland, Rel. Diluv.

majority of the teeth, show that they alone introduced the remains which were found in such abundance.

4. *Position of some of the Remains.*—A glance, however, at the vertical sections will show that some of the remains are not now in the exact position they occupied in the days of the Hyæna. The maximum distance of the bone-layers from the roof is but eight inches, a space manifestly too small to allow of the Hyæna devouring his prey; while in many instances the remains actually touched the roof. This, indeed, has been used as an argument in favour of their having been introduced by water from some unknown repository. On this supposition the introducing current of water must either have passed down the vertical passages or through the horizontal mouth of the antrum. In the former case the three bone-layers would not have been found in the narrow passages, but would have been swept out into the wide antrum, where the force of the hypothetical current must have abated. In the latter case the great bulk of the remains would have been found in the antrum, and not in the smaller passages and innermost crannies of the cave. But, apart from this evidence, the absence of marks of watery action upon the organic remains, and especially of that sorting action which water, as a conveying agent, always manifests, and in no case more remarkably than in the lower jaws of the Stonesfield Mammals, makes the hypothesis of their introduction by water untenable *.

The evidence, indeed, as to the cause of the position of some of the remains is most conflicting. Their condition, their distribution in the cave, and especially the presence of two gnawed rami of the same lower jaw of *Hyæna*, found a few feet apart in the passage B, of two gnawed fragments of the same upper jaw of the Irish Elk, also found apart in the passage D, of the right and left lower molars of the same Elephant, and the right upper and lower molars of a second, also in the passage D, all prove that the organic remains were not introduced by water. On the other hand, the horizontality of the layers, the presence of layers of peroxide of manganese, of the red sediment, and of the sand, show that water certainly was an agent in rearranging and introducing some of the contents of the cave. The only solution of this difficulty that I can hazard is the occurrence of floods during the occupation by the Hyænas, and perhaps for some time afterwards, similar to those which now, from time to time, take place in the caverns of the neighbourhood.

5. *Introduction of the Red Earth.*—A few years ago the outlet of the stream flowing through the great cavern at Wookey Hole was blocked up, and the water rose in it to a height of upwards of sixteen feet, and left a horizontal deposit of red earth similar, in every particular, to that of the Hyæna-den. Now, if we suppose that similar floods were caused by an obstruction in the ravine below the Hyæna-den, it may have been flooded just as the upper galleries

* The caverns of the Liége district, explored by Dr. Schmerling, were filled, without exception, by the action of water, and contain in many cases water-worn bones. Schmerling, Recherches sur les Ossements Fossiles découverts dans les Cavernes de la Province de Liége, vol. i. pp. 18, 19.

of the great cave; and the water, laden with sediment, entering from time to time, might have elevated the layers of matted bone and all the scattered remains on the surface, while the current was insufficient to disturb the stones or to affect, to any extent, the deposit of former floods. The buoyancy of the organic remains is not required to be greater by this hypothesis than is demanded by that of their having been introduced by a current through the swallow-holes.

But if water introduced the red earth, it is certain that it had nothing to do with the introduction of the stones. As the red calcareo-magnesian cement of the dolomitic conglomerate supplied the red earth, so did its imbedded pebbles of limestone supply the latter. Either angular or water-worn, they are in the same state as they were when they formed integral parts of the roof, sides, and floor of the cave, with the exception that they have been worn by carbonic acid, and exhibit a network of calc-spar, stems of Crinoids, and shells of Spirifers in strong relief. It is needless to repeat that, had they been once set in motion, these organic remains must have been ground to powder.

B. Special Description.

1. *Jaws and Teeth of Carnivora.*—I shall pass on now to a brief consideration of the jaws and teeth, omitting, for the sake of brevity, all mention of the bones. Amongst the Carnivora *, *Felis spelæa* is represented by four teeth of the molar series, and six canines. As the difference in the length of the crown of the large upper canine as compared with the largest of the lower ones (1·1 inch) is greater than the difference in an adult tiger (0·4), these teeth may indicate the presence of two species. This difference is, I think, too great to be owing to mere sexual peculiarities. There is no evidence as to whether they belonged to the Lion or the Tiger; for P.M.3, in its size, approaches the corresponding tooth of *Felis tigris*; in the

* *Comparative Measurements of Canines of* Felidæ *and* Ursidæ.

	Length of tooth, measured anteriorly.	Basal circumference of crown.	Length of crown, measured anteriorly.	Length of fang, measured anteriorly.	Maximum circumference of fang.	
	in.	in.	in.	in.	in.	
Felis spelæa. Upper canine	5·5	3·4	2·5	3·0	3·9	maximum.
Felis, sp. Lower canine	4·2	2·4	1·4	2·8	2·7	minimum.
Ursus spelæus. Upper canine	6·0	3·3	1·7	4·3	4·3	maximum.
,, ,, Lower canine	5·6	3·2	1·4	4·2	3·7	maximum.
U. Leodensis (*Schmerling*). Lower canine	4·9	2·2	1·4	3·5	2·7	
U. arctos. Lower canine	4·4	2·1	1·3	3·1	2·5	

The upper canine of *Felis spelæa* has the apex of its fang truncated as in a corresponding tooth of *Felis tigris* in the Museum of the Royal College of Surgeons (4535 of Cat.) and as another in the Oxford Museum.

narrowness of its anterior as compared with its posterior talon, it approximates to *Felis leo*.

The 121 jaws and 342 teeth of *Hyæna spelæa*, the normal inhabitant of the den, show how numerous those animals were, and for how long a time they inhabited the cave. A selected set of rami shows all the changes in their dentition, from youth to old age. The two oldest have each lost one of their two bone-crushers: the one has lost P.M.4, and its alveolus is partially filled up; the other has lost P.M.3, and its alveolus is completely obliterated by osseous tissue. In the three youngest jaws are seen the stages by which the small deciduous molars were replaced by the large and perfect permanent dentition—the most admirable for crushing bone that could be desired. In one lower jaw of a Hyæna in its prime the perfect dentition of the right ramus is preserved; both rami were found some feet apart in the bone-layer in the passage B. In a second ramus of an older animal the angle and the greater part of the coronoid process are preserved—the only instance of their having escaped the teeth of the Hyæna. In a third, covered with tooth-marks, the broken M.1 has been partially thrust out of its alveolus by the teeth of the animal that devoured its possessor. As, however, it was fortunately exposed on the floor to the calcareous dripping from the roof, it is firmly cemented in its place by stalagmite. Of the upper jaws, also arranged according to age, one shows the perfect premolar series, a second the small true molar which disappears early in the *Hyænidæ*, a third the diseased stump of P.M.4. The inflammation resulting from the fracture of the latter has greatly constricted the supraorbital foramen.

The *Canidæ* are represented by *Canis lupus* and *C. vulpes*. The three jaws and two teeth of the latter indicate a size similar to that of the existing species, while the four jaws and three teeth of the former indicate a superiority of size.

The *Melidæ* are represented by *Meles taxus*, of which one humerus only was found. This may be of a date far posterior to that of the other remains.

Of the *Ursidæ* twenty-seven teeth and two jaws were discovered, the larger canines equalling, if not surpassing, in size the largest from Germany; and the molar teeth, of which one upper molar is larger than any from Gailenreuth or Quinger, in the Bucklandian Collection, belong to the gigantic Cave-bear, *Ursus spelæus*. A lower canine also indicates the presence of a second species of Bear, *U. arctos**. Of the equivocal remains, one jaw is closely allied to that from Bacton in the British Museum†; and a canine with a thin compressed fang is identical with that figured by Dr. Schmerling as *Ursus leodensis*‡, though slightly larger in every dimension.

* Comp. Schmerling, *op. cit.* vol. i. pl. 8. p. 8. In the collection of my friend Dr. Spurrell I recognized a lower canine of *U. arctos*, from the Crayford gravel-pits.

† Comp. Owen, Brit. Foss. Mamm. fig. 35 B, p. 106.

‡ Comp. Schmerling, *op. cit.* vol. i. p. 94, pl. 8. fig. 8. Whether *U. leodensis* is a valid species or not, I can offer no opinion.

The tooth-marks upon the remains of the Carnivores prove that they were preyed upon by the Hyænas.

2. *Perissodactyla.*—Of the Perissodactyle Herbivores, the solidungulate division is represented by *Equus fossilis,* of which four jaws and 362 teeth were found, while the multungulate division contains *Rhinoceros tichorhinus* and *R. hemitœchus.* Seven jaws and 190 teeth belong to the former of these. The molars present points of great interest. One series of M.3 shows the inconstant size and form of the posterior column (*Collis tertius* of Brandt), which, rudimentary in some, passes gradually to the summit of the crown in others, and finally, in an abnormal specimen, circumscribes a second deep cavity on its posterior aspect. One of the M.2 is also abnormal. In it the entrance of the principal valley is closed up, leaving the valley so characteristic of *Rhinoceros* as an insulated cavity in the middle of the tooth. The upper milk-molars are remarkable for a cusp at the wide entrance of the valley, quoted by Professor Owen as one of the characteristics of *R. leptorhinus.* The lower jaws prove that in no stage of the dentition was the first premolar developed. The jaws from Lawford and Thame, figured and described by Professor Owen (Brit. Foss. Mamm.) as containing the premolar dentition, are really young jaws with the deciduous dentition. The first milk-molar in the Lawford specimen is mistaken for the first premolar, which, as yet, has not been proved to exist*. Of *R. hemitœchus* but one fragment of a left upper milk-molar was found, for the identification of which I am indebted to Dr. Falconer.

3. *Artiodactyla.*—The Artiodactyle division of Herbivores is largely represented. Sixteen teeth attest the presence of *Bos primigenius,* while one upper molar, smaller in every dimension than the rest, may possibly belong to a second species of the *Bovidæ.*

Twenty-three teeth and twelve jaws are preserved of *Megaceros hibernicus.* One specimen of a right lower ramus shows, besides the perfect molar series, a curious freak of nature. P.M. 2, instead of being in its natural position, has come up hind foremost, the anterior part occupying the place of the posterior, the inner side that of the outer. The fragments of the upper jaw containing M. 1, 2, 3 were found dissociated in the passage D.

Cervus Guettardi, C. tarandus, and *C. Bucklandi* are represented by antlers, some of which have been torn violently from the skull, and not shed by necrosis, as are all those found at Kirkdale. The fact that in the Williams Collection, at Taunton, there is a skull of *Cervus tarandus,* bearing on the left side an antler† of *C. Guettardi,*

* Pallas, indeed, and Fischer doubt the existence of the first premolar. Brandt comes to the conclusion that it is absent from the adult. On the other hand, Cuvier, without ever having seen it, states that it exists, on the authority of Adrian Casper; and Blainville (Ostéographie, p. 107) ascribes four premolars to *R. tichorhinus.*

† Comparative measurements :—

	Right side.		Left side.	
Burr to bez-antler	6	4'''	0	0'''
Burr to brow-antler	0	5'''	2	0'''
Circumference above burr	3	2	2	8
Circumference of brow-antler at base	1	8	1	8

and on the right its own normal antler, shows that the latter is but a variety of the former, consequent upon the irregular position of the brow-antler. The correspondence also of the antler-basements of a skull belonging to the former with the bases of necrosed antlers of *C. Bucklandi* may indicate that this is a second variety of the same species, consequent on varying age. Antlers also indicated the presence of *Cervus elaphus*. Some of the teeth also correspond with those of *C. elaphus*; but I cannot affirm without hesitation that they undoubtedly belonged to that animal.

4. *Proboscidea.*—The twenty-four molars and six tusks of *Elephas primigenius* belonged in the main to young individuals. The longest tusk was 2 feet 5 inches in length; the oldest molar was composed of seventeen plates, four of which were supported by the anterior fang.

IV. *Results of the Excavations.*

1. *The Ancient Physical Geography of the District.*—The group of animals just noticed throws great light upon the physical geography of the district in the days of the Hyæna. In the absence of the Beaver and the Otter, of the Water-rat and the Hippopotamus, we may see that then, as now, there was no river in the immediate vicinity. The great preponderance of the Horse and Rhinoceros is very remarkable. The great number of the former, compared with the few in the Kirkdale Hyæna-den, may perhaps show that they were more numerous in the west than in the north of England*. Both indicate the existence of an extensive plain in the neighbourhood; while the various species of *Cervidæ* point to woodlands on the flanks of the Mendips, and encroaching on the plain at their base. But this evidence does not stand alone. The physical configuration of the west coast of Somerset, the mammalian remains found at low water at St. Audries, the jaws of *Rhinoceros tichorhinus* at Taunton, associated with oak, ash, and alder, prove that a level district extended in those days, with but little interruption, from the Mendips to the Devonian range of the Quantocks, and advanced westwards into the British Channel, and possibly into the Atlantic. The higher grounds of South Wales, in the Mountain-limestone of which bone-caves are so numerous, probably formed its northern boundary.

The Mountain-limestone borders of this great plain would obviously be most favourable for the habitation of the large numbers of Carnivores—the Hyænas, the three, if not four, species of Bear, the two species of *Felis*, the Foxes, and the Wolves. We should naturally expect to find them here in greater variety and numbers than in any less favourable place.

Subsequently to this came a great depression of the district, followed by a gradual upheaval, the evidences of which time does not permit me to bring forward. In neither the marine deposits of the one, nor the lacustrine deposits of the other, have I detected any of the fauna of the bone-cave, with the exception of the Fox, the Irish Elk, and the Red Deer. Thus the palæontology of the district shows that the date of the cave was prior to a submergence of the immediate

* See List of Remains from Kirkdale, 'Reliquiæ Diluvianæ.'

vicinity, while *Rhinoceros hemitœchus* here, as at Kirkdale, associated with *R. tichorhinus*, may perhaps refer it to the earlier part of the newer Pliocene period*.

2. *Evidences of Human Occupation*.—Let us now pass on to the evidences of human occupation. All the ashes and implements were found in positions, near the mouth of the cave, where man himself may have placed them (see figs. 1 to 8), with the exception of an ash of bone imbedded in the earthy matrix between the canine tooth and a coprolite of the Hyæna, and cemented to a fragment of dolomitic conglomerate. This was found far in the cave, either at the entrance of the passage B or in the middle of the passage D. The latter passage yielded the only rolled flint without traces of man's handiwork. The materials out of which the implements were made were used pretty equally. All the spear-heads were of flint; all the sling-stones of chert from the Upper Greensand; while the flakes consisted of both, used indifferently. Besides these three typical forms, which were most abundant, is a fourth, in form roughly pyramidal, with a smooth and flat base, and a cutting edge all round. Of these we found but two examples, both consisting of chert. In form they are exactly similar to some hundreds found in a Celtic village at Stanlake, and to others I discovered in a cemetery of the same date at Yarnton, near Oxford. They strongly resemble a cast I have of one found by M. Lartet in the cave of Aurignac. Were it not for this similarity, I should look upon them as accidental forms. The rest are mere splinters, irregular in form, and probably made in the manufacture of the various flint and chert implements. All the flint implements have been strangely altered in colour and structure, either by heat or, as is more probable, by some chemical action. Without exception, the old surfaces present a waxy lustre (by the absence of which forgeries are easily detected), the colour is of a uniform milk-white, and the ordinary conchoidal fracture is replaced by that of porcelain. Some are not harder than chalk. I have obtained weathered and calcined flints from Sussex in which similar changes are observable, and in which the difference in the results of chemical action and heat can hardly be detected. The chert implements, on the other hand, show no traces of any such changes, but are similar in colour and structure to the rocks from which they came—the Upper Greensand of the Blackdown Hills.

The inferiority of workmanship, on comparison with the implements of Amiens and Abbeville, and of Hoxne, may possibly indicate a higher antiquity, and certainly shows that the Wookey Hole savages were of a lower order than the Flint-folk of the valley of the Somme, or of Suffolk. If also the complete whitening and the total absence of conchoidal fracture in these implements, as compared with the fracture and natural colour of those from the above well-known localities, in which the decomposition is but skin-deep, and causes but a waxy lustre, be any evidence of antiquity, the former are of a far earlier date than the latter.

* Comp. Dr. Falconer, "On the Ossiferous Caves of the Peninsula of Gower," Quart. Journ. Geol. Soc. vol. xvi. p. 491.

All the fragments of calcined bone, with the exception of one already mentioned, were found near the entrance (see fig. 1), and in a place more suitable for a fire than any other in the cave. I can identify none of them as human. The coarse texture, the structure, and the thickness of one indicate a fragment of a long bone of *Rhinoceros* *. All resemble many splinters strewn about in other parts of the cave, which are not calcined, but were evidently introduced by the Hyænas. The calcination may therefore be due to the accident of their lying upon the surface at the time the fire was kindled. The presence of the ashes indicates the occupation of the cave by man.

3. *Conclusion.*—The whole body of evidence† tends to prove that man, in one of the earlier stages of his being, dwelt in this cave; that in it he manufactured his implements out of flint from the chalk-downs of Wilts, and from the less fragile chert from the Greensand of the Blackdown Hills, and arrow-heads out of the chert and the more easily fashioned bone; and that, beyond all doubt, he was a contemporary with the extinct fauna found, with the traces of his existence, in the cave. Then after an interval, in which much of the fauna became extinct, and in which the whole of the district was considerably depressed, we again meet with traces of man in the coarse pottery and the human teeth found by Dr. Buckland in the great Wookey Hole cavern ‡. And, lastly, the discovery of coins of Allectus, Comes littoris Saxonici, together with skeletons near the Hyæna-den, brings us down to the fourth or fifth century after Christ. Thus Palæontology shades off into Archæology, and that into History, and each, taking up the thread where the other dropped it, shows the intimate relation between sciences formerly considered to have little or no bearing upon each other. Until, however, there are data for estimating the magnitude of the breaks in the succession, it is impossible to reduce the interval between ourselves and the Flint-folk to the scale of time used in history. The supplanting of one species by another, and the oscillations in the level of the surface, prove that the lapse of time was enormous, but they do not warrant us in reducing it to any definite number of years.

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2. *On the* Discovery *of* Paradoxides *in* Britain. By J. W. Salter, Esq., F.G.S., A.L.S.

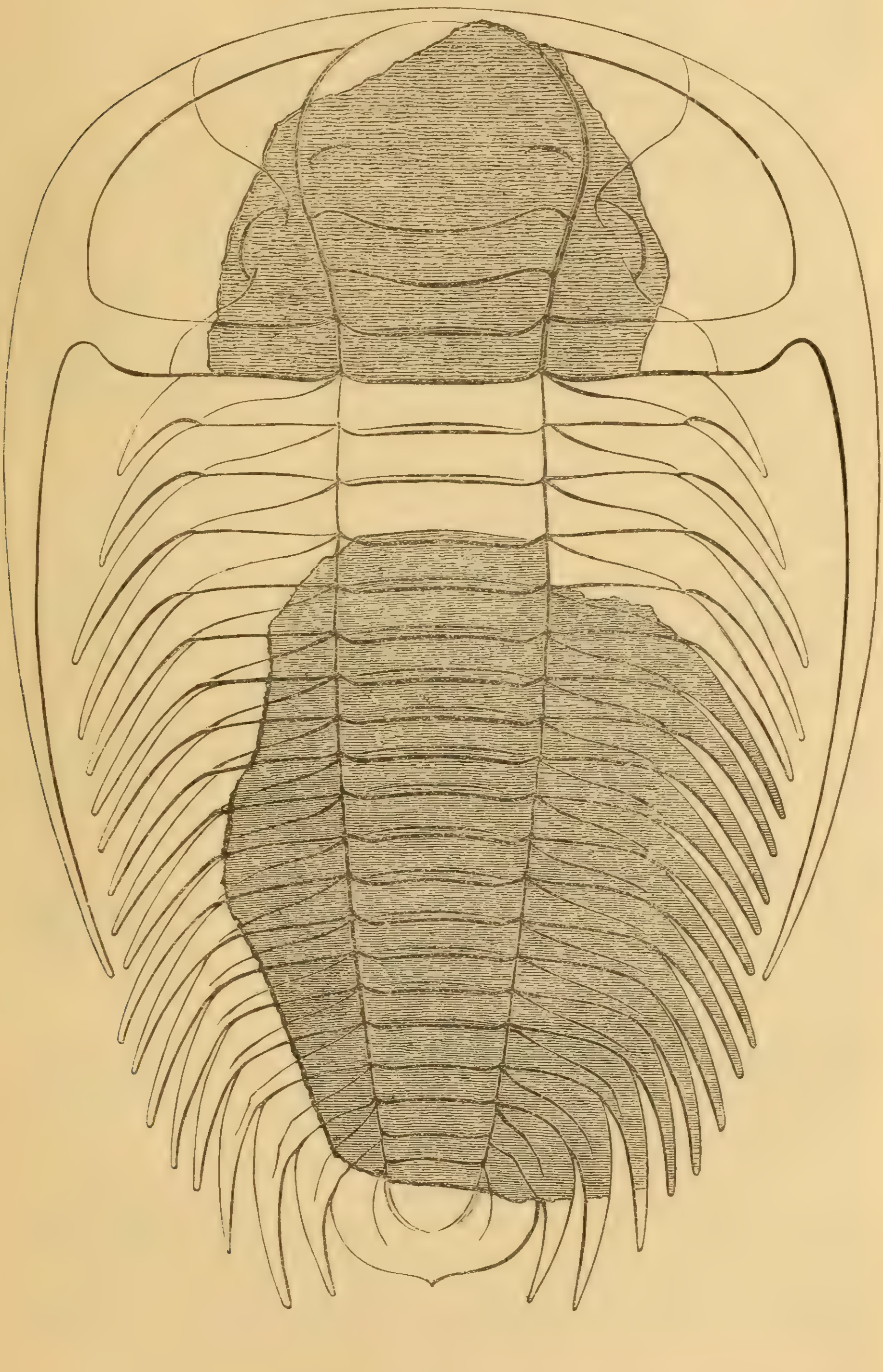
During a few days' holiday in South Pembrokeshire last summer, I went to the neighbourhood of St. David's. I wished to see the Cambrian and Lower Silurian beds recently mapped by Mr. T. Aveline, and to learn if they presented the same characters as the corre-

* Possibly it may have belonged to *Elephas*, but its coarse texture seems to me to indicate *Rhinoceros*.

† For arguments on the relation of the traces of man to the organic remains, see Quart. Journ. Geol. Soc. vol. xviii. p. 119.

‡ See Rel. Diluv. p. 165.

Paradoxides Davidis (one-half the natural size).



sponding beds in North Wales. On this point I hope to have an opportunity of laying some particulars before the Society. My object now is only to point out the locality and geological place of a gigantic Trilobite long looked for in Britain, and lately, I must say accidentally, found by me. I believed I was working at Solva Harbour, in Llandeilo flags*, but by good fortune I had landed instead in a parallel creek a mile to the westward, at the junction of the red and purple Cambrian grits with the Lingula-slates.

Porth-rhaw is a small boat-creek, a mile S. of Whitchurch, on the St. David's road. Black slates occur on both sides of it; but on the west side they pass into and rest upon the red and purple Cambrians; on the east they form magnificent cliffs of vertical or highly curved slates and flags. Sometimes these cliffs show sheets of rippled rock 150 feet to the water's edge. Though much curved, the general dip is to the east and south-east; but I have not traced the slates further in this direction than the Cradle Rock; nor could I find fossils except at one point, where they are in hundreds. This was at Porth-rhaw, before mentioned, in the black vertical rocks on the east side of the little creek. A boat may reach them easily; but, except at low water, it is not very easy to walk down to them.

The fry of some large Trilobite first attracted my attention, and then, by looking along the ledges, I found fragments (head, body-rings, labrum), but none perfect, of the largest species of *Paradoxides* known—scarcely excepting the great *P. Harlani*, from near Boston. *Agnostus* accompanied it as usual, being the smallest, as *Paradoxides* is the largest, Trilobite of the Primordial zone.

I shall describe the species (for it is new), with full figures, in a forthcoming Decade of the Geological Survey; and only now subjoin a short diagnosis, and a reduced figure from a drawing by Mr. C. R. Bone.

PARADOXIDES DAVIDIS, spec. nov.

P. *pedalis et ultra, maximus, glabella clavata, sulcis duobus solum perfectis. Oculi submediani, parvi. Thorax axe fere ut pleura lato, hæc recta, apicibus recurvis, nec abrupte flexis, sulco mediano valde obliquo marginem attingente. Cauda lata. Labrum angulis externis biangulatis.*

Locality.—Lower Lingula-flags, Porth-rhaw, St. David's, Pembrokeshire (1862); also Solva Harbour, west side.

There has been a single specimen of *Paradoxides* for a long time in the Collection of the Geological Survey. It is a much smaller and more slender species; for *P. Davidis* is robust in all its parts, and has a broad axis, like the Bohemian *P. spinosus*. The small species in question† was found in N. Wales by A. C. Selwyn, Esq., now Director of the Geological Survey of Victoria; but the exact locality was never ascertained, nor could the species be again met with. I recommend my North-Welsh friends (after one of whom, conspicuous

* I have since found that the black Lingula-flags, with *Paradoxides*, extend to Solva Harbour.

† *P. Forchhammeri* (see 'Siluria,' 2nd edit. p. 45, fig. 5, 2).

for his zeal and kindness, I name the species*) to work at the lower black slates in the neighbourhood of Ffestiniog, not far above their junction with the Cambrian beds, where they will surely meet with these species.

The following succession of beds, in ascending order, in the Primordial zone, has now been established in Wales, and it is the same in South as in North Wales :—

Red and purple grits, becoming intermixed with some greenish-grey sandstones where they pass up into	Cambrian (Geological Survey).
1. *Lower Lingula-flags.*—A thick mass of black shales, very uniform in its upper part, but with much sandstone in the lower; probably accumulated in deep water.	*Lingulella*, rare. *Olenus*, common. *Agnostus*, common. *Paradoxides Davidis.*
2. *Middle Lingula-flags.*—A thick series of hard light-coloured sandstones, with ripple-markings, worm-tracks and burrows, and other evidences of having been accumulated in shallow water.	*Lingulella Davisii*, abundant. *Olenus*, rare. *Hymenocaris*, abundant.
3. *Upper Lingula-flags.*—A thin series (not more than 300 feet at most) of fine black shales, crowded with small Crustaceans; shells very rare; deep water.	*Olenus*, many species. *Agnostus*, abundant. *Conocephalus.* *Dikellocephalus.* *Orthis*, small species.

The best general section in the neighbourhood of St. David's is at Whitesand Bay, where the Cambrian Rocks and Lingula-flags are seen to be overlain by a lower member of the Llandeilo formation, of which and its corresponding beds elsewhere there is not space here to treat properly; I hope to do so shortly.

The constant occurrence of the same large forms of Trilobite (generally, too, accompanied by the minute *Agnostus*) in the lowest strata in which anything like a fauna is known, of different species in each district, and yet distributed so widely in Europe and America, is surely a curious fact, in any view of the origin or distribution of species. Both these genera depart widely from the general type of the Trilobites.

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3. *On the Fossil* ECHINIDÆ *of* MALTA. By THOMAS WRIGHT, M.D., F.R.S.E., F.G.S. *With Notes on the* MIOCENE BEDS *of the* ISLAND; by A. LEITH ADAMS, A.M., M.B., Surgeon of H.M. 22nd Regiment.

[The publication of this Paper is postponed.]

(Abstract.)

THE Echinoderms described in this paper by Dr. Wright were discovered by Dr. Leith Adams during a careful examination of the strata and geological features of Malta. A description of the Miocene beds was given by the latter gentleman, in which he stated his

* David Homfray, Esq., of Port Madoc, Caernarvonshire, who, together with Mr. F. Ash of the same place, has for many years successfully explored the Primordial zone and the overlying beds.

reasons for not accepting entirely the classification of them proposed by Captain Spratt, and followed by Earl Ducie in his Geological Map of the Maltese Islands. He divided the Miocene strata into the following subdivisions:—1. The Upper Limestone; 2. The Sand Bed; 3. The Marl; 4. The Calcareous Sandstone; 5. The Lower Limestone; and again subdivided the Upper Limestone into three parts. Dr. Wright gave diagnoses and detailed descriptions of forty species of *Echinidæ*, four of which are new; and Dr. Adams added a Table showing their stratigraphical distribution.

FEBRUARY 18, 1863.

John Rand Capron, Esq., Guildford; Julius Haast, M.D., Government Geologist, Christ Church, Canterbury, New Zealand; Thomas Hood Hood, Esq., Member of the Legislative Council of Queensland, Australia; John Randall, Esq., Madeley, Salop; and Samuel Wright, Esq., Cockermouth, were elected Fellows.

The following communication was read:—

On the MIDDLE *and* UPPER LIAS *of the* DORSETSHIRE COAST*. By E. C. H. DAY, Esq.

[Communicated by R. Etheridge, Esq., F.G.S.]

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I. Introduction.

1. Sir H. De la Beche's subdivision of the Dorsetshire Lias.
2. The Middle Lias.
3. The Upper Lias.

II. Descriptions of the Sections.

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2. Stonebarrow Hill and Westhay Cliff.
3. The Golden Cap.
4. Down Cliffs.
5. Fourfoot Hill.
6. Burton Cliff.
7. Generalized Section.

III. Distribution of the Organic Remains.

1. The Belemnite-beds.
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3. The Three Tiers.
4. The Shell-bed.
5. The Starfish-bed.
6. The Grey and Brown Sands with Nodules.
7. The Brown Sands and Sandstones.
8. The Marlstone with its Pleurotomaria-bed.
9. The Upper Lias Limestone.
10. The Cephalopoda-beds.
11. Conclusion.

§ I. *Introduction.*

1. *Sir H. De la Beche's subdivision of the Dorsetshire Lias.*—The only published section giving details of the Lias formation of Dorsetshire, at present in existence, is one made more than thirty

* For an account of the Lower Lias of Dorsetshire, &c., see Quart. Journ. Geol. Soc. vol. xvi. p. 374, &c.; and vol. xvii. p. 494, &c.—EDIT.

years ago by the late Sir Henry De la Beche*. When I undertook the investigation of the geology of the coast in the neighbourhood of Lyme Regis, I soon found that that section, though according well with certain general facts, was, owing to the rapid progress of geological knowledge, and the consequent changes in our system of classification, utterly useless to students. The divisions and subdivisions of De la Beche were founded solely on lithological grounds, whereas those of the present day are based in great measure upon palæontological considerations. He classed all our Upper and nearly half our Middle Lias with the Inferior Oolite Sands †, and he subdivided the Lias, as then understood, accordingly. As he had classed sands with sands, and marls with the Lias, so he divided the latter into "Upper Lias Marls" (which, under the present system, include both the Middle and Lower Lias Marls), "Lias Limestones" (which correspond to a subdivision of the Lower Lias), and "Lower Lias Marls" (which are the "*Avicula contorta* series," no longer regarded even as Liassic).

The section quoted gave to the entire Lias Formation of Dorsetshire a thickness of 600 feet; our present acceptation of the term includes between 1000 and 1100 feet of strata.

The plan which I have adopted, in order to lay clearly before the Society the extent and character of these deposits, is to give, in the first place, a description of them lithologically as they appear in the successive cliffs; and, in the second, to point out, in a generalized vertical section, the palæontological features which characterize the subdivisions and strata. To avoid confusion, I will premise what I understand by the terms Middle and Upper Lias.

2. *The Middle Lias.*—As this term is now accepted, it may be defined as that portion of the Lias Formation which lies between the strata containing *Ammonites raricostatus*, Ziet., as the predominant form below, and those characterized by *Ammonites communis*, Sow., above.

Thus defined, the Middle Lias of this neighbourhood presents a mass of beds which, though including two great and lithologically well-marked subdivisions, is on the whole very distinct, both in its lithological appearance and in most of its fossils, from the beds above and below. The Marlstone and the Middle Lias Sands are generally understood to occupy this interval, or, at least, the greater part of it, throughout the South-west of England; but, in the district under consideration, these beds do not occupy more than two-fifths of the gap, the larger part being filled up by a mass of marls. Throughout the rest of England, moreover, I believe the total thickness of this member of the Lias amounts to much less than in this district, where it includes upwards of 500 feet of strata.

Such an increased development, and other characters very much

* Geol. Trans. 2nd series, vol. ii. 1829; also, Report on the Geology of Cornwall, Devon, and West Somerset, 1839.

† Owing to this classification, fossils from the Middle Lias have been given as from the Inferior Oolite of Bridport (vide *Rhynchonella serrata*, *Pentacrinus gracilis*, &c., in Morris's Catalogue of British Fossils).

in accordance with those of the Continental types, appear to approximate our Middle Lias more closely to foreign equivalents, than that of any other British section hitherto examined; and this is what we might expect to find at the point where our English beds approach nearest in distance to foreign shores; on the other hand, such an approximation in character would lead us to hope that we might here meet with organic forms hitherto supposed peculiar to the Continental Lias.

3. *The Upper Lias.*—This division, as defined by Continental geologists, commences with the strata containing *Ammonites communis*, Sow., and terminates with those containing *A. jurensis*, Ziet. It thus rests upon the zone of *A. spinatus*, Brug., and is in turn covered by that of *A. Murchisonæ*, Sow. Like the Middle Lias, the Upper Lias of Dorsetshire presents us with two lithological subdivisions, the lower one argillaceous, the upper one sandy; but their special characters will be given in the sequel.

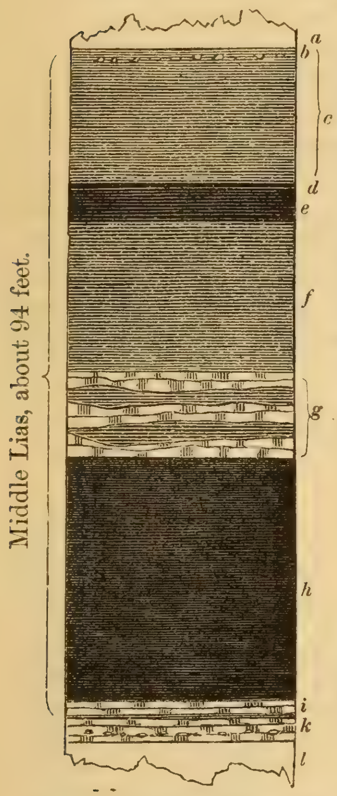
§ II. *Descriptions of the Sections.*

1. *Black Ven.*—The first section in which the Middle Lias is seen as we proceed eastward from Lyme Regis, and upwards in the order of stratification, is in a cliff called Black Ven, situated between Lyme Regis and Charmouth. Above the beach, nearly opposite the highest part of the hill, there is a succession of cliffs of Lias capped by Greensand (*a*, fig. 1). The lower portion of these cliffs, to the height of 180 feet, is of a dark slaty-blue colour, and consists of the "Lower Lias Marls" (*l*); it contains the zones of *Ammonites Brookii*, Sow. (the local equivalent of *A. Turneri*, Sow.), *A. obtusus*, Sow., *A. oxynotus*, Quenstedt, and *A. raricostatus*, Ziet., all well defined. Above these beds is a mass of marl, forming a cliff or wall, the dull-grey tint of which strikingly distinguishes it from the darker strata below. This marl, about 90 feet in thickness, is the lower commencement of the Middle Lias, as well as its most westward extension upon this coast.

On a closer examination we find, however, that the base of the above-mentioned wall (*h*) is blue and not grey, its real colour being concealed by the crumbling away of the beds above. Nevertheless the Middle Lias, as above defined, commences at the very base, where certain Lower Lias fossils cease and Middle Lias forms appear. This change occurs in some tiers of limestone (*i*, *k*) upon which the wall or cliff rests. Between two of these beds of stone, in about eighteen inches of marl, a great number of compressed and metallic specimens of *A. raricostatus* occur, and this, as far as I know, is the highest limit of that form. The next alternate layer of marl is full of Belemnites; and here I think the Belemnite-beds may be fairly assumed to commence, and with them the Middle Lias.

In the 30 feet of blue marl above (*h*), a very elongated Belemnite, *B. longissimus*, Miller, is the characteristic fossil. This blue marl gives place to some irregular beds of impure semi-indurated limestones of a grey colour (*g*), and these are succeeded by grey marls (*f*), becoming shaly in the upper portion. The shales (*e*), 6 feet thick, are very full of Belemnites, as is also the thin band of limestone (*d*, the "Belemnite-stone") by which they are capped. Above this stone there are some 15 or 20 feet more of grey marl (*c*), upon which rests the base of the Cretaceous Series.

Fig. 1.—*Vertical Section of the Middle Lias at Black Ven.*



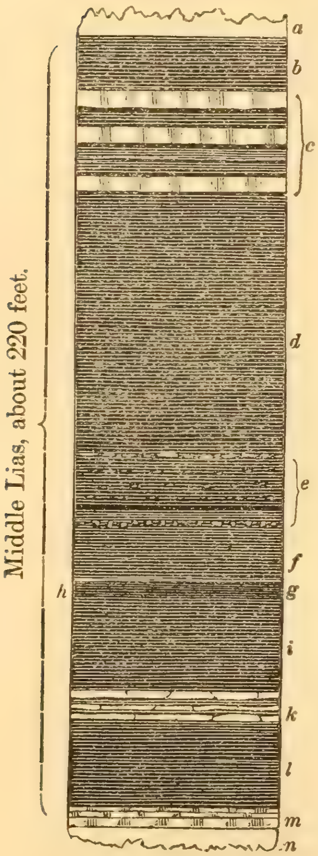
		feet.
a.	Greensand, chert, and Drift, about . .	230
b.	Green Ammonite-nodules.	
c.	Grey marl	20
d.	The Belemnite-stone.	
e.	The Belemnite-shale	6
f.	Grey marl	16 to 20
g.	Impure limestones, in uncertain and irregular beds formed by the induration of the light-coloured calcareous marls	14 to 18
h.	Blue marl containing *Belemnites longissimus*, Miller	32
i.	Limestone and marl with *Belemnites.*	
k.	Limestone and marl with *Ammonites raricostatus.*	
l.	Lower Lias . . . . about	180

The Lias thus terminates in Black Ven at a height of about 270 feet above the sea. The road from Lyme to Charmouth, where it passes through the east "Cuts," is about 70 feet above the highest of the Lias. From this point the beds are somewhat steeply denuded towards the valley of the Char, so that we soon lose the Middle Lias. The Lower Lias beds dip gently in the same direction, that is, towards the east; and, at the mouth of the river, we find a fault which throws them down some 50 feet more in the same direction.

2. *Stonebarrow Hill and Westhay Cliff.*—The base of the Middle Lias is met with in Stonebarrow Hill at the height of about 80 feet above the sea (*m*, fig. 2), and the Belemnite-stone (*g*) at about 80 feet above that again. At 16 feet over the Belemnite-stone we find the first layer of the "Green Ammonite-beds" (*e*)—thus termed by collectors from the green tint of the calc-spar that fills the chambers of the *Ammonites laticostatus*, Sow., the characteristic fossil. Several layers of these limestone-nodules occur in the next 16 or 20 feet. Some of the layers are more persistent than others, and all are not equally fossiliferous.

Above these nodules the marls continue of the same character as in the upper part of the last section (fig. 1) for 75 feet more (*d*, fig. 2), and are then succeeded by three tiers of a fine-grained micaceous stone containing more or less lime (*c*). This is the first appearance of mica in the Middle Lias; and from this horizon upwards it will be found to occur at intervals up to the highest of the Upper Lias Sands. The thickness of the blocks in the "Three Tiers," as I have termed them, varies much, as does likewise that of the intervening marl; in the aggregate they measure from 20 to 26 feet. Above these, in Westhay Cliff, we find some 20 feet more of micaceous marl (*b*), which is succeeded by Greensand (*a*). There is thus a thickness of about 220 feet of Middle Lias in this hill; and the best exposure of the beds is to be seen upon Westhay Cliff at, and to the eastward of, a gully called "Breakneck." From this point to the eastward the cliff decreases in height, and the beds dip in the same direction, as far as a little stream called Ridge Water, near which a piece of broken swampy ground conceals a downthrow to the east, of about 40 feet. This brings us to Gabriel's Water, at which commences the fine section of the Golden Cap.

Fig. 2.—*Vertical Section of the Middle Lias at Westhay Cliff.*

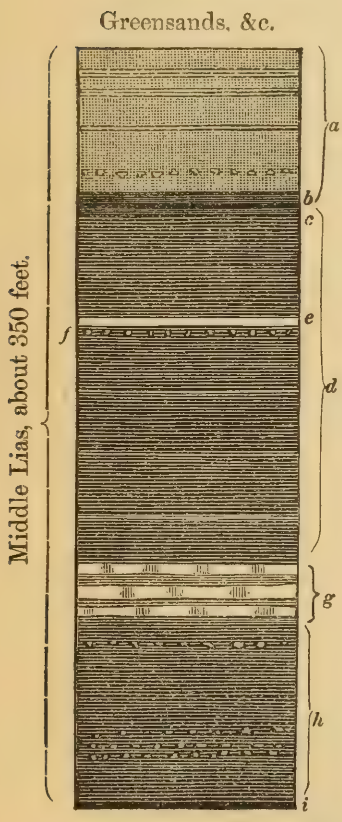


		feet.
a.	Greensand, chert, and Drift . . . . about	180
b.	Grey micaceous marl	16 to 20
c.	"The Three Tiers"—micaceous sandstone in sandy micaceous shale and grey marl—about	20
d.	Grey marl (not micaceous) with thin ferruginous seams, and masses of pyrites . . .	73
e.	The Green Ammonite-beds—nodules imbedded in grey marls	18
f.	Grey marl, as above	15
g.	The Belemnite-stone.	
h.	Grey shale and layers of marl.	
i.	Grey marl	16 to 22
k.	Grey Lias stone	12 to 18
l.	Blue marl	32
m.	Limestone with *Belemnites*; *Ammonites raricostatus* in the lower beds.	
n.	Lower Lias	30 to 40

3. *The Golden Cap.*—The principal portion of this hill is based upon the Belemnite-beds (*i*, fig. 3), and the marls immediately over the beach are those containing the Green Ammonite-nodules. Above these, the "Three Tiers" are here finely developed, and form a remark-

able feature in the cliff, though very uninteresting to the collector. They are succeeded by 160 feet of grey micaceous marl (*d*). Two or three thin bands of mudstone and of occasional nodules occur in the lower part of this mass; and at rather more than 100 feet over the "Three Tiers" a thicker band (*e*), containing shells and calcareous concretions, stands out from the face of the cliff. Underneath this thick band is a curious and persistent layer of small nodules (*f*), containing, chiefly, fragments of Ammonites. The mass of grey marls terminates with a layer made up of shells and fragments of *Pentacrinus*; and this is immediately overlain by a bed of large sandstones from 4 to 6 feet in thickness, which is again succeeded by large nodular masses of indurated sand. Over the nodular layer occur the Middle Lias sands (*a*), grey and marly in the lower part, but gradually becoming brown and more arenaceous in their upper portion. Nodules are plentifully scattered through these ferruginous sandy shales and sands, which are here about 60 feet in thickness, and are succeeded by Cretaceous beds.

Fig. 3.—*Vertical Section of the Middle Lias at the Golden Cap.*



		feet.
a.	Grey and Brown sands with nodules . . .	70
b.	Starfish-bed.	
c.	Shell-bed.	
d.	Grey micaceous marl with layers of mudstones	160
e.	Mudstone with nodular concretions and Shells	4
f.	Small nodules containing Ammonites.	
g.	The Three Tiers	23
h.	Grey marls with the Green Ammonite-nodules	100
i.	The Belemnite-stone.	

We have, therefore, in the Golden Cap, about 290 feet of grey marls, capped by about 60 feet of sands with nodules, all belonging to the Middle Lias.

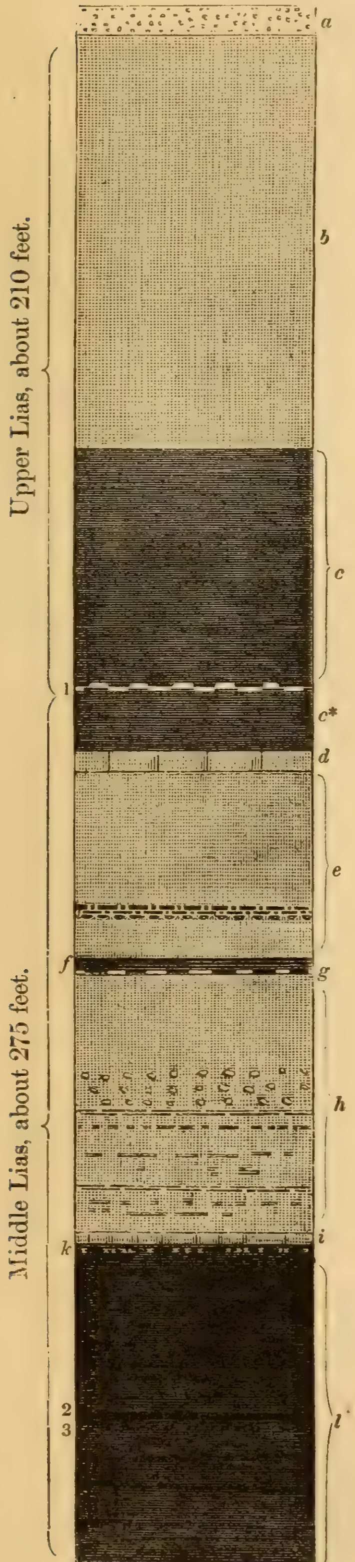
Passing eastwards over a small upthrow, mentioned by De la Beche, there occurs, at the Coastguard-station at Seatown, a powerful fault which carries out of sight the marls below the "Three Tiers," the "Three Tiers" themselves, and part of the micaceous marls over them.

4. *Down Cliffs.*—In consequence of the fault just mentioned, the layer of small nodules already noticed in the Golden Cap (*f*, fig. 3) is seen in Down Cliffs at a height of about 25 feet from the beach (3, fig. 4). The overlying shell-containing mudstone (*e*, fig. 3), of the hill to the westward, is here represented by an equal thickness of hard shelly marl (2, fig. 4). The fault has therefore caused a downthrow of about 200 feet, which great effect is not the result of several small downthrows, but of one well-defined fracture.

Sixty feet or so over the small nodules, a layer of massive sandstones projects from the face of the cliff. These are the Starfish-stones (*b*, fig. 3, and *i*, fig. 4), so called from the beautiful specimens of *Ophioderma Egertoni*, Broderip, collected from their under surface. Beneath them is a layer of marl, rich in shells (*c*, fig. 3, and *k*, fig. 4); and above them, and occasionally forming part of one huge block, are large shaly nodules; the entire series being identical in character with their equivalents already mentioned in the Golden Cap. As in that hill also, over these beds is a mass of shaly sands with nodules (*h*, fig. 4), here attaining to a thickness of about 85 feet, and capped by a band of blue, micaceous, siliceo-calcareous stone (*g*), which yields most of the specimens of *Ammonites margaritatus*, Montf., sp., that are collected here, and which I therefore term the "Margaritatus-stone." Resting upon this layer is a bed of marl (*f*), the grey or blue tint of which renders it a more prominent feature in the section than its thickness of only 6 feet would lead one to expect. This argillaceous deposit forms a remarkable break in the series of sands, which recur over it (*d*, *e*); above, however, they are less calcareous, quite as micaceous, and of a more decidedly brown colour than those below.

Over these upper sands, which are frequently indurated into massive blocks of sandstone rather than into nodules (*d*), and which, from the "Blue Band" upwards, measure about 70 feet in thickness, is a mass of very micaceous grey marl or clay (*c**), about 18 feet in thickness. This is capped by a remarkable band of stone (1), the lower portion of which is in great part a conglomerate, the pebbles being imbedded in a more or less ferruginous matrix, with oolitic granules. In places, however, this part of the bed assumes more the appearance of the Marlstone of other districts; it is separated from the higher portion of the stone by a seam of iron-ore, seldom more than an inch in thickness, but occasionally becoming thicker, and then containing a remarkable assemblage of Mollusca amongst the water-worn pebbles. This "Pleurotomaria-bed," as I have termed it, and the underlying equivalent of the Marlstone appear not to be persistent through the section, but the upper portion of the bed of stone can be traced throughout. This higher part is composed of thin bands of a hard, dense, almost chert-like limestone, separated by thin laminæ of yellow ochreous clay; the whole, however, being consolidated into one block. The entire thickness of the associated

Fig. 4.—*Vertical Section of the Middle and Upper Lias at Down Cliffs.*



		feet.
a.	Drift (Thorncombe Beacon)	15
b.	Upper Lias sands	140
c.	Upper Lias clay	70
*c**.	Clay (same as *c*)	18
d.	Blocks of indurated sand	8
e.	Light-brown sands	60
f.	Blue marl	$6\frac{1}{2}$
g.	Margaritatus-bed	1
h.	Marly sands, with many tiers of sandy nodules in the upper part, and beds of irregular and laminated sandstones in the lower	83
i.	The Starfish-bed	4 to 6
k.	The Shell-bed.	
l.	Grey micaceous marls (Toad's Cove) .	90

1. Upper Lias stone and the Marlstone.
2. Band of hard marl.
3. Layer of small nodules.

marlstone and limestone (belonging to the Upper Lias) varies from 2 to 3 feet*. This extraordinary band of stone, thus including the boundary-line of two formations, is interposed between portions of the same great clay-deposit, since above it there is a mass of grey micaceous marl (*c*) precisely similar in character to that below. This marl is continued upwards for about 70 feet.

We have already seen that blue marl, similar to that of the Lower Lias, is continued some 20 feet into the Belemnite-beds of the Middle division; here, on the contrary, we find the higher limit of the latter, as defined by fossils, carried upwards into a clay-deposit most certainly belonging in the mass to the Upper Lias. We thus see that the organic and inorganic conditions characteristic of two contiguous groups do not always possess the same boundary-line.

Over the great clay-bed last mentioned there are about 140 feet of sands (*b*)—brown, micaceous, and with close-set tiers of large nodules, and layers of indurated sandstone. These are the sands which, till within the last few years, have been called "the Sands of the Inferior Oolite," but which are now, as is well known, generally assigned to the Upper Lias. The highest of these beds immediately underlying the Inferior Oolite have been, in the section under consideration, completely denuded, the total height of the hill being completed by a few feet of drift (*a*). Passing under the height of Thorncombe Beacon, we find the Down Cliffs section sloping away gradually to the eastward. The beds are cut through by the Valley of Eype, but without any fault.

5. *Fourfoot Hill.*—In this hill, at a little distance to the eastward of "Eype's Mouth," we come suddenly to a very strong fault, which carries out of sight not only as much of the Middle Lias as is not denuded, on the one side, but, on the other or eastern side, brings down the highest beds of the Inferior Oolite below the level of the beach, with upwards of 200 feet of Fuller's Earth and Forest Marble resting upon it. As there is a thickness of more than 200 feet of Lias in the one cliff, and as the interval between those beds and the uppermost of the Inferior Oolite cannot be much less than 300 feet, we may estimate this fault as a downthrow of nearly, if not more than, 500 feet, and this too in one great fracture.

The Lias beds of the western side of the fault include the brown sands nearly up to the Upper Lias Stone; but, as the only portion of the section not obscured is to be seen in the faulted face, where the beds are much displaced and coated with the débris of the fault, it is difficult to say much about this, the most easterly extension of the Middle Lias on the Dorsetshire coast.

No more of the Lias is seen till we approach Bridport Harbour, where the Upper Lias Sands are brought up again by a fault corresponding to that of Fourfoot Hill, though not equalling it in magnitude.

* R. Etheridge, Esq., of the Geological Survey, being engaged, in the summer of 1861, in making a section of the Lias strata near Lyme Regis, was the first to discover the existence and true position of the Upper Lias in this cliff, though he did not then suspect the character of the under part of the block in which he found the Upper Lias Ammonites.

In the first cliff east of the harbour, there is a thickness of about 120 or 130 feet of sands with nodules, cut into a perpendicular cliff. Probably some of the highest nodules of the sands cap this cliff, as I have seen a few fossils in blocks fallen from the summit, and as the Inferior Oolite is found a very short distance inland.

6. *Burton Cliff.*—In this section there is the same thickness of sands as in the last-mentioned cliff, but here capped by the Inferior Oolite and Fuller's Earth. As much discussion has taken place in England upon the correctness of the classification which assigns these sands to the Upper Lias, and as I believe some amount of doubt was at one time expressed, not only upon the deductions drawn from the assertions made upon this point, but even upon those assertions themselves, I am happy to be able to add my testimony to the truth of one point which was formerly called in question, namely, the existence of a bed containing numerous Ammonites, of species assigned on the Continent to the Upper Lias, lying in the sands a few feet under the lowest beds of the Inferior Oolite. From the geologist who first pointed out this Ammonite-bed, it is frequently called the Cephalopoda-bed of Dr. Wright *; and I have now found it in this district, not only in Burton Cliff, but underlying the Inferior Oolite of Chideock Hill, of Poorstock, and of Stoke Knap, near Broad Windsor.

Only the highest nodules of the sands are fossiliferous, and the uppermost tier of all is a persistent bed of sandstone, containing much lime and densely charged with the casts of Ammonites and other shells. Under Burton Cliff, on the occasion of a visit thither in the company of my friends Dr. Wright † and Robert Etheridge, Esq., we found the bed of stone here mentioned still attached to the base of the limestone containing *Ammonites Humphriesianus*, Sow.; the zone of *A. Murchisonæ*, Sow., being here absent. In the other localities above given, I have found the same bed underlying the zone last mentioned, the absence of which, in Burton Cliff, appears to be the exception in this district.

7. *Generalized Section.*—With the last section ends my description of the lithological characters of the Middle and Upper Lias of this coast, which divisions I have thus traced, from the first appearance of the lower, in the cliffs of Black Ven, to the point of disappearance of the upper, near the village of Burton-Bradstock.

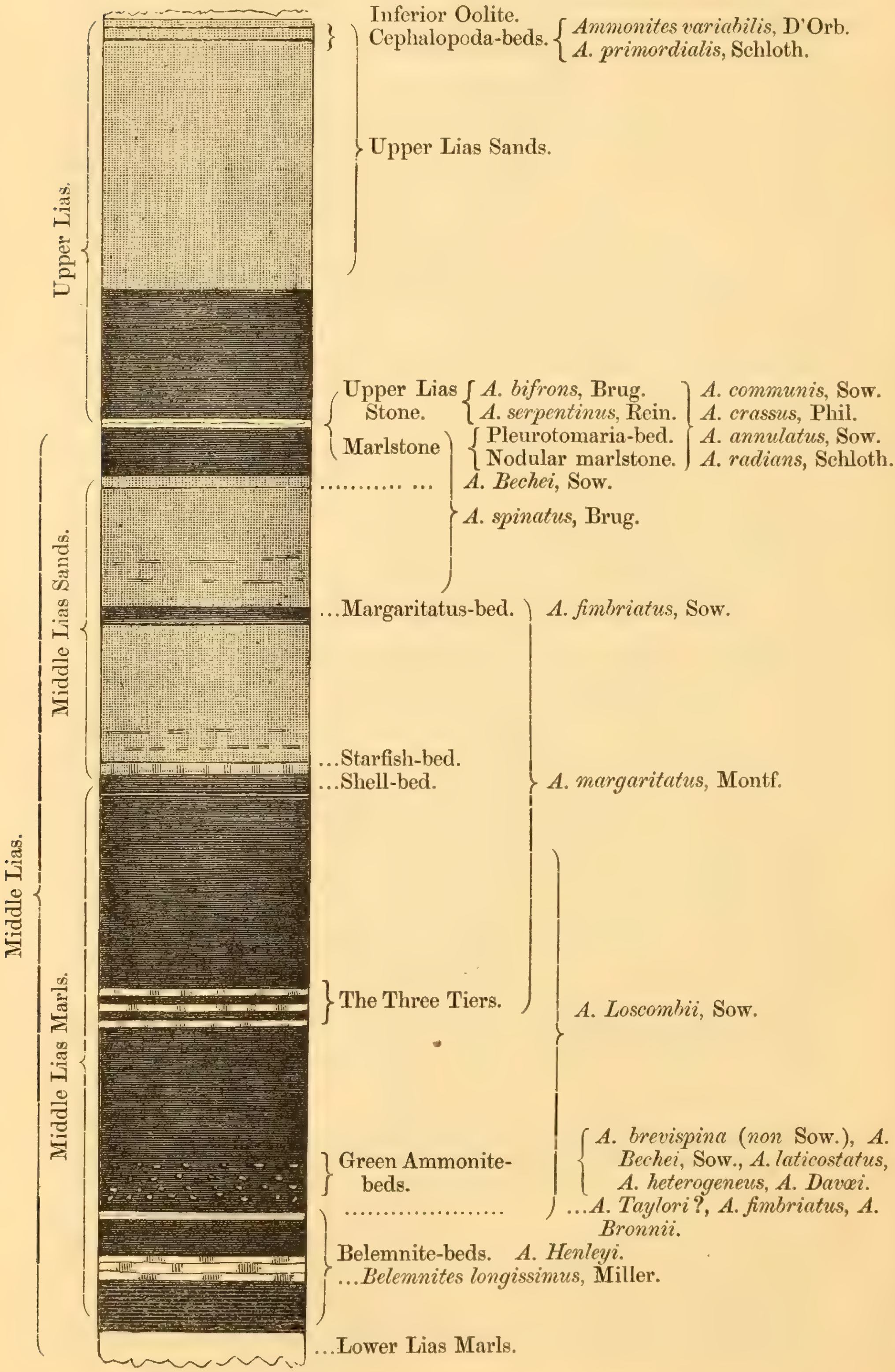
I now propose to condense these several sections into one generalized diagram, in which I shall endeavour to point out how the fossils are distributed through the successive beds of varying lithological character.

Commencing from below, there is first a great mass of marls containing more or less persistent beds of limestones, or limestone-nodules, but all without a trace of mica. This mass, nearly 200 feet in thickness, as seen in Westhay Cliffs, is terminated by a deposit of lime, sand, and mica, forming the "Three Tiers." Over this

* See Quart. Journ. Geol. Soc. vol. xii. p. 292, and vol. xvi. p. 3.

† I have to thank Dr. Wright, with whom I first visited some of the sections described, for his kindness in determining many specimens, which I submitted to him, illustrative of these strata.

Fig. 5.—*Generalized Section of the Middle and Upper Lias of the Dorsetshire Coast.*



is a series, 180 feet thick, of grey marls, which are micaceous, but without sand. Capping these, in Down Cliffs, is the Starfish-bed, above which begin the Middle Lias Sands; at first these are very argillaceous, but higher up, and over the intercalated band of blue marl, they become more purely siliceous. This mass of sand, above and below the band of marl, is altogether 170 or 180 feet in thickness. A great clay-deposit next succeeds, the lower 20 feet of which belong to the Middle, and the remaining 70 feet to the Upper Lias; the boundary of the two divisions, as I before explained, being discoverable in an intercalated band of stone. Over the clay-deposit, I include in my section some 150 feet or more of siliceous sands, densely charged with nodules, the highest tiers of which are slightly calcareous, and capped by a solid bed of stone containing also some proportion of carbonate of lime. These latter, the Cephalopoda-beds, underlie another formation.

§ III. *Distribution of the Organic Remains.*

1. *The Belemnite-beds.*—The lower portion of the great mass of marl without mica includes these beds, in some of which Belemnites occur more abundantly than in any other bed of the Lias; in the words of De la Beche, "seams composed of little else than their remains are seen on ledges, dry at low tide, at the foot of the Golden Cap." The lowest portions of these beds contain chiefly the *Belemnites longissimus*, Miller, but in the higher ones many species are intermingled; and it is more especially these higher beds, immediately underlying the Belemnite-stone, and that band itself, which deserve attention. In the beds below, excepting Belemnites, fossils in a recognizable form are rare; compressed Ammonites and their impressions are abundant, but not in a state to be of much service to the palæontologist. I cannot therefore pretend to give any precise information as to the characteristic Ammonite of this zone. I believe, however, that fragments of *A. Henleyi*, Sow., do occur throughout it. In the Belemnite-shales and -stone, however, there is an abundance of recognizable fossils. The only place where anything like a full and speedy insight into the contents of these beds can be obtained is on the beach between the Golden Cap and Seatown when a favourable wind has cleared away the shingle which generally conceals them. *Belemnites elongatus*, Miller, is, perhaps, the most common form. Another very frequently occurring species is *B. clavatus*; but I suspect that some, at least, of the specimens known by this name are only the young of other species. *B. longissimus*, Miller, is also a form of frequent occurrence. Of other varieties there would appear to be many; but, in the present state of our knowledge regarding these fossils, I may be excused from venturing on further determinations. One fossil, however, found in the stone, calls for special investigation. I allude to the fossil figured and described by De la Beche (Geol. Trans. 2nd series, vol. ii. pl. 4. fig. 4) as an *Orthoceras* *. My specimens indicate that it is more closely

* In his 'Report,' p. 224, De la Beche records it again as "*Orthoceratites? elongatus.*"

allied to the Belemnite,—De la Beche's determination having been founded, as his figure shows, upon a very imperfect specimen. Allied though it be to the Belemnite, yet I think that it must be looked upon as generically different, since it not only differs in the outward form, but also in the internal structure of the guard. The very elongated proportions of the phragmacone also differ from any that I have seen associated with true Belemnites*.

In these layers of shale there are also considerable numbers of *Rhyncholites*, which are assigned by local collectors to the animal of the Belemnite. As they differ considerably from those of the Nautilus found in the Lower Lias, I am inclined to think that the local assignment of these to the dibranchiate Cephalopods may be correct; but more evidence is required upon this point.

Associated with the above remains occur very many Ammonites and Nautili. Amongst the former are large and crushed specimens of *A. fimbriatus*, Sow., old and young specimens of *A. Bechei*, Sow., and occasionally one of *A. Loscombii*, Sow.; this is likewise the chief horizon of *A. Henleyi*, Sow., which however occurs also in the overlying marls. Many forms of small pyritized Ammonites are found in these beds, and several species of *Nautilus* are also to be met with herein.

Gasteropodous shells are common, the most frequent species being the *Trochus Gaudryanus*, D'Orb., and *Pleurotomaria expansa*, Sow. sp. Amongst the Conchifera, *Crenatula ventricosa* and *Nucula variabilis* (?) are the most abundant forms. Brachiopoda are likewise abundant, but so crushed and deformed as to render identification difficult. Upon a specimen of *Ammonites Henleyi* in my possession, from these beds, there is a numerous colony of very small *Craniæ*; and in several other instances I have observed the same form upon fragments of the same species of Ammonite, as likewise upon a specimen of *Ammonites Bechei* from the beds above.

Of the Vertebrata, good specimens of both Saurians and Fish have, I am told, been obtained from these beds, though I have been unable to find any authentic specimens. The Saurian of which bones are most frequently found is the *Ichthyosaurus tenuirostris*, Conyb.; *I. communis*, Conyb., also occurs. Both of these species are likewise met with far down in the Lower Lias.

Of Fish, I have seen fragments of the genus *Æchmodus* from these beds.

Pentacrinus basaltiformis, *Miller.*	Plicatula spinosa, *Sow.*
Terebratula numismalis, *Lam.*	Pecten, several species.
Rhynchonella.	Cucullæa.
Craniæ, upon Ammonites Henleyi.	Nucula variabilis (?), *Sow.*
Crenatula ventricosa, *Sow.*	Pleurotomaria anglica, *Sow.*
Hinnites velatus, *Goldf.*	—— expansa, *Sow.*

* Since writing the above, I have been fortunate enough to obtain the pen of the creature, associated with the phragmacone and guard. This not only fully corroborates my supposition that the animal was generically different from the Belemnite, but presents us with an unknown and extraordinary modification of pen-structure, which Professor Huxley has kindly undertaken to explain in a description of the new fossil.

Trochus imbricatus, *Sow.*
—— Gaudryanus, *D'Orb.*
Turbo.
Chemnitzia Periniana, *D'Orb.*
Ammonites Bronnii, *Röm.*
—— furticarinatus, *Quenst.*
—— Nodotianus, *D'Orb.*
—— Grenouillouxi, *D'Orb.*
—— Henleyi, *Sow.*
—— Bechei, *Sow.*
—— laticostatus, *Sow.*
—— Loscombii, *Sow.*
—— fimbriatus, *Sow.*
And several undetermined species.

Nautilus inornatus, *D'Orb.*
—— semistriatus, *D'Orb.*
Belemnites clavatus, *Blainv.*
—— longissimus, *Miller.*
—— elongatus, *Miller.*
—— acuarius, *Schloth.*
—— brevirostris, *D'Orb.*
Rhyncholites.
Xiphoteuthis Bechei, *Huxley, MS.*
Geoteuthis, sp.
Æchmodus.
Ichthyosaurus communis, *Conyb.*
—— tenuirostris, *Conyb.*

2. *The Green Ammonite-beds.*—These beds, and the higher portion of the non-micaceous marls, contain an assemblage of fossils having many species in common with the beds below. Peculiar to them amongst the Cephalopoda are *Ammonites laticostatus*, Sow., and its aged and extraordinary variety *A. heterogeneus*, Y. & B. (*A. hybridus*, D'Orb.), a species locally known as *A. brevispina* (but not of Sowerby, nor yet I think a mere variety of *A. laticostatus*), and *A. Davœi*, Sow., which is one of the most scarce Ammonites of our locality.

Inoceramus, n. sp.
Chemnitzia Carrucensis, *D'Orb.*
Pterocera liasina, *D'Orb.*
Acteonina, sp.
Straparollus, sp.
Ammonites Bechei, *Sow.*
—— Loscombii, *Sow.*
—— laticostatus, *Sow.*
—— heterogeneus, *Y. & B.*

Ammonites Davœi, *Sow.*
——, sp.
Nautilus semistriatus, *D'Orb.*
Belemnites compressus, *Voltz.*
—— longissimus, *Mill.*
Aptychi of Ammonites.
Ichthyosaurus.
Plesiosaurus.

3. *The Three Tiers.*—These beds are very unfossiliferous, especially in the Golden Cap. The bones of Saurians are, however, occasionally met with, as also Belemnites and the casts of phragmacones, and occasionally an impression or fragment of *Ammonites margaritatus*, *A. Loscombii*, or of *A. fimbriatus* occurs in some of the blocks.

In the marls over them traces of but few fossils are seen, until we come to the layer of small nodules, which contain Ammonites of several species, and other shells. The shelly mudstone above contains, as far as I can judge, the same forms as occur again in the Shell-bed.

4. *The Shell-bed.*—This bed underlies the Starfish-stone, and in it I have found a rich collection of Mollusca, chiefly Conchifera. The only two species of Ammonites which I have obtained from it are *A. margaritatus* and *A. Thouarsensis*, D'Orb. One or two species of Belemnites complete the list of Cephalopoda. Some small species of *Pleurotomaria*, *Trochus*, and *Chemnitzia* occur not unfrequently; but the most abundant shells are those peculiar to this zone, which extends from the small nodules to the Starfish-stone. Numerous genera are represented, as the accompanying list shows. Fragments

of *Pentacrinus* and the spines of *Cidaris* contribute largely to make up the bed. *Cidaris Edwardsii,* Wright, a species very frequent in the Lower Lias, occurs here.

Pentacrinus Johnsonii, *Austin.*
Cidaris Edwardsii, *Wright.*
Crania.
Terebratula cornuta, *Sow.*
—— numismalis, *Lam.*
Rhynchonella furcillata, *Theod.*
Avicula novemcosta, *Brown.*
Lima pectinoides, *Sow.*
Hinnites velatus, *Goldf.*
Modiola.
Hippopodium, young.
Cucullæa elongata, *Sow.*
—— inæquivalvis, *Goldf.*
—— cancellata, *Phill.*
Sanguinolaria vetusta, *Phill.*
Cardinia, sp.
Pholadomya, sp.
Nucula aurita, *Quenst.*
Unicardium cardioides, *Phill.*
Lucina.
Astarte.
Pullastra.
Venus pumila?, *Oppel.*
Isocardia.
Pleurotomaria anglica, *Sow.*
—— araneosa, *Desl.*
—— expansa, *Sow.*
Nerinæa.
Cerithium.
Chemnitzia.
Ammonites Thouarsensis, *D'Orb.*
—— margaritatus, *Montf.*
Belemnites clavatus, *Blainv.*
Teeth of Hybodus.

5. *The Starfish-bed.*—Besides the *Ophioderma Egertoni,* Broderip, this stone affords a closely allied species, or variety, *O. tenuibrachiata,* Forbes. These Echinoderms are collected, as I have already stated, from the under side of the large blocks; in reality the layer beneath which they occur is but a portion, a few inches thick, of the entire stone, and this portion is a more pure sandstone than the part above. As far as one can judge, the thin deposit of purer sand is as local as the occurrence of the imbedded Starfish, and hence the two phenomena appear attributable to the same cause. This consideration, the peculiar situation of the Echinoderms, and the positions in which they occur in the stone, lead me to imagine that we have in this case a true instance of a sudden and accidental deposit and destruction of life, in contradistinction to the gradual and regular mode in which most geological masses were accumulated.

6. *The Grey and Brown Sands with Nodules.*—In these we find here and there a considerable number of organic remains; in some places, lumps composed chiefly of the joints of the stems and arms of *Pentacrinus Johnsonii,* Austin; in others, masses of *Rhynchonellæ* of small size. Intermingled with these are small Gasteropoda and Conchifera, together with fragments of larger shells. The latter, such as *Gryphæa Maccullochii,* Sow., and *Pecten æquivalvis,* Sow., occur very perfect and fine in these sands. *Plicatula spinosa,* Sow., which is found in every collection of fossils from the Belemnite-beds upwards, is here abundant and fine.

In the topmost layer of the nodules, or the "Margaritatus-stone," *Ammonites margaritatus* occurs very large, and occasionally well preserved; as is also *A. fimbriatus,* with which it is associated. From the overlying blue marl I have scarcely seen a fossil, so that I cannot say whether it belongs palæontologically to the sands below or to those above.

Terebratula cornuta, *Sow.*
—— quadrifida, *Lam.*
Rhynchonella tetrahedra. *Sow.*
Lingula Beanii, *Phill.*

Crania, sp.
Gryphæa Maccullochii, *Sow.*
Avicula novemcosta, *Brown.*
Lima, sp.
Plicatula spinosa, *Sow.*
Pecten æquivalvis, *Sow.*
Chemnitzia, sp.
Nautilus semistriatus, *D'Orb.*
Ammonites fimbriatus, *Sow.*
—— margaritatus, *Montf.*
Fragments of Crustacea.

7. *The Brown Sands and Sandstones.*—In these, masses of fossils occur, chiefly collected from the outside of the blocks of sandstone. *Ammonites spinatus*, Brug., is now the characteristic Ammonite, and with it are associated some peculiar *Phasianellæ* and the magnificent *Pinna Hartmanni*. I have two crushed fragments of *Ammonites Bechei* from this zone, and one of *Nautilus semistriatus*, D'Orb.

Ammonites spinatus, *Brug.*
—— Bechei, *Sow.*
Nautilus semistriatus, *D'Orb.*
Belemnites, sp.
Phasianella, two species.
Pinna Hartmanni, *Ziet.*
Goniomya rhombifera, *Quenst.*
Avicula, sp.
Pecten, sp.
Plicatula spinosa, *Sow.*

In the 18 feet of clay over the sands I have found no fossils.

8. *The Marlstone with its Pleurotomaria-bed.*—These beds amply atone for the poverty of the bed beneath. *Ammonites spinatus* is still the characteristic Ammonite, occurring here in great variety. Associated with this most variable and truly Middle Lias form I have obtained specimens of several Upper Lias Ammonites, such as *A. communis*, Sow. and its several closely allied forms, *A. radians*, Schlotheim, and even *A. serpentinus*, Rein.; the first-named species, though not so plentiful, is represented by far larger individuals than in the Upper Lias stone itself. Beautiful as are the Ammonites of this bed, the Gasteropoda are still more remarkable. They are most perfectly preserved, but, owing to the character of the matrix, they are very difficult of extraction. My list, as given below, includes many species of *Pleurotomaria* and *Trochus*, with several of *Turbo*, *Straparollus*, *Phasianella*, *Chemnitzia*, &c. Amongst these are included many of those beautiful shells, figured and described by Deslongchamps and D'Orbigny, from the Middle and Upper Lias of Calvados. Nor are the Conchifera much less remarkable, though even fewer good specimens are obtainable. Many appear to be undescribed species, whilst some are forms but rarely met with; such are *Sanguinolaria cuneata* and *S. vetusta*, figured by Professor Phillips from the Yorkshire coast.

The shells and the pebbles of the conglomerate are coated with *Serpulæ*, and the water-worn stones are perforated by *Lithodomi*.

Brachiopoda are also well represented. *Spirifera Walcotti*, Sow., and *S. rostrata*, Schloth., occur, though rarely. *Terebratula Edwardsii*, Dav., is common, and *T. subpunctata*, Dav., very fine. Several other Marlstone species are represented: *T. resupinata*, Sow., however, which is common in this zone in many localities, is here altogether absent; *T. cornuta*, Sow., elsewhere abundant, is here scarce, being apparently replaced by its variety *T. quadrifida*, Lam., which latter here appears also to have attained to a greater size than elsewhere in England, thus approaching to its Continental types. *Rhynchonella serrata*, Sow., rare elsewhere, is here not uncommon.

Nor is this bed, so valuable in the abundance of its palæontological evidence, less suggestive of physical facts. The thin and interrupted bed which I consider to be the representative of the Marlstone, the pebbles and small boulders imbedded therein, the perforations of the *Lithodomi*, the masses of shells here and there collected into hollows, as it were, of the underlying rock, the *Serpulæ* covering the shells and pebbles, and the very intermixture of Upper Lias species, all point to a sea-bottom upon which, for a long period, little or no deposit took place; the water-worn fragments which lie upon it, on the contrary, indicating that, during that period, previously formed strata were again destroyed. From what I have seen of the junction of the Middle with the Upper Lias, both here and at Glastonbury in Somersetshire, I have been led to believe that, immediately previous to the deposition of the Upper Lias, some disturbing cause for a time changed the direction of the currents which had brought here the mud and sand of the Lower and Middle divisions, and that, in place of continuing gently to lay down these deposits, the action of the water was for a time, and over certain districts, confined to the destruction of beds previously formed and consolidated*.

Serpula, two species.
Apiocrinites ?
Pentacrinus ?
Holectypus hemisphæricus, *Desor.*
Thecidea Moorei, *Dav.*
Terebratula punctata, *Sow.*
—— subpunctata, *Dav.*
—— numismalis, *Lam.*
—— quadrifida, *Lam.*
—— Moorei, *Dav.*
—— cornuta, *Sow.*
—— Edwardsii, *Dav.*
Rhynchonella tetrahedra, *Sow.*
—— serrata, *Sow.*
—— subconcinna, *Dav.*
—— furcillata, *Theodor.*
—— Moorei, *Dav.*
—— cynocephala, *Richard.*
—— acuta, *Sow.*
Spirifera rostrata, *Schloth.*
—— Walcotti, *Sow.*
Lingula, sp.
Perna, sp.
Lima punctata, *Sow.*
—— antiquata, *Sow.*
Pecten dentatus, *Sow.*
—— textorius, *Schloth.*
——, sp.
Hinnites velatus, *Goldf.*
Gryphæa Maccullochii, *Sow.*
Gryphæa gigantea, *Sow.*
Myacites unionides, *Goldf.*
——, two other species.
Mytilus, sp.
Modiola, several species.
Goniomya, sp. (aspera, *Etheridge, MS.*).
Isocardia, sp.
Cypricardia, sp.
Ceromya, sp.
Cardinia concinna, *Stutchb.*
—— cuneata, *Stutchb.*
—— Listeri, var. hybrida, *Stutchb.*
Cardita, sp.
Unicardium cardioideum, *Phill.*
Sanguinolaria vetusta, *Phill.*
—— cuneata.
Mytilus hippocampus, *Y. & B.*
Cardium truncatum, *Sow.*
——, sp. (Dayii, *Etheridge, MS.*).
Arca, sp.
Cucullæa inæquivalvis, *Goldf.*
Pholadomya ambigua, *Sow.*
Lithodomus, sp.
Trochus Gaudryanus, *D'Orb.*
—— monoplicus, *D'Orb.*
—— epulus, *D'Orb.*
—— Emylius, *D'Orb.*
—— Eolus, *D'Orb.*
—— Mariæ, *D'Orb.*

* Since the above passage was written, I have found a notice of this bed, which I had previously overlooked, in a paper by Buckland and De la Beche, "On the Geology of the Neighbourhood of Weymouth, &c." It shows clearly to what formation these beds were in those days assigned, and that the conglomerate-bed and its meaning had been studied years ago by those eminent observers. (See Geol. Trans. 2nd ser. vol. iv. p. 31.)

Turbo Itys, *D'Orb.*
—— Nireus, *D'Orb.*
—— Midas, *D'Orb.*
Pleurotomaria mirabilis, *Desl.*
—— precatoria, *Desl.*
—— bitorquata, *Desl.*
—— sulcosa, *Desl.*
—— rustica, *Desl.*
—— procera, *D'Orb.*
—— pinguis, *D'Orb.* (?).
—— rotellæformis.
—— expansa, *Sow.* sp.
Straparollus sinister, *D'Orb.*
——, sp.
Phasianella, two species.
Turritella, two species.
Chemnitzia, sp.
Pitonillus, sp.
Ammonites crassus, *Phill.*
—— communis, *Sow.*
—— Holandrei, *D'Orb.*
—— spinatus, *Brug.*
—— fimbriatus, *Sow.*
—— serpentinus, *Rein.*
—— radians, *Rein.*
—— Raquinianus, *D'Orb.*
Belemnites, several species.
Ancyloceras, sp.
Fish-scales and fragments of Crustacea.

9. *The Upper Lias Limestone.*—In the lower part of the Upper Lias Limestone, that is, immediately over the ferruginous seam, I have found *Ammonites serpentinus*, Rein., in some abundance, though badly preserved.

In the upper part of the same stone occurs *Ammonites bifrons*, Brug., which I have not met with below, associated with several other Upper Lias species of Ammonites, Gasteropoda, and Brachiopoda.

Terebratula, a small species.
Rhynchonella Bouchardii, *Dav.*
—— Moorei, *Dav.*
Leptæna liassina, *Bouchard.*
Crania, sp.
Cardinia, sp.
Astarte elegans, *Sow.*
Trochus trimonilis, *D'Orb.*
—— Ægion, *D'Orb.*
Ammonites bifrons, *Brug.*
—— Raquinianus, *D'Orb.*
—— radians, *Rein.*
—— communis, *Sow.*
—— serpentinus, *Rein.*
—— complanatus, *Brug.*
—— Holandrei, *D'Orb.*
Nautilus, sp.

In the Upper Lias Clay I have found no fossils, and it may be observed that I have not met with any trace of the fish-bed of Ilminster and Dumbleton in our series of beds.

10. *The Cephalopoda-beds.*—The lower and greater portion of the Upper Lias sands have afforded me no fossils, excepting a few impressions of *Ammonites radians*; but in the topmost part, or Cephalopoda-beds, I have found several species of Ammonites. *A. Jurensis*, Ziet., *A. opalinus*, Quenstedt, and *A. variabilis*, D'Orb., are all forms assigned to the 'Jurensis-stage' of Continental geologists, and the fossils of other classes associated with these Ammonites all belong rather to the Upper Lias than to the Inferior Oolite.

Ammonites Jurensis, *Ziet.*
—— variabilis, *D'Orb.*
—— opalinus, *Quenst.*
Nautilus latidorsatus, *D'Orb.*
Belemnites, two species.
Myacites unionides ?, *Goldf.*
Goniomya, sp.
Pecten barbatus, *Sow.*
Terebratula, sp.
Rhynchonella tetrahedra ?, *Sow.*
—— cynocephala, *Richard.*

11. *Conclusion.*—If we now review the chief features of the different lists of fossils given above, we shall be able to obtain a better idea of the vertical distribution of particular forms (see fig. 5).

To begin with the Ammonites. These, with some exceptions, have more or less restricted ranges, and in no case does the range of an Ammonite equal that of some of the most widely distributed Conchifera. *Ammonites Henleyi*, Sow., *A. laticostatus*, Sow., and several other species characterize the Belemnite-beds and some of the beds immediately above them. *Ammonites Davœi*, Sow., occurs only in the Green Ammonite-beds, in the uppermost layer alone of which is found the form locally known as *A. brevispina*. *A. margaritatus*, Montf., appears with the sand and mica in the "Three Tiers," and disappears again with a deposit of marl; its place is, however, on the recurrence of sand, supplied by a closely allied form, *A. spinatus*, Brug. This species is succeeded by *A. serpentinus*, Rein., and that again by *A. bifrons*; after which is a wide gap assignable to no particular form. Above this interval *A. Jurensis* occurs, underlying the zones of the Inferior Oolite. But though these and most Ammonites have their zones well marked and restricted, it is not so with all. For instance, *A. Loscombii* appears with *A. Henleyi*, abounds with *A. laticostatus*, and goes some way up into the range of *A. margaritatus*, where it makes its last appearance in the layer of small nodules below the shelly marl. It thus passes through most of the grey marls, but does not reach to the permanent appearance of the sand. *A. fimbriatus* and *A. Bechei* are still less restricted, the latter appearing in the Belemnite-beds, and showing itself, in occasional specimens, as far up as the sands of the 'Spinatus-zone'; the former ranging still more widely, from the same starting-point up to the very summit of the Middle Lias. These forms are thus found not only in strata some hundreds of feet apart, but in the highest and lowest of a series of at least four of the more restricted ranges.

But if the ranges of the Ammonites are not very limited, neither I apprehend are those of some of the other Cephalopoda; *Nautilus semistriatus* I find ranging coextensively with *Ammonites Bechei*, and I cannot distinguish some of the Belemnites of the Marlstone from those of the Belemnite-beds.

In the Gasteropoda and Conchifera we find the vertical ranges of several species of very various extent; but they do not appear to me to coincide so much with the distribution of particular Ammonites as with other accidental circumstances. The Conchifera of the Belemnite-beds occur also in the Green Ammonite-marls, but not in the shell-bed under the sand, excepting such a ubiquitous form as *Plicatula spinosa*, Sow. Some of the Gasteropoda, on the other hand, occur also in the Pleurotomaria-bed associated with *Ammonites spinatus*.

The Shell-bed under the Starfish-bed has, as I have said before, many forms peculiar to a zone lying above the frequently mentioned "layer of small nodules" and below the sands, but many of its species occur again above, and these are represented by far finer specimens in the sands. It would thus appear that *Ammonites margaritatus* occurs in two faunas, which, though blending together at their junction, are yet very distinct. In the lower part of the 'Spinatus-zone' there appears to be a different fauna from that of the sands below, and in its upper portion occurs the most remarkable collection of Mollusca of any in the Lias. Along with many new and curious forms are others that I have observed in some one or other of the Middle Lias beds below. And yet, with all the diversity in the extent of the various ranges, we cannot help feeling surprised at meeting here with species that occur far down in the Lower Lias. Such however are, amongst others, *Lima punctata*, Sow., *Lima pectinoides*, Sow., *Cardinia hybrida*, Stutchb., and *Spirifera Walcotti*, Sow., all of which I have myself found in the 'Angulatus-beds' to the west of Lyme. What makes the appearance of these forms so high up the more remarkable is that I have not found them in intermediate strata. The few fossils that I have cited from the Upper Lias and the Cephalopoda-beds do not justify any observations beyond those I have already made—at least, not on the present occasion.

The higher forms of life—fish and reptilia—occur so sparingly in our Middle Lias, that in these likewise there are no materials upon which to generalize.

The questions which arise upon the facts of the distribution of fossils, as herein given, are to my mind of the greatest interest and importance. It would be impossible, however, to treat of such questions in a satisfactory manner without extending my observations beyond the scope of the present paper. In a future communication I hope to lay before the Society some speculations upon the history of the Lias, which have originated in a consideration of the distribution of inorganic materials and organic forms throughout that formation in this district. The details into which I have entered in this paper have been for the purpose of describing some of the less-known facts upon which I have based my theoretical views.

I cannot conclude this paper without expressing my obligations to my friend Robert Etheridge, Esq., F.R.S.E., F.G.S. The sections which he had made, and the knowledge which he had acquired upon the spot before I began my work, he kindly placed at my disposal for reference and comparison; the many fossils which I have entered on my lists have all been submitted to his examination; and before I completed my paper, he kindly went over the various sections with me, so as the more authoritatively to give me the support of his judgment as to the correctness of my measurements and descriptions.

March 4, 1863.

Francis Drake, Esq., Leicester; Il Commendatore Devincenzi, Member of the Italian Parliament, Ministry of Agriculture and Commerce, Turin; Cav. C. Perazzi, Royal Corps of Mining Engineers, Turin; O. C. Marsh, Esq., M.A., 14 Linkstrasse, Berlin; and John Watson, Esq., Whitby, were elected Fellows.

The following communication was read:—

1. *On the* Permian Rocks *of* North-eastern Bohemia. By Sir Roderick I. Murchison, K.C.B., F.R.S., F.G.S., &c., Director-General of the Geological Survey of the United Kingdom.

Lithological Characters.—The Permian rocks of Bohemia differ from those of North-western Germany in not comprising a calcareous member containing marine remains, to represent the German Zechstein, or Magnesian Limestone of Britain. They have all, therefore, been referred by native geologists to the Roth-todt-liegende, or what I call Lower Permian. Being furnished by my old friend M. Haidinger with the Map of the Austrian Geological Survey of the tract lying to the south of the Riesengebirge, I endeavoured to complete my acquaintance with those deposits which, in a previous year, I had seen in the environs of Braunau and Charlottenbrunn, on the south-eastern slopes of the same chain. On this occasion I examined them on the line of railroad from Pardowitz and Josefstadt to Liebestadtl and Semil; which railroad, having a direction from S.W. to N.E., exhibits a complete transverse section of the whole group. I was accompanied by Dr. Anton Fritsch, of Prague, whose accomplishments as a naturalist and geologist were of the greatest service, and without whose assistance in talking his native Bohemian language I could have acquired little information on the spot.

In 1857, M. Emil Porth described these deposits in a memoir published in the 'Jahrbuch der k. k. geologischen Reichsanstalt'*. First enumerating the varieties of crystalline and metalliferous rocks of which the southern portion of the Riesengebirge is composed, he shows how the lowest member of the 'Roth-liegende,' or his 'conglomerate,' dips away from the older chain at angles varying from 20° to 48°, with some intercalated shale-beds containing Plants. He speaks of a bed of bituminous schist or 'Brandschiefer' near the base of the series, which contains remains of Fishes and Plants and gypsum-crystals. Above these he notices a succession of particoloured argillaceous sands and clays, containing copper-ores; and then the peculiar sandstone which is termed 'arkose'—in parts a coarse grit, and partly conglomeratic, with some manganese. In other parts this so-called arkose is a sandstone with interpolated layers of dark-red and white, fine-grained sands, and small courses of limestone. Then follow sands and argillaceous beds, limestone, marls, and other bituminous schists; the culminating masses of the whole group being deep-red shale and micaceous sandstone, with harder siliceous beds. Besides these varied deposits, M. Porth mentions thick bands of regular interstratified igneous rocks, chiefly the melaphyr-porphyry, with amygdaloids and traps, quartzose porphyry, bands of basalt, &c.

The most recent, however, of the descriptions of the Roth-liegende of this tract is by M. Jokely, and was published in 1862†. This author (who surveyed the tract, and prepared the Austrian geological map thereof, with which I was obligingly furnished by M. Haidinger, as stated above) divides the Roth-liegende into three principal parts. The uppermost of these consists chiefly of hard shales and marl, with some sandstone, a little limestone, and some harder siliceous beds; the second of other and darker-coloured marls, shales, and sandstones, passing down into arkose-grit and sandstone; and the third of bituminous shale (Brandschiefer and Schiefer), intercalated

* Bericht über seine diesjahrigen geologischen Aufnahmen in Nord-östlichen Böhmen. Seite 701.

† Jahrb. der k. k. geol. Reichsanstalt Wien. 1862, No. 3, p. 381.

with and resting on sandstone and the coarse lower conglomerate.

My own method of dividing the series, such as it was presented to me in a section from the south of Liebestadtl to Semil, is as follows, irrespective of the exact places of the igneous rocks in other districts:—1st. Overlying red marls and sandstones (see figure, p. 301, Nos. 1–5), which in the sequel will be noticed as possible equivalents in time of the Zechstein of Northern Germany. 2nd. Dark-coloured bituminous shale, with some limestone, coal, and many organic remains, including numerous Fishes, and passing into sandstone and grits, with abundance of Plants (6–10). 3rd. Lower sandstones and conglomerates (11–13).

This triplex series has been subdivided by the Austrian Surveyors into eight parts, each part distinguished on the map by a different colour. To these are to be added the igneous rocks called melaphyr- and felsite-porphyry, as well as certain members of basaltic rock; whilst thin seams of coal and limestone also form integral parts of this compound group*.

* As my inspection of this tract was hasty, I cannot pretend to affirm that the details which I describe in this section are applicable to the whole of the wide Permian region lying to the south of the Riesengebirge. According to the table of colours in the Austrian Geological Map, No. IX., the tract around Liebestadtl is occupied by sandstone and schist, marked No. 14, whilst two other subdivisions, which constitute the 'upper stage' of the Austrian Surveyors, consist of schists and marls, with hornstone and bituminous schist (Brandschiefer and brownish-red argillaceous beds), the Nos. 11 and 12 of the map. As I nowhere saw such an order of superposition, I have not alluded to it In fact, all the dark-coloured schistose and bituminous rocks which I saw between Liebestadtl and Semil pass distinctly *under* the sandstone to the south of the Liebestadtl station, and rest on older sandstones and conglomerates. It is, indeed, evident, from an inspection of the two Austrian maps only (Nos. IX. and X.), that the general succession is that which I have indicated. Thus, in the eastern portion of the sheet No. IX., we find that on the flanks of the crystalline rocks of the Riesengebirge, the lower conglomerates and sandstones, with some schists, are followed by other sandstones, the arkose of the authors, and, thirdly, by the widely spread red sandstones and marls (the No. 14 of the Austrian Table), which range from Trautenau and Pilnekaw on the east to Liebestadtl and Lomnitz on the west.

Again, one of the arkose-sandstones, which underlies No. 14 on the north, or towards the Riesengebirge, rises again in the south, and throws the overlying beds, No. 14, into a trough. It is specially in the western half of the sheet No. IX., or the neighbourhood of Hohenelbe, that the bituminous schists occur, and, where I saw them, they most assuredly underlie the red sandstones and marls south of Liebestadtl, as in my section. Since the arrows inserted on the map, as regards this tract, indicate the south-easterly dip correctly, and are in accordance with my section, it is probable that, in the complication of colours used, an error may have arisen, for which the original observer is not responsible. The succession which I found in this section is exactly analogous to that which I formerly described as occurring at Braunau, far to the east, where limestones and bituminous schists, with *Palæoniscus*, &c., reposing on older sandstone and conglomerate, are surmounted by red sandstone, &c. (See 'Siluria,' 2nd edit. p. 343.)

In the table of colours of the Austrian Geological Map, the igneous rocks termed felsit-porphyry and melaphyr are placed above all the divisions of this group, from which I presume that the author, M. Jokely, wished to show that these eruptive rocks traverse all the strata, and occasionally overlie them. From my observation, however, I should infer that these rocks are for the most part regularly associated with several members of the group. Thus, near Semil, It seems to me, therefore, that the term Roth-todt-liegende, which was first simply applied to the pebbly unproductive rock beneath the Zechstein and Kupferschiefer, ought no longer to be applied to such a diversified series of deposits of various colours and of very different lithological structure, and which contain copper-ores and many fossils.

Let me here state, that true Carboniferous rocks, with coal, as worked in the north-eastern part of the territory under consideration, crop out unconformably from beneath the conglomerate and bottom-beds of this Permian series.

But to call attention to the tract which I last examined. After passing an outlier of old and crystalline rocks to the north-west of Königinhof, we first halted at the Station of Falgendorf, to the west of which we made an examination of the harder sandstones of Alt Paka, through alternations of red sandstone, mapped as arkose by M. Jokely, and which are overlain, in a fine escarpment, by a zone of melaphyr and amygdaloid. The latter is followed by very hard cherty sandstone, and then surmounted by the softer red and greenish sandstone and marls of Falgendorf, which form the upper members of the series. As all these strata are inclined to the N.E., and had been thrown into undulations, a reversed dip might naturally be expected to occur where these deposits approached the chain of the older rocks of the Riesengebirge, to which we were travelling.

Such proved to be the case. After passing certain masses of porphyry and amygdaloid, and on travelling to the N.W., we met with extensive masses of marls or shales with red sandstones and marls, occasionally greenish and whitish, which at Liebestadtl* assumed a steady or reversed dip to the S.E., or away from the older rocks of the Riesengebirge. Between Liebestadtl and Semil the railroad lays open so clear a descending section of the whole group, from the overlying red marls and sandstones to the underlying conglomerates which repose on the older slaty rocks, that, after fixing our quarters at Semil, my companion and myself re-examined on foot nearly all the intervening cuttings as laid open by the railroad, and also made excursions to the east of the little town of Semil.

The result, as exhibited in the accompanying section, is simply offered to convey a clear general idea of the succession; it being understood that in the midway portion of the distance the continuity of the order is not well exposed.

The following is the descending order of the strata:—

1. Red marls and traces of limestone, with micaceous sandstones, in parts spotted, in parts flaggy. These beds are of considerable thickness, and dip to the S.E., being on the limits of the diagram.

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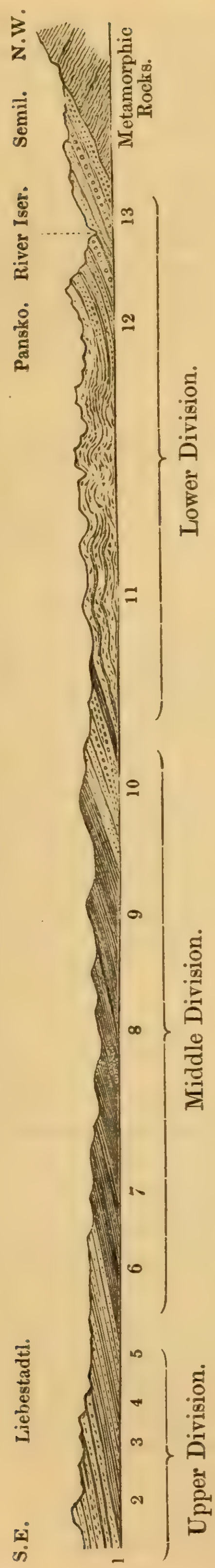
basaltic clinkstone forms tabular masses on one of the lower members, midway to Liebestadtl, with the schists of the central part; and near Falgendorf and Alt Paka the melaphyr occupies the summits of hills of red marl and sandstone. In my section I have only represented these igneous rocks as I saw them in that particular tract. Most of these may therefore be considered as contemporaneous with the deposits.

* At Liebestadtl we profited by the attention of the intelligent clergyman of the village, the Rev. J. Marishka, who presented to me two good specimens of fossil Fishes out of his little collection, and was very useful and obliging.



Section across the Permian Rocks of North-Eastern Bohemia (5 to 6 miles).

This member of the group was not much examined by us, and I can by no means affirm that it does not contain fossil remains.

2. Sandstone, becoming more marly and argillaceous.

3. Thicker-bedded sandstone, passing down into

4. Dark-coloured shale.

5. Coarser and reddish-brown sandstone in dark-coloured shale.

6. Blackish shale, with small nodular concretions of cement-stone and septaria, passing down into thin laminæ of argillaceous limestone, with concretionary potato-stones, Fish-scales, and Coprolites.

7. Thin courses of black shale, graduating with dark bituminous flagstones, with fossil Fishes — *Palæoniscus*, &c. (These occur a little to the north of the Liebestadtl station, at Kostialow.)

8. Sandy and argillaceous dark-coloured shale, becoming in the lower part what is locally called 'Thon-schiefer.' In the lower part is one layer of thin flinty limestone, concretionary in parts, and below it the bituminous shale graduates into a true coal, with impressions of Plants in the associated shale. This coal was formerly worked to some extent in the adjacent hill of Cikoasko, though as exposed on the side of the railway it is of small thickness.

It is in this portion of the series, and particularly in its western extension to Hohenelbe, that many of the Fishes and Reptiles have been found which characterize this central member of the group. The dip here is about 20° to the S.E.

9. Brown shale with strong sandstone bands of about 6 feet each in thickness. These sandstones graduate into the so-called 'arkose' of the Austrian Surveyors, one of the lower beds of which is a conglomerate, with many pebbles of white quartz. Fossil plants (notably large stems of *Araucarites*) occur in the sandstones and shales.

10. Courses of 'copper-slate,' contain-

ing fine blue carbonate of copper, with some coaly matter, and footprints of small Reptiles in the accompanying shale. Copper-works were formerly in activity here. It is in the extension of these shale-beds that the best Reptilian footprints have been obtained at Kalsia, near Hohenelbe.

11. Argillaceous beds, becoming more sandy downwards. These occupy a considerable thickness, and are exposed in partial undulations. On the whole, however, they rise to the N.W., and are associated with much melaphyr (amygdaloid) and thin-bedded basalt or clinkstone, which is exposed in great tabular masses in the hill called Pansko, and are accompanied by hardened sandstone and shale; the whole dipping away to the S.E., from Semil and the valley of the Iser.

12. Reddish glossy shale, and thin courses of grit, with ripple-marked surfaces and many Plants (Calamites and Ferns), alternating with bluish-grey beds. In a dark, papyraceous, leather-like schist are the lowest Fish-remains, *Palæoniscus*, &c.; and the section, as terminated in a north escarpment on the river Iser, exhibits at its base sandstone and grit, which are succeeded by

13. The bottom-rock of the series. This consists of coarse conglomerates of water-worn and well-rounded pebbles of the older crystalline rocks of the Riesengebirge, which, alternating with bands of coarse gritty sandstone, are well seen to the north of Semil. These beds, of very great thickness, dip under and support all the before-mentioned succession, and rest in their turn on the subcrystalline, Palæozoic, or metamorphic rocks of the Riesengebirge*.

Organic Remains.—In his excellent new work, 'Dyas' (to the *name* only of which I demur), Professor Geinitz describes the following organic remains as belonging to the Roth-todt-liegende, or his Lower Dyas. A large portion of these fossils occur in Bohemia, and many species are common to the same rocks in Saxony, Bohemia, Russia, and other tracts:—

Saurians in the Roth-liegende.	Localities.
Sphenosaurus Sternbergi, *V. Meyer* ...	Königratz, Bohemia.
Phanerosaurus Naumanni, *V. Meyer* ...	Oberlungwitz, near Hohenstein.
Osteophorus Roemeri, *V. Meyer*	Klein Neundorf, Silesia.
Rhopalodon Wangenheimi, *Fisch.*	Dioma, Bielabei, Corlavisk, and Nischi Troitsk, Russia.
—— Murchisoni, *Eichw.*	Bielabei (Copper-sandstone), Russia.
Deuterosaurus biarmicus, *Eichw*..........	Klutchewski, Dioma, Bielabei, Russia.
Zygosaurus lucius, *Eichw*....................	Copper-sandstone, W. Ural.
Melosaurus Uralensis, *V. Meyer*	Nischi Troitsk, Russia.
Onchiodon labyrinthicus, *Gein.*	Plauenschen Grunde, Dresden.
Saurichnites salamandroides, *Gein*.......	Hohenelbe, Bohemia.
—— lacertoides, *Gein.*	Ebendaher, Bohemia.

In all nine genera and eleven species of Saurians in the Roth-liegende; whilst in the Kupferschiefer two only, the *Protorosaurus* and *Parasaurus*, are known.

* M. Porth estimates these lower beds as being 600 feet thick.

Fishes in the Roth-liegende.	Localities.
A Sauroid genus, *Gein.*	Plauenschen Grunde, Dresden.
Palæoniscus Vratislaviensis, *Ag.*	Klein Neundorf, Rappendorf, Braunau, Hohenelbe, Bohemia; Erbendorf in the Palatinate.
—— lepidurus, *Ag.*	Klein Neundorf, Rappendorf, Braunau, Hohenelbe, Bohemia; Erbendorf in the Palatinate.
—— Blainvillei, *Ag.* (Rohani, *Hecker*)	Semil, Bohemia.
—— obliquus, *Hecker*	Semil, Bohemia.
—— luridus, *Hecker*	Semil, Bohemia.
—— caudatus, *Hecker*	Ebendaher, Bohemia.
—— Reussi, *Hecker*	Ebendaher, Bohemia.
—— angustus, *Ag.*	Hüttendorf, Hennersdorf, and Hohenelbe, Bohemia. Also from Pont de Muse, near Autun, France.
—— Kablikæ, *Gein.*	Hüttendorf, road to Ob Kalna, Bohemia.
Acanthodes gracilis, *Beyr.*	Klein Neundorf, Hohenelbe, Bohemia; Oschatz, Saxony.
Xenacanthus Decheni, *Goldf.*	Klein Neundorf, Braunau, Hohenelbe, and other places in Bohemia, as well as at Oschatz in Saxony.

Thus, while nine species of *Palæoniscus* occur in the so-called 'Roth-liegende,' seven other species of the same genus occur in the Kupferschiefer or marl-slate at the base of the Zechstein. Is the one set to be considered of marine, and the other of freshwater origin? or may they not all be of estuarine characters?

The north-eastern part of Bohemia is characterized by an abundance of the stems of the large silicified fossil trees, *Araucarites*. In former communications I have alluded to the great abundance of this plant in the escarpments of the Lower Permian rocks south of the Harz*. Again, at Radowenz, to the west of Braunau, in Bohemia, I have alluded to its occurrence†. At the last-mentioned locality, and also at Peckau, which lies a little to the west of the line of section just described, the bed of indurated sandstone in which these great plants are included being at the surface, and nearly horizontal, the huge stems are seen to be spread over several acres of land. A large collection of these is to be seen at the seat of the Prince Lippe-Schoenburg. They are indeed common in many museums; and one of the largest specimens with which I am acquainted, measuring 5½ feet in diameter, was pointed out to me in the Zwinger, at Dresden, by Dr. Geinitz.

Referring to the description of the Permian plants by Dr. Göppert, I would remind my associates that this eminent botanist has shown that, as a whole, they contain about eight per cent. of Carboniferous species of plants ‡. Dr. Geinitz has also come to the same conclusion. Now, independently of the clear order of superposition which the Upper Carboniferous strata bear to the lowest division of the Permian, or bottom-beds of the Roth-todt-liegende, any one examining the public collection at Dresden at once sees that the

* For references see 'Siluria,' 2nd edit. p. 337.
† *Ibid.* p. 343. ‡ *Ibid.* pp. 355, 356.

characteristic fossil Permian plants, such as the typical *Psaronites* and *Araucarites*, *Guglielmites Permianus*, Gein., *Alethopteris prismatifolia*, Gein., *Walchia pisiformis*, *Sigillaria Danziana*, Gein., *Nœggerathia*, and *Neuropteris* of peculiar species, are all plants of this particular period, and differ essentially from those of the Carboniferous age.

Concluding General Observations.—Though it is out of my power to make a correct estimate of the thickness of the strata exposed in the section above described, yet, as the distance from a mile south of Liebestadtl, where the upper beds have already a dip to the S.S.E., to a spot north of Semil, where the conglomerates or bottom-beds of the series still dip in the same direction at an average angle of about 10° to 15°, is about five or six miles, we cannot but assign a vast thickness to these deposits, even allowing for a certain amount of undulation and repetition in the central part of the section. For in this case the succession is not only one of beds of red sandstone and pebble-beds with porphyries, such as the geologists of North Germany have hitherto regarded as the Roth-liegende, but it consists of diversified alternations of sands, marls, bituminous shales, copper-schists, limestone, hard and soft sandstones, and conglomerates, with interpolated porphyries and other igneous rocks.

Any doubt which might have existed as to the thickness of the whole, as derived from a transverse section like the preceding made across the strata which are successively exposed at the surface, has, however, been set aside in other places where no such great variety in the strata occurs. Thus, near Eisenach, in the borings alluded to in former communications, 2600 feet of sandstone and conglomerate-beds were passed through in search of coal*. Recently, indeed, still more satisfactory evidence has been transmitted to me by Professor Naumann of Leipzig, who is about to bring out a work descriptive of the two great divisions into which he separates the Roth-liegende or Lower Permian of Saxony. His upper division, of considerable dimensions, consists of schistose red clay and marl, sandstone, and fine conglomerate. A shaft has actually been sunk at Erlbach through 2200 feet of the lower Roth-liegende only, with its conglomerates and interstratified porphyries, claystone, and tuffs.

At that depth of 2200 feet true Carboniferous strata were indeed reached; but by the last accounts no bed of coal had been found in them, though the Carboniferous formation had been penetrated to the additional depth of 400 feet, making the total depth of the pit 2600 feet.

After this last-mentioned positive evidence of the order of superposition, showing that the lowest member of the Permian rests unconformably on subjacent Carboniferous strata, coupled as the fact is with the demonstration of Professors Göppert and Geinitz that the fossil flora of these beds is distinct from that of the Coal-period, and also with the physical proofs brought forward by Geinitz as to the clear and unconformable separation of the two, it is to be hoped that my able contemporary, M. Beyrich, will no longer class the Roth-liegende with Carboniferous deposits.

* See 'Siluria,' 2nd edit., p. 333.

In Germany, as in Britain, there are two zones of the Carboniferous group, each of which has been clearly described by Geinitz. The lower of these, which Professor Sedgwick and myself showed, in the year 1839, to be of the age of our Mountain-limestone, has been elevated with, and is conformable to, the Palæozoic rocks (Devonian and Silurian) beneath it,—a phenomenon which ranges, indeed, through Germany and France. The other, or overlying, coal-field, like that of Bohemia and Saxony, is quite unconformable to the lower, and is also quite unconnected with the base of the Permian,—it having been clearly shown by Geinitz that its surface was abraded before the lowest portion of the Roth-todt-liegende was deposited; whilst the latter formation contains within it rolled fragments, derived from the uppermost coal-strata in the environs of Dresden. It is thus proved that the Permian group is independent of all the subjacent Palæozoic rocks, as established by stratigraphical and palæontological data.

In concluding this sketch of the Permian rocks of Bohemia, let me add a remark or two on the physical and geological conditions under which these deposits may have been accumulated. Unlike the Permian rocks of Northern Germany and England, the conglomerates, sandstones, shales, marls, and limestones which constitute the so-called Roth-liegende of Bohemia are not overlain by the Zechstein with marine shells. Nor, as in Russia, do we meet with alternations of deposits which were unquestionably marine with others which, from their plants and some of their included remains, were probably of lacustrine and terrestrial characters, showing rapid alternations of level.

That portion of the Bohemian deposits which is most richly charged with fossils has, from the character of its imbedded animal remains, been referred by Geinitz to a freshwater origin. But if it be granted that the small lizards which formed the impressions called *Saurichnites* are of terrestrial origin, is it settled that all the Fishes which have been enumerated lived in fresh water? I confess that on this head I am very sceptical, after seeing what has transpired respecting the fishes of the Old Red Sandstone of Scotland, which for a time were believed to have lived in fresh water, but which in Russia have been found associated with unquestionably marine shells. Leaving, however, naturalists to settle these points by some direct working out of the true affinities of these fishes, I may state that my friend Sir P. Egerton is of opinion that the *Palæonisci* were probably fishes that lived in estuaries. On this point I would observe that, after all, these Bohemian ichthyolites do not differ essentially from those of the copper-slate of Northern Germany, which constitutes the natural base of the Zechstein, just as the marl-slate is the bottom of the purely marine Magnesian Limestone of England. Now, what if, in this great development of Permian strata in Bohemia, the upper red marls and sandstones of considerable thickness, which there overlie the bituminous and cupriferous schists with Fishes, should be found to contain a few sea-shells like the red Permian marls at Manchester, and of forms like those in the Zechstein? Why, then the conclusion would fairly be drawn, that in Bohemia, as to the west of the Pennine chain in England, there exists a full Permian series, but with a different mineral-development from that of Northern Germany.

Throwing out this hypothesis as a caution, I would only add that the well-rounded pebbles of the coarse and fine conglomerates, which compose the lowest member of the group, seem to me to have been formed by the waves of a sea beating on the shore of an estuary, adjacent to which exuberant forests prevailed, with trees like the *Araucarites* and *Guglielmites*, which must have required a genial if not a warm climate to bring them to their large dimensions. When we also consider that these water-worn sediments are at intervals interlarded with outpourings of igneous matter, in the form of porphyries, basalts, tuffs, and amygdaloids, we have before us nearly all the material data for speculating upon the condition of large portions of the surface of the northern hemisphere at the close of the Palæozoic era, and antecedent to the origin of those new orders of Animals and Plants which began to prevail in Mesozoic times.

March 18, 1863.

Samuel Baines, Esq., Holroyd House, Lightcliffe, near Halifax; Hilary Bauerman, Esq., Geologist of the North American Boundary Survey; Robert Mushett, Esq., Royal Mint, Tower Hill; and Frank M'Clean, Esq., B.A., C.E., late Scholar of Trinity College, Cambridge, 2 Park Street, Westminster, were elected Fellows.

The following communications were read:—

1. *On the* Correlation *of the several* Subdivisions *of the* Inferior Oolite *in the* Middle *and* South *of* England. By Harvey B. Holl, M.D., F.G.S.

(Abridged.)

Introduction.—The Inferior Oolite in the South of England comprehends two well-defined subdivisions: namely, an upper member, consisting of light-coloured, coarse-grained, more or less thin-bedded or flaggy oolite, containing few fossils, and those chiefly in the form of casts; and a lower member of hard, brown, ferruginous lime-rock, often much speckled with ovoid grains of peroxide of iron, and abounding in fossil remains. The relationship which these two beds hold with respect to the other members of the Inferior Oolite has been differently viewed by geologists.

The late Mr. Strickland evidently regarded the lower brown fossiliferous limestone as the equivalent of the Cephalopoda-beds of Haresfield Hill*.

On the other hand, Dr. Lycett, referring to the same bed at Dundry, remarks that, "considering the position of the Mollusca-bed beneath the Freestones, and overlying the Cynocephala-stage, it

* Quart. Journ. Geol. Soc. vol. vi. p. 250 (1850), as quoted by Dr. Wright.

may approximately be placed upon the parallel of the Cheltenham ferruginous pisolite."*

More recently, Dr. Wright communicated to the Geological Society a paper in which these lower beds at Dundry form the type of his "zone of *Ammonites Humphriesianus*," while the white-oolite beds above constitute his "zone of *Ammonites Parkinsoni*." The former he has referred to the horizon of the Upper Freestone of the Northern Cotteswolds, and the latter to that of the Trigonia- and Gryphite-grits†.

The result of my own investigations is at variance with each of these views; and, having followed the beds stratigraphically along the line of their outcrop, I shall endeavour to show that their true position is higher in the series than is stated by any of these geologists, and that they are, in fact, the southern extensions of the Upper and Lower Ragstones of Mr. Hull, the uppermost of which is not represented in the typical section at Leckhampton, having risen above the level of the country, and cropped out before reaching the brow of the hills.

Southern side of the Mendips.—On the southern side of the Mendips the Inferior Oolite nowhere exceeds 28 or 30 feet in thickness, of which from 8 to 10 feet belong to the lower subdivision. The upper subdivision immediately underlies the Fuller's Earth; and its light colour, lithological structure, and general poverty in organic remains readily distinguish it from the hard, brown, more or less massive or rubbly limestone beneath, which is everywhere very fossiliferous.

Both members are well exposed in quarries and lane-side sections, along the whole length of the belt of oolite as it ranges through Dorsetshire and Somerset, but especially so in the neighbourhood of Bridport, Yeovil, Castle Cary, Bruton, and, further to the north, at Batcombe, and on the hills east of Shepton Mallet. At the "Half-way House," between Yeovil and Sherborne, we find the following section, which fairly represents the general characters of both subdivisions:—

Section at the "Halfway House."

	feet.
A. Upper Ragstone. Thin-bedded oolite, with partings of brown, sandy, laminated clay	13
B. Lower Ragstone:—	
1. Hard, ferruginous, thick-bedded limestone, divided near the middle by a soft, friable, light-coloured band	6
2. Hard, light-coloured, fine-grained, sandy limestone....	3

The upper part of *B* contains many Ammonites; and the soft friable band which divides the bed contains several species of Gasteropods in a fine state of preservation, and also *Collyrites ringens*, *C. ovalis*, *Hyboclypus gibberulus*, *Terebratula Phillipsii*, *T. sphæroidalis*, *Rhyn-*

* 'Cotteswold Hills,' p. 72, 1857. See also Proceedings of the Cotteswold Club, vol. i. (1853) p. 64.

† "On the Subdivisions of the Inferior Oolite of the South of England, compared with the equivalent beds of that Formation on the Yorkshire coast," Quart. Journ. Geol. Soc. vol. xvi. pp. 17 & 24 (1859).

chonella spinosa, and, more rarely, *R. acuta*, Sow.*, *R. ringens*, and *R. Forbesii*, with many other shells. The fossils of the lower part of the bed are chiefly *Conchifera*.

Following the escarpment of the hills northward, past Blackford and Yarlington, we meet with numerous exposures in one or both of these beds, and near Castle Cary and at Hadspen the lower one was formerly extensively quarried. In the former locality the Lower Ragstone contains *Clypeus Agassizii*, and in both *Clypeus altus* occurs, while in the latter, as also in the quarries near Bruton-Bradstock, *Terebratula sphæroidalis* is met with in immense numbers. Ammonites are rare.

At Sunny Hill, near Pitcombe, between Castle Cary and Bruton, in a quarry above the Railway Station, we find the following section, which, as it is at some distance from the last, will serve to show the persistence with which these two subdivisions preserve their characters.

Section at Sunny Hill.

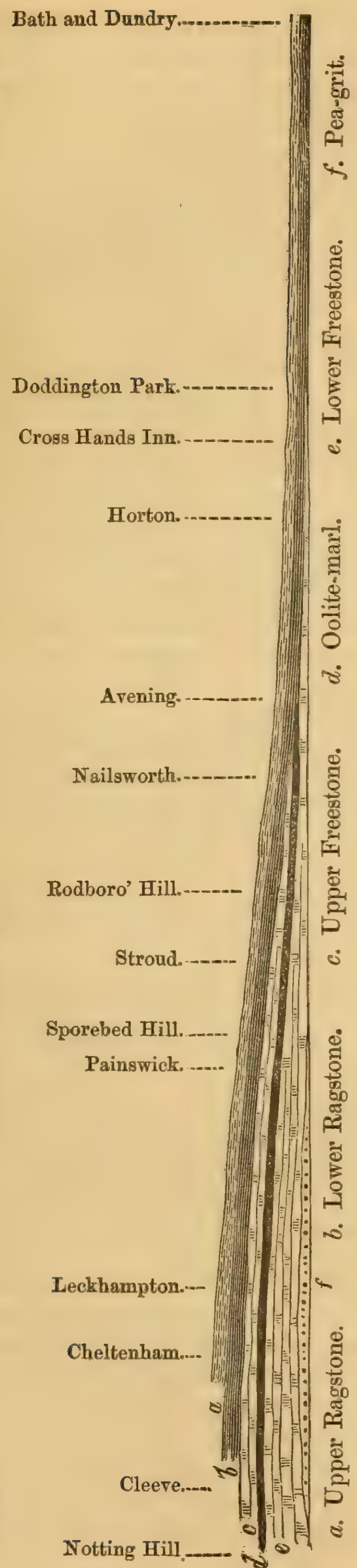
	feet.
A. Upper Ragstone. Coarse, white, flaggy oolite	6
B. Lower Ragstone:—	
1. Hard, brown, thick-bedded, highly fossiliferous limestone	12
2. Hard, sandy, compact, light-coloured limestone, with a few fossils	2

In this quarry the fossils of the Lower Ragstone are chiefly *Conchifera* and *Brachiopoda*. It is worthy of remark that the only Ammonite observed was *Ammonites Parkinsoni*. Among the fossils noticed were *Rhynchonella spinosa*, *R. angustata*, *Terebratula Phillipsii*, *T. sphæroidalis*, *Gryphæa subloba*, Desh., *Ostrea pixiformis*, Wr., *Lima gibbosa*, *Trigonia costata*, *Pholadomya Heraulti*, *Holectypus hemisphæricus*, &c. The bed No. 2, or basement-bed, contained a few fossils, very difficult to extract.

In the quarries around Bruton, and in the railway-cutting near the church, both series of beds are exposed, as also on the road through the Hedgestock turnpike-gate to Batcombe, and at Creech Hill. At the latter locality, ascending the hill from Lamyat, through a deep lane-cutting in the Ammonite-sands, to the brow of the hill, the lower fossiliferous limestone, not well exposed, is seen above the sands, and above this the Upper Ragstone, which is here about 15 feet in thickness, and is, in part, a tolerably thick and evenly bedded rock, while some of its beds exhibit lines of oblique lamination. About the middle of these upper beds there is a layer in which the fossils have the shell preserved.

The hard, pale-coloured, sandy limestone which formed the basement-bed of the Lower Ragstone in the sections at the "Halfway House" and at Sunny Hill does not appear to be continued much further to the north, as it was not observed at Creech Hill, and is absent at the Vallis Farm, 1½ mile north-west of Frome, where, in the quarry on the right bank of the stream, the Lower Ragstone is

* I am not aware that this fossil has hitherto been recorded as an Oolitic species.



Generalized section of the Inferior Oolite from Cheltenham to Bath.

seen separated from uptilted Carboniferous strata by alternate layers of more or less compacted clay, with pebbly bands, resting on a bed of conglomerate, beneath which Mr. C. Moore, of Bath, detected a thin stratum containing *Avicula contorta* *.

North side of the Mendips.—Between the Mendips and the valley of the Avon the same beds continue to represent the Inferior Oolite, and are well exposed in the railway-cuttings between Wells and Ammersdown, and, in a series of roadside-quarries, on to Radstoke, and further north, by the side of the canal near Dunkerton, at the foot of the Viaduct Bridge near Limpley Stoke, and at Widcombe Hill, near Bath. In all these localities they continue to preserve those general features which serve to distinguish the one from the other. In the neighbourhood of Dunkerton the Upper Ragstone is about 20 feet in thickness, and contains Corals of the genera *Anabacia*, *Stylina*, and *Isastræa*.

The outlying patch of Inferior Oolite at Dundry Hill is connected with this portion of the main body of the range by the smaller patches of the Barrow Hills, Stanton Prior, and Timsbury. At Dundry the light-coloured, partly flaggy, partly thick-bedded oolite which caps the hill belongs to the upper subdivision, and in certain layers at the top of the hill contains Corals of the same genera and species as the similarly situated beds in the neighbourhood of Dunkerton and Bath. Beneath this we find beds of rubbly and ferruginous lime-

* This interesting section has been given in detail in Mr. T. R. Jones's recent Monograph of Fossil *Estheriæ* (p. 74), published by the Palæontographical Society.

stone belonging to the Lower Ragstone, and having a somewhat greater aggregate thickness than in other parts of the country; but this may possibly be more apparent than real, and owing to some slight settlement of the hard ragstones, around the flanks of the hill, upon the yielding sands and Upper Lias clays beneath.

The Cotteswolds.—Passing across the valley of the Avon, we are able to trace these beds past Dryham Park to the quarry half a mile east of Doddington Ash, where the junction of the two Ragstones is well exposed, the lower one abounding in fragments of *Trichites.*

But, two miles further to the north, in the lane leading from the 'Cross Hands' Inn to Old Sodbury, the Ragstones are seen underlain by about 6 or 8 feet of thin-bedded white oolite, the lower beds of which are made up, in part, of comminuted shells. It rests upon a yellowish sandy bed, 2 or 3 feet thick, containing casts of *Gresslya*; beneath this are the brown-coloured argillaceous Cephalopoda-beds, with Belemnites and casts of Ammonites. Nearly the whole thickness of this white oolite is seen in the lane-side cutting. The Lower Ragstone crops out in the field above the section, and is also seen a little further along the lane, while the Upper Ragstone and overlying Fuller's Earth are exposed in a quarry opposite the inn.

This white oolite, when followed northward, is seen gradually to increase in thickness, and its relationship to the Ragstones may be well studied in a quarry near Horton Rectory, while its basement-beds and its junction with the upper part of the Cephalopoda-beds are exposed in the lane half a mile south of the Rectory.

Section near Horton Rectory.

		feet.
A.	Upper Ragstone. White, thin-bedded, friable oolite	12
B.	Lower Ragstone. Massive, hard, brown limestone, in two or three beds, with many fossils	about 10
C.	Freestone. Thick-bedded white oolite, used for building-stone	12
D.	Yellow sandy rock, containing *Gresslya*	2 to 3
E.	Cephalopoda-beds (Ammonite-sands or Upper Lias sands). Alternate beds of marly, more or less indurated, and rubbly rock, speckled with oolitic grains of peroxide of iron, and containing Belemnites and Ammonites; 8 feet exposed	8

The Lower Ragstone is here crowded with fossils, among which are *Trigonia costata* in great numbers, *Lima proboscidea*, *Ostrea Marshii*, *Trichites*, *Belemnites*, *Rhynchonella spinosa*, *Rhynchonella quadriplicata*, &c. The lower beds of the underlying Freestone contain a small *Pecten* in great abundance, which occurs also in the same position at Hawkesbury and Leckhampton.

A similar section exhibiting both the Ragstones, overlain by the Fuller's Earth, and resting upon the Freestone, which is probably 25 feet in thickness, is seen near Hawkesbury, on the road to Pool Farm.

The Freestone continues to increase in thickness as we proceed from the last section to Wotton Underedge, being 35 or 40 feet thick at Coneygore Wood, a mile north of the town. Continuing to thicken towards Frocester and Painswick Hills, it acquires its full development in the vicinity of Cheltenham, where it constitutes the "Building Freestone" of Leckhampton. The overlying Ragstones at the same time gradually rise to higher levels, and at Coneygore Wood crop out before reaching the brow of the hill, but may be found on higher ground half a mile further along the road, towards the Rushmire turnpike-gate.

From the section in Coneygore Wood and the sides of Symond's Hall Hill, the upper of the two Ragstones may be followed northward to Nympsfield and Avening, and along the sides of the Vale of Nailsworth, where it becomes identified with the "Upper Ragstone" or "Clypeus-grit" of Mr. Hull*, and the "Pholadomya-grit" of Mr. Lycett†, the casts of *Pholadomya* and *Homomya* and the remains of *Clypeus* (*Nucleolites*) *Plotii* especially characterizing this highest zone in the northern part of the Cotteswolds, but being by no means common south of the Valley of Stroud.

In like manner the fossiliferous limestone immediately beneath it is continued onward to Rodborough Hill, where it becomes continuous with the Trigonia- and Gryphite-grits of Messrs. Wright, Lycett, and others, and the Lower Ragstone of Mr. Hull‡. In the neighbourhood of Nympsfield this latter has associated with it a band of hard pale-coloured limestone, crowded with *Rhynchonella spinosa*.

In the vicinity of Wotton, as at Symond's Hall Hill, the Lower Ragstone rests directly on the Building Freestone; but, crossing the high ground on the east to the Vale of Nailsworth, we find, in the smaller tributaries of Horsley and Avening, a few inches of the Oolite-marl, with its characteristic *Terebratula fimbria*, underlying the base of the Ragstone, and resting upon 4 or 5 feet of pale-coloured argillaceous limestone, which graduates downwards into the Freestone. This is the earliest appearance of the Oolite-marl in the southerly direction, and a little further down the valley it begins to be separated from the base of the Ragstone by the interposition of some more or less sandy oolite belonging to the Upper or "Bastard" Freestone. This latter, at Nailsworth, is about 3 feet in thickness; but, passing along the valley to Stroud, both it and the underlying Oolite-marl gain in thickness and importance, and separate the Ragstones more and more widely from the Lower Freestone.

At Rodborough Hill the Lower Ragstone is about 10 or 12 feet in thickness. The basement-bed is crowded with *Conchifera*, and constitutes the Lower Trigonia-grit, or lowest of the three members into which it has been subdivided. As we proceed northward, however, both this and the middle, or Gryphite-grit division, increase in thickness. At White's Hill, near Randwick, Mr. Lycett has estimated it at 5 feet. At Kimmersley Castle it is somewhat more, and contains

* Memoirs of the Geological Survey, "Geology of parts of Wiltshire and Gloucestershire," p. 10.

† 'Cotteswold Hills,' p. 68.

‡ *Op. cit.* p. 10.

many *Conchifera* in a good state of preservation; but it attains its greatest development at Leckhampton Hill.

Over a considerable portion of the north-western part of the Cotteswolds, especially towards the verge of the hills, the Upper Ragstone has been denuded, and it is only beneath the isolated patches of Fuller's Earth, brought down by faults, that it occurs, and in these localities it is seldom well exposed. It may be seen, however, to the east of the fault at Cold Comfort, and still better on the hills beyond Andoversford.

The cropping-out of this bed before reaching the verge of the hills in the neighbourhood of Cheltenham appears to have led Dr. Wright to overlook it altogether*.

I quite agree with Dr. Wright in his suggestion that, away from the western escarpment of the hills, the Upper and Lower Trigonia-grits have come into contact, as the great Oyster-bank which constitutes the Gryphite-grit extends only from the vicinity of Rodborough Hill to Cleeve Cloud, and eastward to the neighbourhood of Andoversford; but the Lower Ragstone, as seen in the quarries between the latter place and Hampen, consists chiefly of the *Upper* Trigonia-grit, having at its base a bed, from 1 to 2 feet in thickness, of very hard, brownish limestone, pierced everywhere by small vertical tubes, probably the work of some species of Annelid. These Lower Ragstone-beds may be seen *in situ* on the Stow Road, a mile and a half east of Andoversford, and again half a mile beyond Naunton Inn, and on the top of a hill a mile south-west of Aylworth, where its junction with the Upper Freestone is exhibited.

But above this Lower Ragstone, and resting upon it, there is seen, over all the country around Naunton and Turk Dean, and west of North Leach, a higher bed, 15 or more feet in thickness, of very coarse-grained, rubbly, white oolite, containing fossils in abundance, but not in great variety. This is the northern extension of the Upper Ragstone, which has here become fossiliferous and more coarsely oolitic. The lower part of the bed is crowded with *Terebratula globata*, and the central portion contains *Clypeus Plotii* in great numbers. In going from Naunton Inn to Harford Bridge, we cross in succession the outcrop of the Upper Freestone, the Lower Ragstone, and then the Upper Ragstone to the Fuller's Earth, and we again find the two latter, on the opposite side of the stream, in the lane above Harford.

The Upper Ragstone is well exposed at Aylworth, where it has been brought down to a lower level by faults, and also by the side of the road leading from Turk Dean to Aston, where an upper bed is exposed, made up of badly preserved fossils imbedded in coarse white oolite. *Clypeus Plotii* is most abundant in the middle portion of the bed.

The junction of the Upper Ragstone with what remains of the Lower Ragstone is well seen in a quarry by the side of the Roman Foss-way, near the fifth milestone from Stow, where we find the following section:—

* Quart. Journ. Geol. Soc. vol. xvi. pp. 38 & 43.

Section near Stow. feet.

A. Coarse, rubbly, white oolite, becoming darker-coloured towards the base, and containing in its lower portion great numbers of *Terebratula globata, Lima gibbosa,* and *Pecten lens* 8

B. Very hard, compact, brown limestone, covered on its upper surface with a large flat species of *Ostrea* 3

C. Lower Freestone to the bottom of the section.

The Lower Ragstone is here reduced to 3 feet in thickness, and rests upon the Lower Freestone, the intervening members having thinned out between this place and Turk Dean. A mile further to the south-west, in the quarries above Clapton, this subdivision has nearly reached its extreme limit in this direction; some hard, brown, sandy rock, with fossils, and a mere trace of the basement-bed being all that remains to represent the Lower Ragstone. At Little Rissington both this and the underlying Freestone have entirely thinned out, and the Upper Ragstone rests directly on the Upper Lias clay; but north of Stow, on the road to Moreton, there is still some portion of the Lower Freestone remaining.

Fossils of the Upper Ragstone.

Nerinæa, sp.	Little Rissington.
Myacites, casts of three species	Naunton, Aston, &c.
Gresslya abducta, *Phill.*? (cast)	Aston, Clapton.
Homomya gibbosa, *Sow.* (cast)	Aston, Naunton.
Pholadomya Heraulti, *Ag.*	Aston, Naunton, Little Rissington.
—— Dewalquei, *Lyc.*	Little Rissington.
Isocardia (cast)	Stow, Aston.
Astarte elegans, *Sow.*	Aston.
——, sp.	Stow, Aston.
Trigonia angulata, *Lyc.*?	Abundant around Naunton, Aston, &c.
—— costata, *Park.*	Little Rissington.
Nucula variabilis, *Phill.*?	Aston.
Lima duplicata, *Sow.*	Stow.
—— gibbosa, *Sow.*	Naunton, Stow, Aston, &c.
Pecten lens, *Sow.*	Aston.
—— vagans, *Sow.*	Aston.
Ostrea acuminata, *Sow.*	Stow, Naunton, Aston.
Terebratula globata, *Sow.*	Very abundant everywhere.
Rhynchonella angulata, *Sow.*	Naunton, Stow, Aston.
—— concinna, *Sow.*	Aston.
Serpula, sp.	Clapton.
Nucleolites (Clypeus) Plotii, *Klein*	Abundant everywhere.
Echinobrissus clunicularis, *Lhwyd*	Aston.
Holectypus depressus, *Lamk.*	Aston.
Isastræa limitata, *E. & H.*	Aylworth.
Anabacia orbulites, *Lamk.*	Naunton, Stow.
——, sp.	Naunton.

The "Rolling Bank" Quarry.—Dr. Wright has referred all the fossils of the Rolling Bank Quarry to the Upper Freestone beds of Cleeve, and considers them to be the northern equivalents of the Conchiferous Lower Ragstone of Dundry, Yeovil, &c.* That this is

* Quart. Journ. Geol. Soc. vol. xvi. p. 18.

not so, however, is, I think, made manifest by a careful examination of all the beds which occupy the interval between the Oolite-marl and the base of the Ragstone, where they occur *in situ*. Leaving the Rolling Bank Quarry, which has been opened into "tumbled oolite" resting upon the Upper Lias Clay, and ascending the hill in an easterly direction, we come to two quarries situated in the Lower Freestone, and in the higher of the two, distant from the Rolling Bank Quarry about 200 paces, the Oolite-marl occurs, 9 or 10 feet thick, resting upon the Lower Freestone, and overlain by 5 feet of the Upper Freestone. The hill rises only a few feet above the top of the quarry, and a little further on, at the very summit of the hill, is a second quarry. The lowest beds on the western side of this quarry belong to the base of the Upper Freestone, and, formerly, a portion of the upper part of the Oolite-marl was also exposed. These beds, which dip slightly towards the east, pass upwards into a brown, calcareous, sandy rock, the uppermost stratum of which is, in parts, composed entirely of yellow and brownish sand. Resting upon this, and immediately under the turf, on the eastern side of the quarry, is the Lower Trigonia-grit, with *Terebratula impressa*, *Trigonia costata*, *Goniomya angulifera*, *Ceromya Bajociana*, *Myacites*, *Gresslya*, and many other fossils.

These beds are again seen in a third quarry, a little further on in the same direction. Eleven feet of rock are here exposed, the upper three feet of which are sandy and ferruginous, and similar to the top-beds in the last quarry. The lower eight feet consist of brown sandy oolite, moderately thick-bedded. Neither the uppermost nor the lowermost beds can be seen; but, close by, at only 3 or 4 feet higher elevation, the junction of the former with the Lower Trigonia-grit may be seen in some small superficial excavations which have been made in searching for the sand, which here and there occurs at the top of the Upper Freestone.

The junction of the Upper Freestone with the overlying Lower Trigonia-grit is, however, better seen in a number of small pits along the north side of the ravine which lies a little to the right.

From all these exposures the following section may be constructed:—

Section of the Rolling Bank Quarry.

	feet.
A. Lower Trigonia-grit.	
a. Rubbly limestone, with many fossils—Corals, &c. . .	
b. Brown and blue clay	1 to 2
B. Upper Freestone.	
a. Hard, brown, coarse-grained limestone, with fragments of Shells, not persistent	6 in. to 2
b. Yellow and brownish sand, with lenticular masses of sandstone	3
c. Ferruginous arenaceous limestone and sandy oolite, the lowest bed pierced by the vertical tubes of Annelids, about	14

C. Oolite-marl.	feet.
a. Pale-coloured, argillaceous limestone, with *Terebratula fimbria*, &c.	3 to 4
b. Cream-coloured marl, with *Terebratula fimbria*, Corals, &c.	6
D. Lower Freestone.	

The hill is capped by Gryphite-grit, with *Gryphæa subloba*, Desh.

Thus, at Cleeve, a series of beds of very unstable character occupies the interval between the top of the Oolite-marl and the base of the Lower Ragstone, and represents the Upper Freestone of Leckhampton; but nowhere, in these beds *in situ*, do we find any of the fossils of the Rolling Bank Quarry. Apart, however, from this negative evidence that these beds are not on the same horizon as the Conchiferous limestones of Dundry, we have the fact that this Lower Ragstone may be traced continuously from Dorsetshire, through Somersetshire, and along the escarpment of the Southern Cotteswolds, up to the Trigonia-grits of Rodborough and Leckhampton Hills.

The Rolling Bank Quarry has been excavated into an accumulation of fallen débris which has collected at the foot of the oolitic cliffs, and consists chiefly of Lower Ragstone; and nearly all the fossils that are found there belong to this subdivision.

The Pea-grit.—The lowest member of the Inferior Oolite is the Pisolite, or Pea-grit, which immediately underlies the Lower Freestone. This bed has been generally stated to thin out at Notting Hill. Its southern limits have been somewhat more variously defined. Its northern attenuation at Notting Hill is true, however, only as regards its pisolitic structure, as the bed itself, although no longer pisolitic, appears to underlie the Lower Freestone of the Bredon outlier.

Below the brow of the eastern extremity of the hill, above Aston, *Rhynchonella cynocephala*, Rich., the small dwarfed variety similar to the one which occurs at Wotton Underedge *, is found in detached blocks of hard limestone; but I have not been able to find the bed *in situ*. This is the most northern locality at which this fossil has hitherto been met with in the Cotteswold district. Further round the hill, above Elmley Lodge, there is a bed of hard, yellow, sandy limestone, some layers of which are full of fragments of *Pentacrinus* and spines and plates of Echinoderms, with some fossils entire. *Terebratula plicata* is the dominant fossil, but the valves are usually separated. Still further on, beneath the ancient encampment of Bredon Tower, nearly 10 feet of this bed is exposed, having the Lower Freestone resting upon it. On the surface of the blocks, besides the fragments of *Crinoidea* and *Echinoidea*, are many specimens of *Cricopora verticillata*, Mich.?, and other *Bryozoa*.

To whatever position the grey and yellow limestone with *Rhynchonella cynocephala* may be assignable, the bed above referred to belongs, I think, to the Pea-grit.

Towards the south the Pea-grit ceases to be pisolitic, or is only

* The specimen, with part of the matrix, is in the author's cabinet.

very slightly so, at Painswick Hill. Beyond this it is represented by yellowish sandy limestone and ferruginous oolitic rock, which, near the Horseponds, are less than 20 feet, and at Haresfield Hill are about 12 feet in thickness. At Frocester Hill, the light-brown sandy rock, with casts of *Gresslya* and *Pholadomya*, overlying a hard fossiliferous bed, together about $7\frac{1}{2}$ feet in thickness, is all that remains to represent the Pea-grit of Crickley Hill; and the 2 or 3 feet of yellowish sandy rock, with *Gresslya*, which was seen underlying the Freestone in the sections at Horton, and near the Cross Hands Inn, probably belongs to the same zone, and indicates the approaching southern limits of the bed.

All these beds thin out in a south-easterly direction, as already shown by Mr. Hull *. The Upper Ragstone alone crosses the valley of the Evenload, and in Oxfordshire is the only representative of the Inferior Oolite, but finally it thins out in the vicinity of the Cherwell. The Lower Ragstone was seen to have nearly reached its eastern limits at the quarries above Clapton, and is absent at Stow, Seizincote, and Bourton-on-the-hill. The Upper Freestone and Oolite-marl are on the eve of disappearing at Condicote and Turk Dean, and do not extend southward further than Avening; while the Lower Freestone is seen thinning out at Stow, Sherborne, and near Doddington Park, ten miles north of Bath. The northern and southern limits of the Pea-grit have already been indicated. Eastward it ceases to be pisolitic before reaching Dowdeswell, beyond which the bed has not hitherto been recognized.

Geographical Distribution of the Fossils.—The fossils of the Upper Ragstone, as far as they are at present known to me, have been already enumerated. Those of the Lower Ragstone have been recorded by Dr. Wright, Mr. Lycett, and Mr. Hull. With respect to the lists given by Dr. Wright, however, it must be borne in mind that the Humphriesianus-zone of Dorsetshire and Somerset, and the Parkinsoni-zone of the Northern Cotteswolds, are on one and the same geological horizon.

The geographical distribution of the fossils of the Lower Ragstone is very unequal, and many of the species and even genera, although abundant, are altogether local. The Ammonites, for instance, are numerous only in a few localities in the southern part of the district; elsewhere only scattered individuals are met with, and not more frequently than they are in the northern part of the Cotteswolds †.

* "On the South-easterly Attenuation of the Lower Secondary Formations of England," Quart. Journ. Geol. Soc. vol. xvi. p. 71.

† With respect to *Ammonites Parkinsoni* and *Ammonites Murchisonæ*, these fossils are by no means so restricted in their range in time as some authors suppose. *A. Parkinsoni* is stated by Mr. Lycett to occur in the Pea-grit "but sparingly" (Cotteswold Hills, p. 37). It has been met with in the Lower Ragstone of Somersetshire, and occurs very generally in the Upper Trigonia-grit of the Northern Cotteswolds. *A. Murchisonæ* was found by the officers of the Geological Survey in the Lower Ragstone of Leckhampton and Stanley Hills (Hull, Geol. Cheltenham, p. 48), together with *A. Sowerbyi*, *A. concavus*, and *A. Dorsetensis*, and in the Upper Ragstone near Churchill, in Oxfordshire (Geol. of Country around Woodstock, p. 13). On the authority of Professor

Among the *Brachiopoda*, we find *Terebratula Buckmani*, Dav., in great abundance at Cleeve, Leckhampton, and Sherdington. *Terebratula Wrightii* is equally gregarious, as in the Perna-bed at Cold Comfort; but it is only sporadically distributed elsewhere in the neighbourhood, and does not occur in the south. Near Andoversford, a small *Terebratula*, probably a dwarfed variety of *T. ornithocephala*, is met with in great abundance, and more sparingly so at Leckhampton, but I have not found it anywhere else. In the southern part of the district we find *Terebratula sphæroidalis* occurring in the same great abundance at Hadspen and Bruton-Bradstock, while in neighbouring quarries they are by no means numerous. The Gasteropods are mostly southern forms, while the conditions of the sea-bottom upon which the calcareo-argillaceous beds of the Lower Trigonia-grit were deposited appear to have been favourable to the life of the *Anatinidæ*. Of the Echinoderms, most of the species of the northern part of the Cotteswolds are different from those of the southern side of the Mendips, and instead of *Clypeus* (*Nucleolites*) *Plotii*, *Hyboclypus caudatus*, *Pedina rotata*, and *Holectypus depressus*, we find *Clypeus Agassizii* and *C. altus*, *Hyboclypus gibberulus*, *Holectypus hemisphæricus*, *Collyrites ringens*, and *C. ovalis*, and others that are not, or only rarely, found in Gloucestershire. Omitting, however, these local and also the rarer forms, most of the more common and characteristic fossils on both sides of the Mendips are identical *.

In this communication I have endeavoured to show the relationship the several subdivisions of the Inferior Oolite hold with respect to each other,—and that the conclusions that have been arrived at by some writers on this point, based on the evidence of fossils only, are not borne out when the beds come to be traced stratigraphically from one end of the Oolitic range to the other.

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2. *On the* Occurrence *of large Quantities of* Fossil Wood *in the* Oxford Clay, *near* Peterborough. By H. Porter, M.D., F.G.S.

[Abstract.]

The author gave a short description of the Oxford Clay area in the neighbourhood of Peterborough, and mentioned the properties which caused it to be worked, in the parishes of Eye, Thorney, Whittlesey, Stanground, Fletton, and Stilton, for the manufacture of bricks and tiles. The clay is very fossiliferous at all these places, the most abundant remains being those of *Belemnites Puzosianus*, *Gryphæa dilatata*, *Ammonites Elizabethæ*, *A. Duncani*, *A. convolutus*, *A. cordatus*, *A. fluctuosus*, *A. hecticus*, *A. Comptoni*, and a few other species of

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Morris (Cat. Brit. Foss.), it occurs at Chideock, Sherborne, and Dundry, localities where the Ragstone is the lowest member. Both *A. Parkinsoni* and *A. Humphriesianus* have been found in Yorkshire in beds which are probably younger than the Inferior Oolite of Gloucestershire.

* Some of the Inferior Oolite forms of Somersetshire pass upwards into the Fuller's Earth—*Hyboclypus gibberulus*, *Collyrites ovalis*, and *Holectypus depressus* being not uncommon in this bed near Bruton.

Ammonites which Dr. Porter had not been able to determine. There were also *Cerithium Damonis*, *Serpula vertebralis*, *Belemnites gracilis*, *Pecten*, 2 sp., *Nucula*, *Corbula*, *Avicula*, abundant remains of *Ichthyosaurus*, *Plesiosaurus*, *Pliosaurus*, and *Steneosaurus* (?). The author had also found a portion of a spine of *Ptychacanthus ornatissimus*, and a few palatal teeth of *Strophodus subreticulatus*. What, however, he particularly called attention to in this communication was the occurrence of large quantities of fossil wood, in pieces sometimes more than a yard in length, highly bituminous, quite black, having a fracture similar to jet, and capable of almost as high a degree of polish as that mineral; it is also exceedingly brittle, and, when exposed to the air, cracks in all directions. Most of the specimens are flat, and bear on their surface impressions of Ammonites and other shells.

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3. *On a new* Macrurous Crustacean (Scapheus ancylochelis) *from the* Lias *of* Lyme Regis. By Henry Woodward, Esq., F.Z.S.

[Communicated by Professor Morris, F.G.S.]

[Plate XI.]

This beautiful and very perfect Crustacean (from the collection of James Harrison, Esq., of Charmouth) was obtained from the zone of *Ammonites Bucklandi* of the Lower Lias of Tape-ledge, near Lyme Regis.

A complete detached fore-limb of large size, from the collection of E. C. H. Day, Esq., of Charmouth; an imperfect fore-limb, and perfect termination to a secondary limb, from the collection of Capt. Hussey; together with two fragmentary portions of limbs and abdomen, from the collection of Mr. J. W. Marder, of Lyme Regis, are all the remains of this new and very remarkable form hitherto discovered.

From the length of the fore-limbs, their monodactylous extremities, and also the peculiar spatulate form of the penultimate joint of the succeeding pairs of limbs, I am convinced of the propriety of placing it near Bronn's genus *Megacheirus**, many species of which are described and figured in Münster's 'Beiträge zur Petrefactenkunde,' Part II., from the Lithographic Limestone of Solenhofen.

That genus has been obtained from the Oxford Clay of Wiltshire and Normandy, and from the Inferior Oolite and Lower Lias of Bavaria.

There are, in the British Museum, several examples of the genus *Megacheirus* from Solenhofen, and also from the Oxford Clay of Wiltshire; but I have only been able to refer to the figures and descriptions given by H. von Meyer and F. A. Quenstedt, of the species

* The name *Mecocheirus* of Germar (1826) would have been entitled to priority over Bronn's *Megacheirus* (1836), but Germar omitted to give a definite description of his fossil. *Megacheirus* should also properly include the genus *Pterocheirus* of Bronn, all the *Megacheiri* being "wing-fingered," although the fringe of hair upon the fore-arms is not always preserved.

Woodward del. Geo West lith.

W. West imp.

SCAPHEUS ANCYLOCHELIS, H. WOODW.

found in the Oxfordian Oolite of Normandy*, and those occurring in the Inferior Oolite† and Lower Lias ‡ of Bavaria.

After careful comparison, I am satisfied that our Liassic Crustacean is quite distinct from any of these.

SCAPHEUS, gen. nov.

The carapace of *Scapheus* differs from the nearly smooth cephalothorax of *Megacheirus*, which is quite destitute of the spines and prominent rostrum so conspicuous in this fossil; and the smooth, slender fore-limbs of *Megacheirus* (considerably exceeding the entire length of the body) contrast strongly with the more robust spiny arms and great terminal hooks of *Scapheus*. In the basal joints of the outer antennæ, the form of the abdominal segments, and the laminæ of the tail, this new genus is also distinguished by well-defined characters. I propose to name the only known species, represented by Mr. Harrison's specimen, *Scapheus ancylochelis* §.

The long monodactylous fore-limbs are quite peculiar to these fossil genera of Crustacea. The nearest living analogues are found in the fossorial group *Thalassinidæ*, but the resemblance is only evident in the structure of the limbs and in the hirsute character of both limbs and abdomen; the termination of the fore-arms in *Scapheus* being similar to *Ranina*, another burrowing Crustacean of a different group. The abdomen, however, in nearly all the *true fossorial* species is more or less rudimentary, and but little adapted for natation, whereas in this genus the marginal (or *epimeral*) portion of the abdominal segments is as well developed as in *Nephrops* or *Homarus*; and the laminæ of the tail and the traces of false abdominal feet also indicate a Crustacean well adapted for swimming. Taking these points of structure into consideration, we cannot suppose this to have been an habitual burrower, but simply as searching for its food and concealing itself among stones, for moving which its powerful fore-limbs seem well adapted, although (from the very rudimentary character of the fixed ramus of the penultimate joints) but little suited for organs of prehension.

The great similarity of the *Crustacea* of our English Lias with those from Solenhofen has appeared to me to be a most interesting point, and I hope hereafter to offer figures and descriptions of several others not yet enumerated from our Lias, and all analogous to those of the Upper White Jura of Bavaria.

SCAPHEUS ANCYLOCHELIS, spec. nov.

Cephalothorax one-third longer than deep. Rostrum prominent,

* Palæontographica, vol. i. p. 144. t. 19. f. 2–19.

† Der Jura, p. 520. t. 69. f. 8–11. This species, described by H. von Meyer under the name of *Eumorphia socialis*, from Dives in Normandy, &c., is the same which Quenstedt describes as *Mecocheirus socialis*, from the Inferior Oolite of Bavaria. It is much smaller than *M. longimanus* from the Solenhofen limestone.

‡ Quenstedt describes two species from the Lower Lias of Bavaria—*Mecocheirus grandis*, Q. (p. 88. t. 11. f. 15, 16), and *M. olifex*, Q. (p. 89. t. 11. f. 17). I consider *M. grandis* more nearly related to our Lias genus than to *Megacheirus*, so far as Quenstedt's figures permit me to judge.

§ From σκᾰφεὺς, a "digger," and ἀγκῦλοχήλης, "with hooked claws."

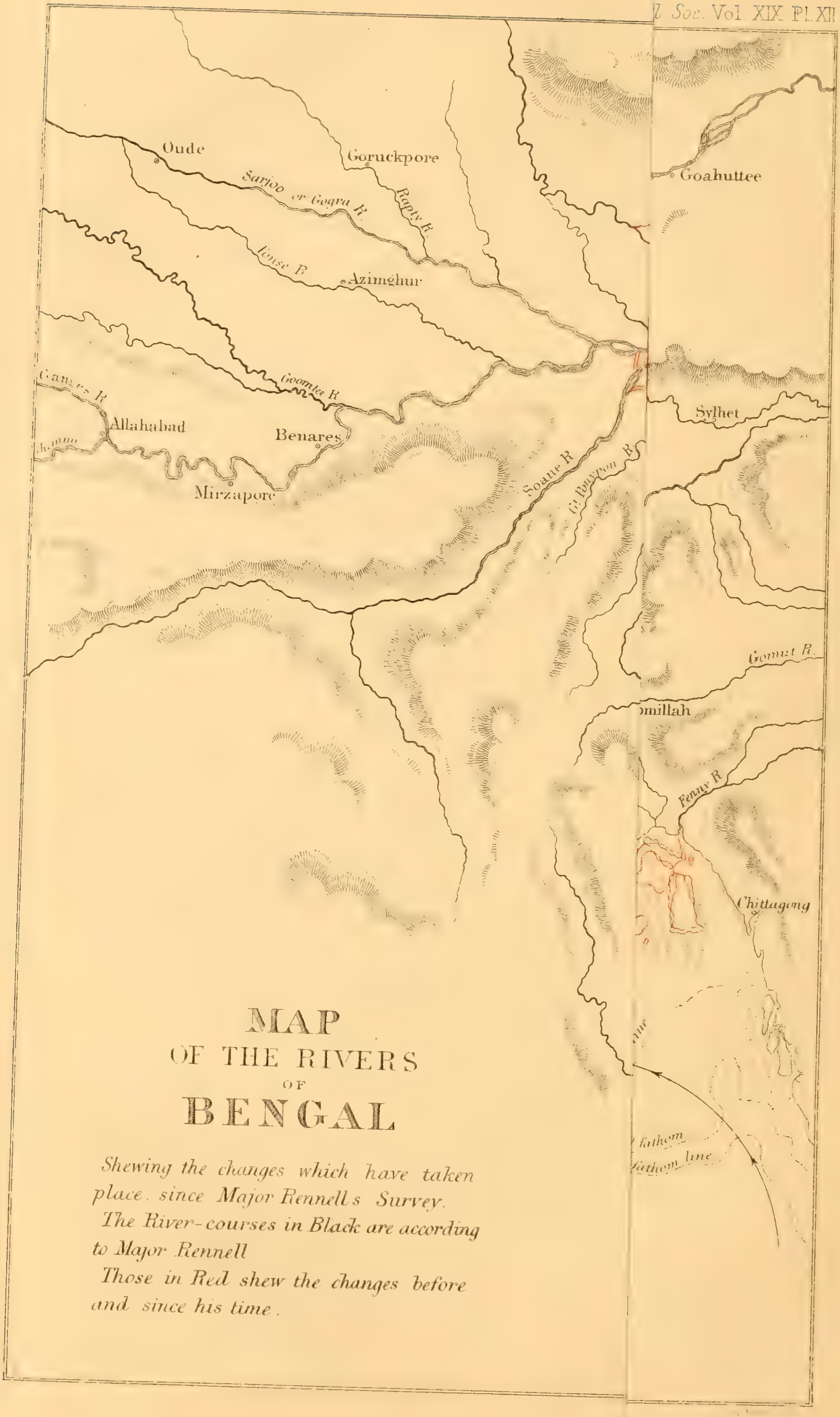
curving upwards, armed with a double row of conical, slightly curved spines, nearly $\frac{1}{8}$ inch in length, and extending back to the cervical furrow, thence in a single row down the median line of the carapace to the posterior margin. Cervical furrow broad and strong, terminating in a smooth rounded sinus near the antero-lateral margin; the branchial region divided from the gastric by two slender parallel furrows, which, passing obliquely down the sides of the carapace, unite with the cervical furrow near the margin. The posterior and lateral borders of the carapace are raised, and have a sulcus within the margin; the surface of the posterior portion is scabrous, of the anterior portion finely punctate, the antero-lateral portion being covered with minute irregular spines. Two lines of minute spines extend forward from the cervical furrow obliquely on each side of the median furrow towards the rostrum, and another line extends backwards and upwards from the posterior margin of the same furrow, on either side, obliquely to the median line. Eye globular (?), and, from the size of the orbit, probably large. Outer pair of antennæ large, multi-articulate, 4 to 5 inches long; three basal joints large and armed with spines. Inner antennæ smaller, multi-articulate; basal joints crushed, and insufficient for description.

The legs forming the first pair are symmetrical, and equal in length to the entire body; they are scabrous, and armed with several rows of smooth, strongly curved spines; extremities monodactyle, the fixed ramus of the penultimate joint being only represented by a large spine one-fourth the length of the ultimate joint, which is curved and pointed. The limbs of the second pair are also armed with spines along their margin; the penultimate joint is flat and very broad at the distal extremity, the ultimate joint small and pointed. Third and fourth pairs like the second, but nearly smooth. The fifth pair is much smaller than the rest, and only very imperfectly preserved. Abdomen rather longer than the cephalothorax. The epimeral portion of the first segment *much less* produced, and of the second segment *much more* produced, than in those succeeding; all the segments minutely punctate at, and spinous upon, their lateral margins. Each segment deeply curved in front to receive a small polished ball-articulation attached to the posterior margin of each joint of the abdomen. The tail-lobes are broad, the outer lamina having a crescent-shaped division near its extremity, bordered by 2 or 3 spines; the inner lamina is smooth, and the central lobe slightly punctate, with 2 or 3 small spines along its margin.

False abdominal legs apparently fitted for natation; but two only are preserved, and those very imperfectly.

Dimensions.—Length of the carapace $3\frac{1}{8}$ inches; greatest depth $1\frac{5}{8}$ in. (in profile). Length of the rostrum $\frac{5}{8}$ in. Depth of the first abdominal segment $\frac{3}{4}$ in., of the second $\frac{7}{8}$ in. Length of the abdomen and tail-lobes $3\frac{3}{4}$ in. Length of the outer antennæ 4–5 in. Length of the fore-arm $2\frac{3}{8}$ in., wrist $\frac{3}{4}$ in., hand 2 in., finger $1\frac{5}{8}$ in.

Length of a detached hand and arm:—arm $2\frac{1}{2}$ in., wrist $\frac{3}{4}$ in., hand $2\frac{1}{4}$ in., finger $2\frac{1}{8}$ in.



MAP
OF THE RIVERS
OF
BENGAL

Shewing the changes which have taken place, since Major Rennell's Survey.
The River-courses in Black are according to Major Rennell
Those in Red shew the changes before and since his time.

P.S. 27th June, 1863.—Since the foregoing communication was made to the Geological Society, I have received a copy of Dr. A. Oppel's 'Palæontologische Mittheilungen,' Stuttgart, 1862.

The first part of this most valuable work is devoted to a description of Macrurous Crustaceans of the Jurassic formations of Germany, &c., and is illustrated by 38 excellent plates. The author has, I observe, adopted Germar's generic name of *Mecocheirus* in his descriptions of the Solenhofen *Crustacea*.

Although Dr. Oppel has added more than 50 new species to the list of Jurassic *Crustacea*, none of them agree, even generically, with that just described from the Lias of Lyme Regis.—H. W.

EXPLANATION OF PLATE XI.

Scapheus ancylochelis, H. Woodw., four-fifths the natural size.

April 1, 1863.

S. N. Carvalho, Jun., Esq., 6 Aberdeen Park, Highbury Grove, N., and William Edwards Wood, Esq., Tamworth Castle, Tamworth, were elected Fellows.

The Rev. Dr. O. Heer, Professor of Botany in the University of Zurich; Sign. P. Savi, Professor of Geology in the University of Pisa; Sign. G. Ponzi, Professor of Comparative Anatomy and Physiology in the University of Rome; Dr. J. Leidy, Professer of Anatomy in the University of Pennsylvannia; Il Marchese Pareto, of Genoa; and Professor A. Daubrée, of the Jardin des Plantes, Paris, were elected Foreign Correspondents.

The following communication was read:—

On Recent Changes *in the* Delta *of the* Ganges.

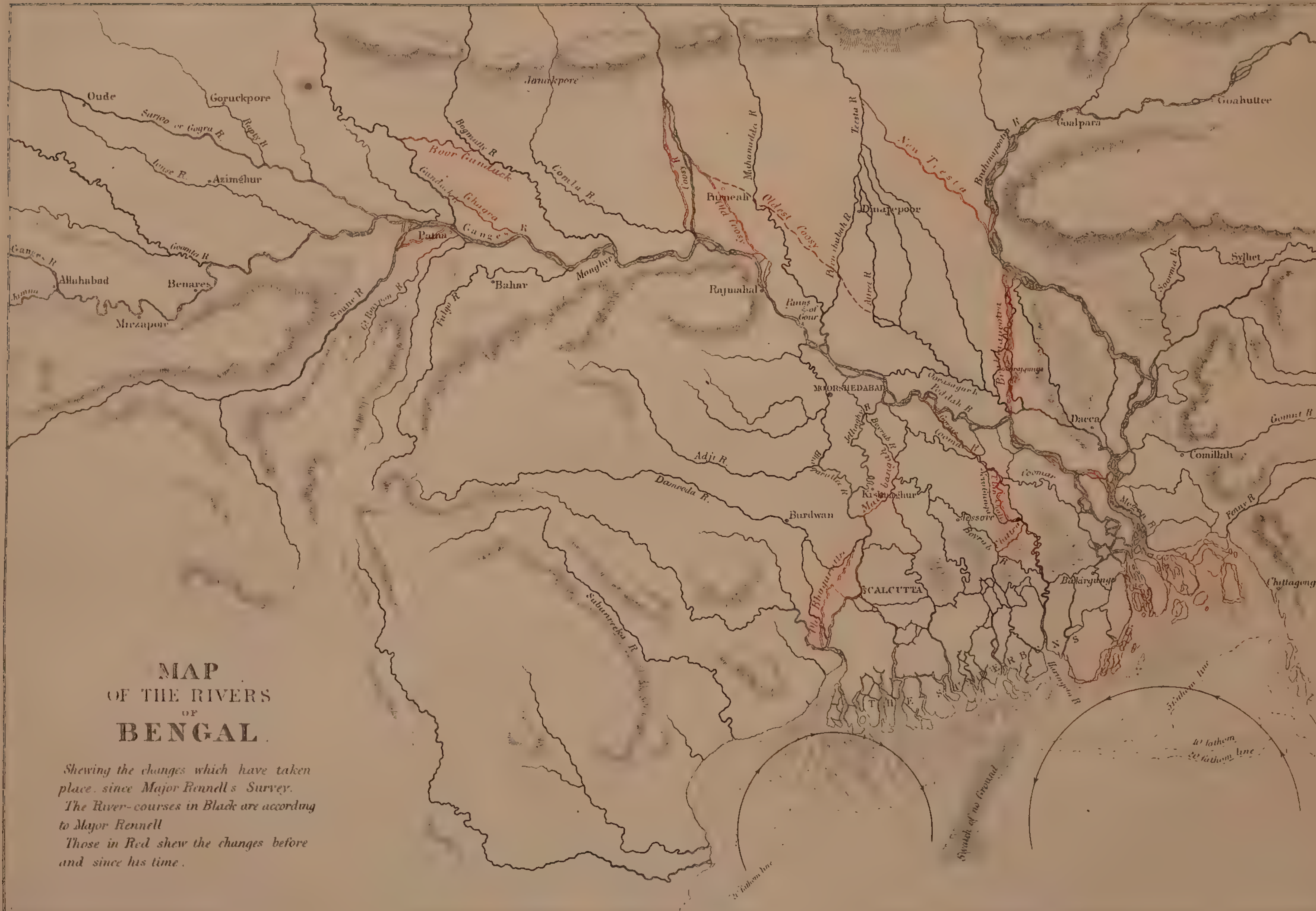
By James Fergusson, Esq., F.R.S.

[Communicated by the President.]

[Plate XII.]

Contents.

I. General Considerations.
1. Introduction.
2. Oscillation of Rivers.
3. Elevation of the Banks of Rivers.
4. Secular Elevation of Deltas.
5. Mode in which Deltas are elevated.
II. Physical changes in the Valley of the Ganges.
1. Upheaval of the Madoopore Jungle.
2. Silting-up of the Sylhet Jheels.
3. Eastern Gap in the seaward face of the Delta.
4. Change in the bed of the Brahmapootra.
5. Opening of the R. Jennai.
6. Jessore group of rivers.
7. Natore group of rivers.
8. Kishnaghur group of rivers.
9. Changes in the course of the R. Teesta.
10. Retrocession of the junctions of tributary streams with main rivers.
III. Historical evidence of the changes in the Delta of the Ganges.
IV. Increase of the Delta seaward.
1. Silt held in suspension in Ganges waters.
2. Swatch of "No Ground."
V. Appendix.


MAP
OF THE RIVERS
OF
BENGAL.
Shewing the changes which have taken place, since Major Rennell's Survey.
The River-courses in Black are according to Major Rennell.
Those in Red shew the changes before and since his time.
Oude
Goruckpore
Sarjoo or Gogra R.
Azimghur
Goomty R.
Allahabad
Benares
Mirzapore
Soane R.
Patna
Ganges R.
Boor Gunduck
Bagmatty R.
Janukpore
Comla R.
Bahar
Monghyr
Coosy R.
Old Coosy
Oldest Coosy
Mahanadda R.
Purneah
Rajmahal
Teesta R.
Dinajepoor
New Teesta
Brahmapootra R.
Goalpara
Goahutty
Sylhet
Dacca
Comillah
Chittagong
Feny R.
MOORSHEDABAD
Adji R.
Damooda R.
Burdwan
Kishnaghur
Jessore
CALCUTTA
Bakirgunge
Bhagirathi R.
Subanreeka R.
Swatch of no Ground
10 fathom line
5 fathom line

I. *General Considerations.*

1. *Introduction.*—It may seem presumptuous in one who is neither a geologist nor has any pretension to geological knowledge to venture to address this Society on a subject so nearly akin to their special science. My excuse must be that, having resided for five years on the banks of one of the most active of the Bengal rivers, I have had opportunities which are not vouchsafed to every one of observing their phenomena, and have been a witness of the changes I am about to describe. I may also, perhaps, be allowed to state that, when I first became aware of the disturbance that was taking place around me, I set myself carefully to measure and observe what was passing; and, in 1835, made a sketch-survey of the lower Ganges and Brahmapootra, from Jaffiergunge to the sea. This was published by Mr. Tassin a few years afterwards, and is, so far as I know, the only survey that was made—certainly the only one published—between that made by Major Rennell and the survey now in progress, but which has not yet been given to the world. I may also mention, in extenuation, that I have waited for more than a quarter of a century in order that some one more worthy might undertake the task; but, as no one has come forward, I may perhaps be now excused for venturing upon it.

In order, however, to obviate the reproach of presumption, my intention is to confine myself wholly to the historical period, and practically to the time that elapsed between the survey made by the celebrated Major Rennell, between the years 1780–90, and the survey now in progress; and though I shall be obliged, occasionally, to mention facts that may have occurred before the Christian era, they will be only such as are based on human evidence, and not such as properly fall within the domain of the geologist.

2. *Oscillation of Rivers.*—Before describing the actual phenomena, it may be necessary to call attention to certain principles—not very recondite, perhaps, but indispensable to a clear understanding of what is to follow.

The first of these is:—

All rivers oscillate in curves, whose extent is directly proportionate to the quantity of water flowing through the rivers.

An inspection of any good map is sufficient to prove the general correctness of this dictum, but its consequences have been strangely overlooked both by engineers and potamologists. Without attempting to enter into the theory of the question, it may be sufficient for the present to state, in illustration, that the action of rivers appears to be the exact converse of that of the pendulum.

The pendulum is a body in stable equilibrium, whose natural condition is consequently that of rest, and, being once disturbed, it seeks to regain that position; but, the original force remaining, it would go on oscillating for ever if we could abstract all the natural conditions of friction, resistance of the atmosphere, &c.

A river, on the contrary, is a body of water in unstable equilibrium, whose normal condition is that of motion down an inclined plane; and, if we could in like manner abstract all the natural conditions of inequality of surface or of soil, it would flow continuously in a straight line; but any obstruction or inequality whatever necessarily induces an oscillation, and, the action being continuous, the effects are cumulative, as those in the pendulum are discumulative; and the oscillation goes on increasing till it reaches the mean between the force of gravity tending to draw it in a straight line, and the force due to the obstruction tending to give it a direction at right angles to the former.

If this be so, it will immediately be perceived that the extent or radius of the curves will be directly proportioned to the slope of the bed of the river. If, for instance, a river were flowing down a regular slope, through a perfectly homogeneous soil, with a fall of, say, 10 feet per mile, or 1 in 500, the curves would be so extended as to appear nearly a straight line on the map. With a fall of 1 foot per mile, the radius of the curve is, as nearly as I can ascertain, double that of a river with a fall of 6 inches; and when the fall is about 3 inches per mile, the direct and tangential forces so nearly balance one another that the curves are practically semicircles. In the latter case the chord of the curves is practically four times the width of the river. Thus a river 1000 feet wide would oscillate once in 4000 feet in the general direction of its course, and the extent of its curve, measured along the centre of the stream, is a little more than 6000 feet. Between a fall of 6 inches and 1 foot per mile, the oscillation is, apparently, once in about six times the width; above a foot it rises to one in ten or twelve, above which it is extremely difficult to find examples uninfluenced by natural obstructions. It need hardly be remarked that these observations apply to rivers when their beds are full, which is the only time when they are shaping their courses *.

There are a number of other consequences flowing from these, to which I shall not allude here, as they have no direct bearing on the subject in hand, though it would be extremely interesting if they were observed and tabulated; for not only would these tables enable any one on inspecting a map to calculate approximately the slope of a country, and to estimate the relative importance of every river there delineated, but they would enable the engineer to regulate their courses, and the statistician to predict the result of the changes he sees taking place. To make this clearer, let me take one example. The Austrian engineers have of late years spent enormous sums of money in the attempt to straighten the course of the Danube by cutting off its lateral branches. This has been done by embanking across their mouths with dykes of fascines and piles. For a time this resists, and might resist so long as the river finds some other place where it can readjust its curvature; but, as these are stopped one after the other, it bursts through the barriers and resumes its old course. The fact is, the Austrians are trying to make the whole body of water flow in curves due only to a portion, and they have hitherto, as might be expected, found this impossible; had they taken the trouble to calcu-

* The average width of the Nile between Koum Ombos and Memphis is

late the curve due to the whole body, a few simple groins would have sufficed for all their purposes. It is precisely the same question as if it were proposed to make a 10-inch pendulum beat seconds, or one 39 inches long beat once in two seconds. It can be done by main force, but the moment the pressure is removed or weakened the pendulums resume their natural beat; and a clockmaker who constructed his clocks on this principle would fail as certainly as the Austrian engineers.

3. *Elevation of the Banks of Rivers.*—The second point to which I wish to call attention is the tendency of rivers in alluvial soils, especially in deltas, to raise their banks, and so confine themselves in their beds.

This process has been well described by Sir Gardner Wilkinson as regards the Nile, and by Sir Charles Lyell for the Mississippi; but neither of these gentlemen appear to me quite to have caught, or at least explained, the true cause. As regards the Ganges certainly, and the other rivers so far as I can judge, it is owing to the existence of great sheets of still water in the low lands beyond the banks of the rivers. These, being still, have deposited their mud, if they ever had any in suspension; and being too massive to be set in motion by the rivers, they reduce the flowing streams to inaction the moment

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2000 feet; the average length of oscillation 8500 or 4·25. The slope about 6 inches per mile. The following Table gives the approximate extent of the oscillation of the Ganges and the three Kishnaghur rivers.

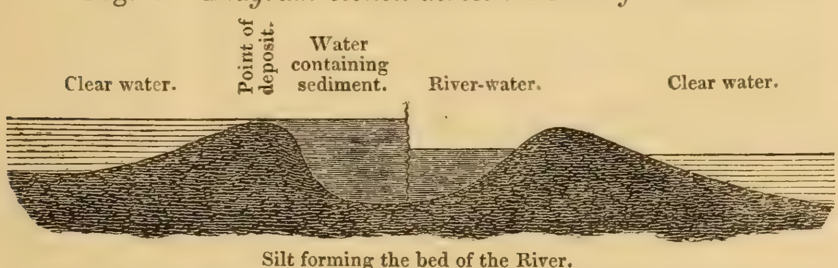
	Distance, direct, in miles,	Distance, per river, in miles.	Width of stream, low water, dry season, in feet.	Number of oscillations.	Length of oscillation, in miles.
GANGES.					
Allahabad to Chunar	62	104	3500	17	3·7
Chunar to Buxar	80	113	4000	20	4·
Buxar to Patna...............	74	96	5000	15	5·
Patna to Monghyr	82	106	6000	11½	7·
Monghyr to Rajmahal......	96	108	7000	10	9·5
Rajmahal to Rajapore	90	100	7000	10	9·
Rajapore to Pubna	30	44	4000	6	5·
Pubna to Jaffiergunge	32	36	3000	8	4·
BHAGARUTTEE.					
Chokah to Nuddya	96	120	1200	62	1·5
Nuddya to Chogdah	24	30	2000	9	2·5
Chogdah to Calcutta.........	34	42	3000	11	3·
JELLINGHY.					
Jellinghy to Nuddya.........	50	112	1000	42	1·2
MATABANGAH.					
Ganges to Coomar	18	28	1500	9	2·
Coomar to Kissingunge ...	30	50	800	46	⅔
Kissingunge to Chogdah ...	24	29	500	47	½

they leave their beds, and consequently force them to deposit their silt in their immediate proximity.

The first consequence of this is, that water resists water far better than earth does. A river can attack its banks in detail, can eat them away bit by bit, and carry off the spoil; but the still water, seizing the silt, forces the river to deposit it exactly where it is most useful in forming a barrier against further incursions, and so finally repels its advance.

In India these backwaters are called jheels, and are large sheets of clear water existing during the cold weather at about the same level as the river. During the rains they rise nearly *pari passu* with the rivers, partly owing to the quantity of rain-water that drains into them, partly to leakage through sandy strata, partly to small creeks or openings from the rivers, and partly also from almost all of them being open at their lower ends, so as to feel the reflex of the inundation. From all these causes, when the river is at such a height as to overtop its banks, it meets this body of still water (fig. 1), and, not being able to set it in motion, it deposits its silt in the limit between the moving and the still bodies. Even when the jheel has not risen so fast as the river, a few days' overflow serves to restore the equilibrium, and then the deposition goes on as before. In most parts of Bengal indigo-planters and others avail themselves of this interval to cut canals, or khals, through the banks, in order that the river-water may flow into the jheels, and so raise their beds and render them fit for cultivation. Even under the most favourable circumstances, however, the action seldom extends more than 100 or 200 yards from the banks; and, when the equilibrium of water is restored, the silt is deposited in the canal, which requires consequently to be cleared out every year, and after a few years the deposit beyond has raised itself to the height of the bank, so that further progress in that direction is impossible, and the opening in the bank of the river is then soon completely obliterated.

Fig. 1.—*Diagram-section across the Bed of a River.*



It is extremely difficult to fix the exact point at which this deposit begins to take place; but, as far as I have hitherto been able to ascertain, rivers flowing through a country whose slope is more than 6 inches in a mile have rather a tendency to deepen their channels and abrade their banks, and the land in their immediate proximity is lower than at a little distance*. At 3 inches in the mile, or

* The fall of the Indus from Attock to the sea being on an average 1 foot per

under this, the deposit always takes place; and its extent is nearly in the inverse ratio to the slope.

The exact turning-point of the two systems still remains to be fixed; but my own impression is, that we are not far wrong in taking 6 inches as the limit at which the deposit begins to take place; in many instances, however, 5 or even 4 inches may be taken as the starting-point*.

4. *Secular Elevation of Deltas.*—The only other point to which I will venture to call attention is what is called secular elevation, which I shall endeavour to define.

There was a time, before the formation of the Deltas of the Nile and the Ganges, when the sea or tide extended to Memphis in the one case, and to Rajmahal in the other. If at that time the slope of these rivers had been measured from any fixed point, such as the cataracts in Egypt in the one case, and the rock of Chunar in the other, it would have been found that the slope of both of them was very much greater than it now is, it having been diminished in the exact ratio in which the ground at the apex of the deltas has been raised—about 80 feet at Rajmahal, and 60 feet at Memphis. Little or no silt was consequently deposited in the up-country in early times, but everything was swept to the sea, and the extension of their deltas has consequently been in an immensely more rapid ratio than at present. But, besides this, for every mile that the delta extended seaward, the slopes, as shown on the diagram (fig. 2), would tend to become parallel in a geometric, and not in an arithmetical, ratio. And when the elbows at Memphis and Rajmahal were completely obliterated, the secular increase must have been infinitesimally small.

Taking first only the mathematical view of the subject—if we assume a point such as Patna, say 200 miles above Rajmahal, and that the delta is now extended 200 miles below that point, assuming also that Patna is now 200 feet above the level of the sea, and Rajmahal 100 feet, all which figures are sufficiently correct for illustration, it is evident that, if we divide the time since the sea was at Rajmahal into four equal epochs, the level at Rajmahal during the first period of the extension of the delta fifty miles seaward would have risen 40 or 42 feet, during the next 27, during the third

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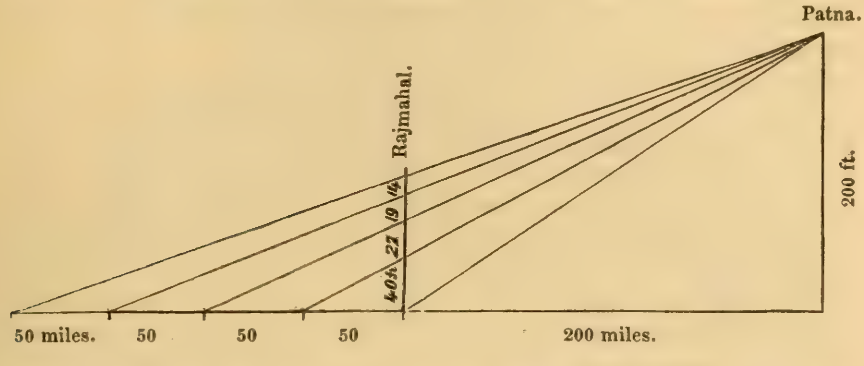
mile, it is not a depositing river. The only part of its course where the slope is less, judging from the lateral extent of its oscillation, is between Kyrpore and Sehwan. Between these places it may deposit to some extent, but elsewhere its course is steep and straight.

* No argument on this subject can be depended upon if derived from observations on the course of the Nile, the slope of whose bed from the cataracts to the sea appears to be about 6 inches per mile, for the reason that, between the bank of the river and the hajar, or desert, the natives have at different times constructed numerous causeways, as may be seen in the atlas prepared by the French savants in the beginning of this century, and explained by Sir Gardner Wilkinson (Journ. Royal Geogr. Soc. vol. ix. p. 432 *et seq.*). These act as so many dams or silt-traps during the inundation or depositing season. But for these dykes, it is by no means clear that there would have been any deposit in recent times on the plain of Thebes, instead of 7 feet in 1700 years, which Sir Gardner calculates; and the variation in the thickness of the deposits in different places seems to be almost wholly due to these artificial obstructions.

Fig. 2.—*Diagram illustrating the Secular Elevation of Deltas.*



20, and during the last 13 or 14, or less than one-third of what was due to the accumulation during the first period. But this is far from representing the whole truth; first, in consequence of the greater quantity of silt brought down by the river when its slope was 12 inches, which it must have been during the first period, instead of less than 6 inches as it is now. And, secondly, the area or breadth of the delta is necessarily less near its apex than at its base, and, consequently, the area over which the silt had to be deposited much less than at present.

From these and other minor causes I feel convinced that if we assumed the deposit to be 50 feet, or one-half, during the first period, it would be rather under than over the mark; and, say, 25 feet during the second, 12 or 13 during the third, and 5 or 6 during the last of the four periods indicated in the diagram. From the conformation of the ground I should be inclined to assign a higher rate of progression for the rise of the land of Egypt in the neighbourhood of Memphis. But it is difficult to speculate on the phenomena of that river while we remain so ignorant of the physical condition of the country from which the inundation proceeds. But even more uncertainty has been superinduced, as pointed out above, by artificial obstructions.

All this is assuming that the silt is distributed quite evenly over the whole delta. This, however, is practically very far from being the case. The mode in which deltas are raised is by a river, flowing through some low part of the country, gradually embanking itself, and then raising its bed till the body of its water is higher than some neighbouring region; it then falls into this, and, going through the same process, it fills that depression, and then goes on to the next. After a long cycle of years it comes back again to the country it first left, which probably has not risen 1 foot since, while the neighbouring country may have been raised 30 or 40.

From these data it will be perceived how fallacious any conclusions must be which are drawn from borings into the strata of deltas, and calculations formed from local superficial deposits. I myself have seen the bricks which formed the foundation of a house I had built carried away, and strewed along the bottom of a river at a depth of

30 or 40 feet below the level of the country. Since then the river has passed on, and a new village now stands on the spot where my bungalow stood, but 40 feet above its ruins; and any one who chooses to dig on the spot may find my "reliquiæ" there, and form what theory he likes as to their antiquity or my age. If we add to this local disturbance the varying degree of elevation just pointed out in the secular increase, it must be seen that the problem is of a much more complex nature than has hitherto been assumed.

5. *Mode in which Deltas are elevated.*—Independently of the changes wrought by the varying quantity of water in the different branches of the deltaic rivers, and the consequent necessity for enlarging or contracting the extent of their oscillations, there is another class of changes superinduced by the accidents to which so complicated a system must always be liable. If one of the tributaries, for instance, which before fell into the hollow side of a curve presses on the convex side, if a sand-bank is formed anywhere, or if any natural or artificial obstruction forces the river to change its bed in any part, the whole system is so rigid that the alteration is felt in every direction, both above and below, as far as the alluvial plain extends.

One consequence of any such alteration in the course of the main stream is, that the initial or terminal oscillation of any tributary or distributary is continually altering its position, and the oscillations cut their way through the whole plain * of the river, both in an upward and downward direction.

Such a river as the Ganges between Patna and Rajmahal must have eaten through its plain several times since it has occupied its present position. But when the delta is so raised as to reduce its slope from 6 to, say, 3 inches per mile, it is not difficult to foresee a time when the river will so raise its bed as to be obliged to seek a new "plain" further north, and may again resume the position it once occupied in the centre of its valley, but from which it has been forced against the southern hills, by the greater "*vis viva*" which the Himalayan streams derive from the rapid slope of their beds and their preponderating body of water.

None of the rivers of the delta have in historical times, so far as we know, worked their way twice through the same plains. The first operation so raises their plains that they generally find it easier to seek a new course in the lower lands on either hand; and the stream in their old beds consequently becoming sluggish, they gradually silt up and become, after a while, altogether obliterated, except here and there where a reach has been cut off in the process, and remains, like a fossil, to mark the previous existence in that spot of a river of a given oscillation, which may still be measured with perfect certainty in the fragment that is left. It is by this continual shifting of the plains of rivers that the whole delta is gradually raised to a higher level.

* By "plain" in this sense is meant the district occupied by the river between the extreme outward edge of its oscillations on either side. With a river 1000 feet wide, its plain may extend from one to two miles in width, and others in like proportion, varying, of course, according to the slope of the country.

This is a curious and complicated process, which I shall now try to make as clear as I can, by describing the phenomena as they have occurred in the valley of the Ganges.

II. *Physical Changes in the Valley of the Ganges.*

1. *Upheaval of the Madoopore Jungle.*—Although the principal object of this paper is to describe the phenomena resulting from the deposit of silt by the rivers of Bengal, there is one of a contrary nature which has had so marked an influence on the river-systems of the delta that it is impossible to pass it over. The circumstance I allude to is the upheaval of a large tract of country known as the Madoopore Jungle, which there is every reason to suppose took place in very recent times.

This tract extends for about seventy miles due north from the city of Dacca, which is built on its southern extremity. Its greatest width in the centre is about thirty-five miles. On its western face it has a well-defined boundary, and rises in hillocks to a height of about 100 feet from the level of the alluvial plain along its whole length; in the centre its average height is from 40 to 60 feet above the plain, and it gradually slopes away to the eastward, dipping below the old bed of the Brahmapootra, and losing itself in the Sylhet Jheels.

The surface of this district is a hard ochreous clay, identical, so far as I can judge, with the strata found below the peat and recent deposits at Calcutta, where it exists at a depth of from 70 to 120 feet below the surface of the soil.

There is, at all events, no *à priori* improbability against this upheaval having occurred in very recent times. An inspection of the map will show that it occurred in the axis of the belt of volcanic action which extends from Narcondam through Barren Island on to Cheduba and Ramree, and thence to Chittagong and Dacca.

Without going further back than the great earthquake which occurred at Chittagong in April 1762*, I may remind the Society that a large tract of land was then submerged, that other parts were elevated, that two volcanos broke out, and the whole settlement was shattered, and that at Dacca the shocks were so violent that the wave from the river swept off a large number of the inhabitants.

It was not then, however, that any upheaval took place, nor at any period subsequent to the foundation of that city in the beginning of the seventeenth century by Jehanguire; for its oldest buildings, though cracked, are not destroyed, as they would have been by such a convulsion. And how long before that time it occurred we can only guess by trying to estimate how long it would take the Brahmapootra to fill up the Sylhet Jheels to the extent it has done, and by the uncertain light of native traditions, some of which will be alluded to in the sequel.

As hinted above, there exists to the eastward of the upheaved region a depressed area of about equal extent. For a description of this I cannot do better than refer to Dr. Hooker's 'Himalayan

* Phil. Trans. vol. liii. p. 251.

Journals' (vol. ii. p. 256). He sailed for some days among these Jheels, and found by his barometric levellings that they were very slightly raised above the Bay of Bengal. Their bottom generally consisted of accumulations of decaying vegetable matter—incipient peat—through which he could not reach a bottom by thrusting in the boat-poles.

It is not necessary here to insist on this depression being the effect of the upheaval of the Madoopore Jungle, or to inquire whether it pre-existed; but I think there can be very little doubt that the disturbance caused by the upheaval was what turned the Brahmapootra towards the east into these jheels.

A mere inspection of the map is sufficient to establish the probability that this change must have taken place not very long ago; and though the length of the course of the Brahmapootra is only half that of the Ganges (for it is not clear that it has any connexion with the Sampo of Tibet), still the two rivers are quite equal in volume, inasmuch as both enter the deltaic plains of Bengal with a ten-mile oscillation before parting with any of their waters through their distributaries below Rajmahal on the one river, or at Rangamutty on the other.

Although equal in volume, the Brahmapootra brings down an immensely greater quantity of silt than the Ganges—probably one-half more; as Buchanan Hamilton phrases it, "It is the dirtiest river I ever saw." This arises, principally, from the fact that the slope of the valley of Assam, from Sudya to Goahuttee, appears to be more than 6 inches per mile. The consequence is, that neither the principal branch of the Brahmapootra nor any of the tributaries deposit their silt, but all is swept onwards; and, owing also to the greater quantity of rain that falls there than falls to the westward, the denudation of the land is much more rapid. This condition of matters will not be changed till the section across the valley opposite Goalparah has been considerably raised beyond its present level, or, in other words, till the land between Goahuttee and Goalparah attains an elevation corresponding to that attained in the valley of the Ganges about Rajmahal. At present the elevation of the river at Goahuttee, with 350 miles to run, is apparently lower than the Ganges at Rajmahal, within 250 miles of the ocean*.

Until this extra elevation takes place, the physical condition of the valley of Assam will so closely resemble that in which the valley of the Ganges probably was when the sea was at or near Rajmahal, that few problems connected with this subject would be more interesting than to compare the condition of the two valleys, in so far as materials exist for the purpose.

At that early time the River Ganges must have flowed with greatly increased velocity nearly in the middle of its valley; but as its slope and consequent velocity decreased, it was pushed southward against

* The level of the river at Goahuttee is assumed from a long series of barometric observations, checked by those of the brothers Schlagintweit ('India,' vol. ii. p. 103); that at Rajmahal, from the levels of the East Indian Railway, checked by those of the great Trigonometrical Survey.

the hills by the greater energy of the northern streams, and the mass of their accumulations, the only southern stream of sufficient power to keep it off its hills being the Soane.

The Brahmapootra still maintains itself nearly in the centre of its valley for the greater part of its course, but it must be pushed southwards, as the Ganges has been, in the exact ratio in which the quantity of water flowing from the Himalayas exceeds that draining from the southern hills; and, as this takes place, the valley must rapidly be filled up and become habitable, which it hardly can now be said to be in most parts.

Though it is dangerous to descend to particulars in such matters, my impression is that hardly more than 4000 or 5000 years have elapsed since the sea, or rather the tide, was at or near Rajmahal; or, to speak more correctly, since the greater part of the province of Bengal Proper was a great lagoon, like those which exist at the mouths of the Brenta or the Po, or the Lakes Mensaleh and Boorlos, at the mouths of the Nile: for there is no reason to suppose that there did not always exist—in historical times at least—a bar or barrier where the tides turned somewhere very near where the Sunderbuns now are; but between this and the apex of the Delta all seems to have been a tidal swamp. When this was the case, the upper valley of the Ganges was in the semi-habitable state in which we now find Assam; and I fancy we can, in history, trace the settlements that were made one after another, proceeding eastward as the Delta extended, and, by its elevation, diminished the slope of the bed of the Ganges to what we now find it.

2. *The Silting-up of the Sylhet Jheels.*—To return, however, to the Sylhet Jheels. When the Brahmapootra was first turned into them, they consisted of an immense tract of submerged country, covered with clean still water of no great depth, and consequently every particle of silt that was brought into them was seized upon and deposited; and the Luckia and Megna, which flowed out of them, must then have been, as they are now, clear and pellucid streams, as compared with the turbid waters of the two great rivers.

The first effect of this invasion, that we trace on the map, is that the Soorma and other streams which flowed from Munnipore due westward, along the foot of the Cossya Mountains, were deflected southwards, which it was easy enough for the great river to do, so long as it could take them in detail. It was not until they were all united in the bed of the Megna, and pressed between the Tiperah Hills and the upheaved tract, that the real struggle began.

In this case, though the Megna was much the smaller river, it had certain advantages necessary to be pointed out in order to appreciate the result.

The first of these is, that the Sylhet rivers depend wholly on the monsoon rains for their supply. The clouds, striking early on the Cossya range, discharge their waters with a violence hardly found elsewhere; and, as is well known, from 500 to 600 inches of rain fall on the slopes of these hills during the three months of the rainy season. It may also be mentioned that, owing either to the nature of the rocks of which these hills are composed, or because the violence of the monsoon has long ago denuded them of every moveable particle, these rivers bring down little or no silt even in the height of the monsoon, and are quite clear in the cold weather.

The Brahmapootra, on the other hand, depends for its floods partly on the melting of the snow, partly on the far more moderate and later rains of the valley of Assam, probably hardly exceeding 100 or 120 inches; having also a longer course to run, it arrived later at the scene of the struggle, and found the country already occupied by the waters of the Megna to such an extent as to be able to dam back its waters for the first month of the rains, and to force it to deposit its silt in its own bed. It could not, of course, have done this with any effect until the large river had reached the higher lands beyond the jheels to the southward, and with its silt had bridged across the whole width of the jheel-country, and, by this process, had embanked itself along the whole extent, so as to make it difficult for it to change its course. So long as the Brahmapootra was only forming an inland delta in the depressed country, the Megna had no hold upon it; but when it came to flow in what was practically an aqueduct, along the top of an embankment of its own making, it was rendered powerless, and the struggle was soon over. Had it not been for the upheaved tract already alluded to, it would, of course, have sidled away westward, and so have avoided the contest with the Sylhet rivers; but that being impossible, we find it retracing its steps nearly seventy miles northwards, and finding a new channel for itself above Dewangunge in the bed of the Jennai.

3. *Eastern Gap in the Seaward Face of the Delta.*—Before leaving this branch of the subject, it may be well to allude to another geographical fact, which I believe to have been in a great measure the result of this diversion of the Brahmapootra into the Sylhet Jheels. It is the great gap or gulf that exists to the eastward of the Gangetic half of the delta.

From the Hoogly to the Horringotta the seaward face of the Sunderbuns is tolerably level and fixed; at all events, it has undergone no sensible change within any period to which our knowledge extends; and, so far as can be ascertained, it shows no tendency to go forward. In that portion of the delta, however, allotted to the Brahmapootra a great deal of work has yet to be done; everything there is so new, and in such a constant state of change, that, even in that climate, vegetation has not been able to settle upon the islands, and these are continually moving and changing their places. A great deal has been done to fill up the gap since the Brahmapootra last changed its course, in the beginning of the present century; but we want a new survey to be quite sure to what extent this has gone. If I am correct in my view, that the gap is mainly the result of the straining of the waters of the Brahmapootra through the Sylhet Jheels, and their consequently reaching the Bay of Bengal deprived of all their silt, it follows that the process of filling up will now be comparatively rapid, and that the eastern face of the delta will assume before long the same fixed character which now marks that of the western portion, and which is due—as will be afterwards explained—to the joint action of the tidal and fluviatile forces which meet at that point.

4. *Change in the Bed of the Brahmapootra.*—It would have been extremely instructive if the progress of the struggle between the Megna and the Brahmapootra had been carefully watched and recorded; all we now know is, that when Major Rennell surveyed these rivers in 1785, neither he nor any of his assistants had any idea that the Brahmapootra had not always flowed, and would not always continue to do so, in the channel in which he then found it. We now know that, though a considerable body of water may flow that way in the rains, yet during nine months in the year a creek, or rather chain of ponds, 100 or 200 feet wide, and everywhere fordable, represents the river that a little more than half a century before flowed through that country in seven-mile reaches, and with a breadth of more than a mile and a half even in the dry season.

It is unfortunate that Buchanan Hamilton * did not visit this country when surveying the neighbouring districts in 1807–10, as the change must then have set in; and his greater knowledge of the language and of the customs of the natives would have led him to remark upon the anomaly of the smaller stream (the Megna) giving its name to the Brahmapootra, from their junction at Sonerampore to the sea, proving that the bed belonged to the smaller river, and that it had been invaded by the larger; and proving also—for this class of evidence is very cogent in these regions—that the invasion had taken place after the country had been sufficiently inhabited and settled to have the names of its rivers fixed on the bases they now maintain. So far as we can judge from appearances, this could hardly have occurred very long ago.

When the survey now in progress is completed, it will not be very difficult to estimate this epoch approximately. The first thing to be ascertained is, of course, the quantity of silt brought down by the Brahmapootra; then to estimate the area of the Sylhet Jheels filled up by the great delta formed in them by the waters of the Brahmapootra, checking this with the area of the delta at the mouth of the Megna, which remains to be filled in; and, with a few borings, all this ought not to be very difficult. In the meantime, it certainly is to be regretted, in an economic point of view, that the combined Sylhet rivers prevailed in this struggle. They cannot fill up their own swamps, because they possess no silt; and they shut out the only river that is capable of doing it for them. Now, however, every year must make their condition worse; for, as the delta extends, the land between them and the sea, below Dacca, must rise, and they consequently must deepen, and their water spread, until the whole province may become a submerged peat-factory, from which fate nothing can save it but inviting back the river they have just expelled.

5. *Opening of the R. Jennai.*—The first river the Brahmapootra met which could afford it a means of escape was, as just mentioned, the

* His surveys, in a mutilated form, were published in 3 vols. 8vo, by Montgomery Martin, in 1838.

Jennai. Having no earlier maps than those of Rennell, it is impossible to be certain what the condition of this river was before he surveyed it. He found it flowing due north and south, in one-mile oscillations, with a breadth of between 400 and 500 yards, and flowing so regularly that I cannot help suspecting that it was then a very young river; if I may be allowed to guess, I should say not more than twenty years old. In fact, it seems to have been the first product of the struggle between the Megna and the Brahmapootra, and did not exist till the waters of the latter river had been dammed back so as to flow in this direction.

When Buchanan Hamilton visited this country in 1810, he merely remarked that the Brahmapootra threatened to "carry away all the vicinity of Dewangunge" (which it has since done), "and perhaps to force its way through the Konnai (Jennai) into the heart of Natore."*

It was not, however, till ten years later that it had increased to such an extent as to affect the Jessore rivers; and it was not till about the year 1830 that any reliable information was obtained regarding it. About that time a party of engineer officers was sent to connect Assam with the Great Trigonometrical Survey then in progress in Bengal. They carried a series of triangles up the bed of that river; and it was at the same time attempted to navigate it with steamboats. Nothing, however, was published until the river was laid down on a map of Bengal which I constructed, in conjunction with the late Mr. Tassin, on a scale of eight miles to one inch, in the year 1836. At that time it was flowing through Natore with an oscillation of nearly seven miles, and has continued to do so ever since; for though in its oscillations it sweeps away hundreds of miles of land every year, it is only very lately that it has shown any restlessness, or any tendency to leave its present direction, and whether it will be successful or not in so doing still remains to be seen. In the meanwhile the river is *nearly* where it is shown on the map; but, as it was there in 1850–53, it certainly is not there now, as it never is exactly in the same place for two successive years, being young and active, and roaming through a new and unconsolidated country. It may also be mentioned that the city of Serajgunge—the largest and most important mart in that part of the country—is somewhere in that neighbourhood now, but not where marked on the map, of course, as it is annually obliged to accommodate itself to the vagaries of the stream, and change its locality. It may be ten miles further up the stream, or ten miles further down, or five miles further east or west; but it is somewhere thereabout; and that is all the information geographers can hope for in a country where land can only be classed with floating capital.

6. *Jessore Group of Rivers.*—The first result of this invasion of the Gangetic territory by the Brahmapootra was, that it should seek to re-enact the part which had just been performed on the other side of the Madoopore Jungle and should threaten to shut up the Ganges, and send it back through its own distributaries. It was so nearly successful that, in 1838, the Great Ganges was fordable at

* Martin, vol. iii. p. 396.

several places above the junction. As the Brahmapootra has an oscillation of seven or eight miles, while the Ganges has only one of five miles at that place, and as even that is gradually diminishing, it must have been successful if the Ganges had been able to find another outlet. This, however, was not so easy, the whole of the country to the southward and westward having been traversed repeatedly by powerful rivers, and the country consequently well raised and consolidated.

The Chandna was the first river it met above the junction, from which it could look for relief. This river, however, was old, its oscillation short, and its banks high and consolidated. But, even if it could have been opened, its natural outlet to the eastward, the Coomar, was older still, and less likely to give way; from a two- or three-mile oscillation, which can still easily be traced, it had sunk to one averaging half a mile or less. No water runs through it in the dry weather, and during the inundation the flow is so sluggish that all the silt it receives is spread on its own banks; consequently it has raised its district higher than any of the surrounding country.

Proceeding up the stream, the next river was the Goraie. This was more tractable; it was not originally a distributary, but a local stream, draining some jheels—it was consequently only at its head that its banks were at all stiff or consolidated; lower down the land was low, and the river divided into several branches, each of which could be opened out separately. Even its upper reaches were so tractable, that, from a width of 600 feet, at which it stood in 1828, it has increased to 1908, which is now the least width at the lowest season. The next river upwards was the Upper Coomar. It has not been opened to the same extent for the reasons just stated; but, as the pressure the Ganges could bring to bear upon it was infinitely greater than could be effected by the Chandna on its lower division, it has been opened and increased from 330 to 792 feet, and both these rivers are still increasing.

When these three came together above Baboocally, there were several courses open to them; the most natural one—for the Coomar at least—would have been to have opened the Novo Gunga. Though called *new*, this, however, was the next oldest stream of the district, after the Coomar. Its oscillation is only half a mile, and its banks are consolidated and thickly inhabited; and though, no doubt, some of its reaches might have been lengthened, still if, at any one place, two or three oscillations are so stiff that they cannot be extended, they govern the whole; and as there are several such in this river, its increase was hopeless.

The Barassya looked more favourable, and a part of its bed was actually appropriated and widened; but there were two oscillations opposite Muddenderry Factory which were in such stiff soil that they could not be extended, and, though the river has been somewhat widened and deepened, it remains now practically the same as when Rennell surveyed it.

To any one unacquainted with the habits of rivers, it will immediately suggest itself that the easiest escape from these difficulties would have been to break into that long low range of jheels behind Mahmudpore, and so get to the sea without difficulty. As I have, however, tried to explain above, water resists water better than land. It broke several times into the low land, but was on every occasion repelled, being forced to deposit its silt so as to make a barrier against its own incursions.

The only remaining course, and the one that eventually was adopted, was to seize on a small khal, or creek, called the Ellan Khalee, and widen it for the purpose. This was not difficult, as the land was low and friable, no great river having come that way in recent times.

In Rennell's time the creek was so insignificant that it is not mentioned in his maps, and even in 1818–20 it was so small that it could be easily leaped on horseback; when I first knew it in 1830–33 it was sweeping through the country with two-mile oscillations, as regular as if they had been drawn by hand. It was nearly 800 yards wide, and deeper in proportion than the older rivers. It was, in fact, the only river that all the year round was open for steam-navigation between Calcutta and the upper provinces. After being rejoined by the Novo Gunga and Barassya, it increases its reaches to three miles, and carries this oscillation to the sea—certainly the largest and finest of the delta-rivers after the great Poddah* or Megna.

Since I surveyed it in 1833 it has been getting straitened in its bed, and it evidently has been embanking itself too rapidly. Its reaches have lost their beautiful regularity and have become contorted; and one of them has stretched about two miles to the eastward, so as to cut off the Muddenderry reaches. If it has accomplished this—which I believe it has—it may be able to open out the lower part of the Barassya River, and get into the low country behind; and then, perhaps, joining some of the old branches of the Ganges which existed in Rennell's time, so get to the sea.

If this should be accomplished, the Goraie and the Upper Coomar, with the Chandna, will practically become the great outlets of the Ganges, and the whole of the eastern half of the delta will then be abandoned to the Brahmapootra. This will certainly be the case if the Ganges' waters find a sufficient outlet in this direction; and the chances are so equally balanced that the struggle is extremely interesting at the present time.

7. *Natore Group of Rivers.*—The Ganges at Jaffiergunge, united with the Natore rivers at Oorasagur, is so nearly a match for the Brahmapootra, that the latter river is attempting to escape the conflict by cutting off the angle at Attree, and joining the Dallaserrai through the Elamjanee River. To do this effectually, however, it must open

* Poddah, or Padma (the Lotus), is the stream, running nearly east and west, by which the Bhagaruttee, or true Ganges, above Bauleah at some recent time connected itself with the Brahmapootra somewhere above Jaffiergunge. The tradition of this junction taking place is quite distinct in the minds of the natives inhabiting its banks, who do not consequently look on the Poddah as a sacred stream. Still it must have taken place before the diversion of the Assam river into Sylhet.

out some eighty miles of tolerably settled watercourses; and this would occupy some twenty years, even if it succeeded eventually. Our knowledge of the country is still too imperfect to enable us to predict the result with certainty. Whether it can accomplish this or not depends more on the success of the Goraie and the Jessore rivers in finding an outlet for the waters of the Ganges, than on the resistance of the eastern country. I may, however, be allowed to remark, in passing, that it will be a great advantage to the delta if the Brahmapootra does maintain its present course, and continues to act as a *barrage* to the waters of the Ganges. There is a great deal of land to the westward that would be improved by being raised, while it would be an immense benefit to the internal navigation if the Kishnaghur rivers could again be opened, and these objects can only be attained by the persistence of the eastern rivers in their endeavour to confine the western to their own territory.

If the Brahmapootra is able to maintain its present position at Jaffiergunge, another effect will be, that by continually damming back the waters of the Oorasagur, it will force the Natore rivers to deposit their silt, and to fill up the very low country through which they run. A good deal has already been done in this direction since Rennell's survey; and if the action continues much longer, they must abandon the struggle with the Brahmapootra, and seek an outlet somewhere between Bauleah and Surdah, some eighty miles further up the stream of the Ganges.

It follows from all this that, if the Brahmapootra continues in its present bed, it will almost certainly close the eastern outlet of the Ganges. At present it is kept open by a rather curious process, which it may be worth while to describe.

As before mentioned, the principal means by which the Megna defeated the Brahmapootra was by being first in the battle-field; and though the Brahmapootra is slower than the Megna, it is quicker than the Ganges, owing to the length of course of the latter river, and its depending more on the melting of snow than on rain.

The consequence of this is that, for the first month of the inundation, the water in the Ganges above Jaffiergunge almost flows backwards, and the Echamuttee at Pubna flows into the Ganges instead of out of it; and, during this season, the deposit in its bed is very considerable. But, during the last month of the rains, when the waters of the Brahmapootra have nearly run off, the immense body of water spread over the vast plains of Hindostan rushes into the partially deserted bed of the Brahmapootra, which then acts as a waste-water reservoir, and with a force that, to a great extent, clears out the deposit of the earlier months, and so restores the equilibrium.

This has been so entirely the case of late years that the Ganges has straightened its course very considerably below the head of the Jellinghy. The first result of this was to cut off a great six-mile bend on the left bank just above Pubna. This took place some thirty years ago. Within the last two years it has cut off the next bend on the right bank, leaving the Koostee Station of the Eastern Bengal Railway some two or three miles below the head of the

Goraie, instead of two miles above it on the Ganges as it originally was, and was designed to be; and if this sudden rapid rush at the end of the rains can be maintained, it probably will suffice to keep the river open, and so maintain the present *status*.

It will be easy to perceive how this effect takes place, if we bear in mind that the fall of the country between Pubna and Jaffiergunge (thirty-six miles) is only about seven feet; and if all the waters were supplied by one river, that would be their slope; but if, at any moment, the waters of the Brahmapootra should be seven feet lower than those of the Ganges, the slope will be doubled; and if ten feet, the scour must be tremendous; and it is believed that this was the difference when the last bend was cut off.

8. *Kishnaghur Group of Rivers.*—After the Jessore rivers just described, the only other great group of distributaries of the Ganges is that known as the Kishnaghur rivers, and consists of the Bhagaruttee, Jellinghy, and Matabangah, which, uniting above Sooksaghur, form the Hoogly.

Of these the oldest is the first-named. Indeed, if we consult either native traditions or internal evidence, it is the Ganges itself, and bears the same sacred name here as it does at its source; the name Ganges, which is applied to the intermediate portion, merely means Gunga or Gonga—the *river* "par excellence."

Whether we look at it from a geological or an historical point of view, there can be little doubt that the original river, after passing Rajmahal, would naturally run southward, parallel, or nearly so, to the course of the Brahmapootra at that time, the distance between the two being probably under ninety miles. The intermediate space would then have been fully occupied by the Coosy, Mahanuddee, Atree, Teesta, and other Himalayan torrents, all of which were probably at that time tributaries to the Brahmapootra; though, in consequence of the extension of the delta, they have most of them seceded to the Ganges.

It is probable that the Bhagaruttee River, or true Ganges, always flowed very nearly in the direction it now does, the extension of the delta on the left being about sufficient to counterbalance the repulsive action of the More, Adjie, Damooda, and Roopnarain, on its right bank. There is, indeed, no improbability in supposing that the original state of things may be, to a great extent, restored before long. All the silt of the two great rivers has been employed for a considerable time in raising the eastern half of the delta, and as that rises it throws the waters westward; and though we can hardly contemplate the Great Ganges flowing again past Moorshedabad, there is every reason to suppose that the body of water flowing through the Kishnaghur rivers will largely and steadily increase.

It is not very easy to ascertain now which were the earliest assistants of the Bhagaruttee in distributing the waters of the Ganges; but, of those which have left any traces, three may be mentioned as the best known. The first of these was the Coomar, mentioned before, and running E.S.E. nearly parallel to the bed occupied by the Ganges fifty years ago; the Boyrub, running south-east; and the

Echamuttee, taking an intermediate course between the last-named and the Hoogly, whose course is due north and south. As mentioned above, the lower part of the first-named river was cut off by the Chandna, and it then dried. The upper half long remained moribund, but was revived by the late invasion of the Brahmapootra. The second was extinguished, probably some 300 or 400 years ago, by the Jellinghy, which, when the slope of the delta towards the east became less, turned its waters from the south-east to south by west, and with them joined the Bhagaruttee at Nuddea, the Nyadwipa of olden times—a new island when the neighbourhood was a sea, or at least a tidal swamp. The third was nearly meeting a like fate from the Matabungah, which, appropriating a part of the bed of the Coomar, and then a part of the Echamuttee, opened out the Choornee nullah of Rennell, and joining the Hoogly above Sooksaghur, it promises, if not checked, to play an important part in the fluviatile history of the delta.

The cause of the recent increase of the Matabungah is, of course, the action of the Brahmapootra on the lower Ganges, and its inability to open up the Coomar suddenly, or the Echamuttee, which is an old and thoroughly settled river, with high consolidated banks and very short oscillations. Its success, however, will mainly depend on whether it can so open out the Hoogly as to admit of its taking off the extra supply of water it may bring down. Whatever the ultimate result may be, it began vigorously. At Sooksaghur there was a noble country-house, built by Warren Hastings, about a mile from the banks of the Hoogly. When I first knew it in 1830, half the avenue of noble trees, which led from the river to the house, was gone; when I last saw it, some eight years afterwards, the river was close at hand. Since then, house, stables, garden, and village are all gone, and the river was on the point of breaking through the narrow neck of high land that remained, and pouring itself into some weak-banked nullahs in the low lands beyond; and, if it had succeeded, the Hoogly would have deserted Calcutta. At this juncture the Eastern Bengal Railway Company intervened. They were carrying their works along the ridge, and they have, for the moment at least, stopped the oscillation in this direction. If they are able to do so in future, it will remain to be seen whether the Matabangah has the power to open out the reaches of the Hoogly so as to take off the water; but this I doubt. The river is old, its banks are high and much built upon, and great sums of money would be spent in groins and embankments to stop its encroachments. These may be successful; in which case it must open up the Echamuttee, or break through somewhere and get behind Calcutta. This might not be a serious misfortune for that city; indeed, the Hoogly becoming a mere tidal estuary like those of the Sunderbuns, without any silt-bearing streams flowing into it, would be an advantage, were it not that lower down there are two rivers, the Damooda and the Roopnarain, which would probably, during the rains, be able to shut it up if there was not a very heavy counterbalancing pressure from the Kishnaghur rivers to keep it open.

Not very long ago, if we may trust tradition, the Damooda joined the Hoogly at Satgong, above Hoogly; and even in Rennell's time the old bed was open, and is marked in his maps; but it was bent back, and was evidently, in his time, losing its gripe on that stream. It has now, like the Sylhet rivers, been bent south, and, like the Megna, lies in wait further down, prepared, in conjunction with the Roopnarain, to retaliate if any accident or moment of weakness should come over its old antagonist, the Hoogly.

According to the natives, this great change took place only in 1757–1762 *, when the Damooda burst into what had been the old channel of the Bhagaruttee and joined the Hoogly—the new name of the new stream—close to the mouth of the Roopnarain, which the natives persist in asserting is an old mouth of the Ganges; and they are probably right, though Major Rennell, in his Atlas, takes the trouble of denying it.

If the time when this great change is said to have taken place be even approximatively true, it affords a much more satisfactory explanation of any change that may have taken place in the navigability of the Hoogly than can be derived from any silting-up of the Kishnaghur rivers, which seem to have remained unaltered at least since Tavernier travelled in India in 1666, when these rivers seem to have been pretty much in the state they now are. But if the land is rising rapidly in the eastern half, especially about Jaffiergunge, which there seems no reason to doubt, while there has been no change of level in recent times in the western half, it follows, almost as a certainty, that the western rivers must go on gradually but steadily increasing in volume, and with them the quantity of water flowing through the Hoogly.

On the whole, therefore, it seems fortunate for Calcutta that the Hoogly did not break through at Sooksaghur; and this circumstance will be a benefit to a large portion of the delta if it forces either the Echamuttee or the Boyrub again to open its oscillations. As mentioned above, both these rivers were cut off by the Jellinghy and Matabangah when this part of the delta had been so raised that the inclination was rather to the west than the east or south. When the town of Jessore was built on the Boyrub, some 350 years ago, it is said that it was situated on the sea-shore, though this probably only means that the country to the southward of it was a tidal swamp, which, so far as we can judge, was the condition of a great portion of the delta at that period, though the seaward face of the Sunderbuns was probably the same as it now is.

It must have been immediately after this that the Kishnaghur rivers cut across the Boyrub, and deprived it of its supply of Ganges water; for at a distance of about six miles below the town of Jessore it ceases to be a "depositing" river. Up to that point its banks are high and firm, its oscillations quick, and it has all the appearance of an active river. For twenty-five miles from that point it runs to Culna, and beyond it, as straight as a canal, through an immense tract of jheel-land. It has had no silt to form banks, or

* Capt. Sherwell's Report on the Rivers of the Ganges, 1858.

to raise the country, for nearly forty miles in length and some twenty to thirty in breadth; while, as the more active rivers on either hand have raised theirs, this remains an immense half-inhabited tract, which is yearly getting relatively lower, and will become absolutely uninhabitable unless some active silt-bearing river turns in that direction. Whether it will be from the westward or the eastward that the succour will come remains to be seen. My impression is that it will be in the latter direction. Already the Ellankhally has sent the Chittra in a south-westerly direction across the Boyrub at Kulna; and it has done a great deal of good in raising the depressed country. This stream is not marked in Rennell's maps. When I knew it, it was narrow and crooked, but deep and navigable. It has now one-mile oscillations, with a width of about 1200 feet, and is increasing. Its only defect is, that it strikes the Jheel-country too low. What is wanted is that the Ellankhally should send off a branch a few miles below the junction of the Novo Gunga, which would enter the heart of the swamps. If it does not find an opening to the eastward, across the Barassya (which, as mentioned above, it is now seeking), it will probably turn in this direction, as it affords an opening which, though not so promising, is yet probably more easily accessible than the other.

9. *Changes in the Course of the R. Teesta.*—Before leaving the rivers of the Delta, there is one that exhibits phenomena of so different a class that it may be well worth while noticing them, in order fully to understand the subject.

The largest tributary to the delta-streams, east of the Coosy, is the Teesta. It rises in the Sikkim Mountains not far from Darjeeling; and when surveyed by Major Rennell, it took a course due south after passing Julpigoree, joined the Attree, and, after flowing past Dinajepoor, joined the Natore rivers, and thence, passing through the Oorasagur, joined the Ganges at Jaffiergunge. In the year 1787, either one or two years after Major Rennell's survey was completed, an unusual flood occurred; the river brought down from the hills a sufficient quantity of sticks and stones to throw a dam across its junction with the Attree, and, taking a south-east course, it joined the Brahmapootra above Dewangunge.

The curious part of the matter is that, on looking into Rennell's original MS. surveys, a chain of ponds is marked in this direction as "the old bed of the Teesta," too insignificant to be marked in his Atlas; but at their junction with the Brahmapootra he does mark "Teesta Creek." To those who know how permanent the names of rivers are, this is proof positive that the river once before flowed in this direction; but, unfortunately, we have no knowledge when it deserted this bed and became a confluent of the Attree. Since the separation, however, it has shown no tendency to go back, but runs steadily in the direction it took seventy-six years ago, and in which it now flows with an oscillation of two miles, and a width, even in the dry weather, of some 2000 feet.

One thing, however, may be remarked, namely, that it certainly was not any change in the level or the course of the Brahmapootra which induced the change. Julpigoree, where the alteration took place, is 200 feet above the level of the river at its mouth, and it flows for the first forty or fifty miles with a fall of 3 feet per mile; for a like distance further on the fall is 2 feet, and the slope gradually sinks to 6 inches, or it may be less; but nowhere is it a depositing river or, consequently, influenced by back-waters; and it therefore appears to have been merely an accident which caused the change, though being so, it is as likely to go back any day as to remain in its present position.

10. *Retrocession of the Junctions of tributary Streams with main Rivers.*—There still remains one class of phenomena to which I must direct attention before concluding, namely, the shifting upwards of all the mouths of the tributaries of the Ganges along the main stream. This is, perhaps, the most generally interesting of the alterations that are taking place, not only from the magnitude of the changes it superinduces, but because of its forming the best chronometric scale for estimating the extension of the delta and the recent sequence of events.

Although I am not aware that they have been anywhere alluded to before, the causes that lead to the changes appear to be tolerably obvious when pointed out.

In order, however, to make myself perfectly understood, let me first refer to what I said about secular elevation in an early part of this paper, and then assume two hypothetical cases, which I trust will make the matter quite clear.

First let me assume hypothetically that the Ganges, from Allahabad to Rajmahal, was a perfectly horizontal canal or arm of the sea, running due east and west. It is evident that the slope formed by the rivers bringing down detritus from the hills on the north and south would dip north and south—but their plains would equally be horizontal in a direction east and west—and consequently that all the

Figs. 3–6.—*Diagrams illustrating the Junctions of tributary Streams with Main Rivers.*

Fig. 3.

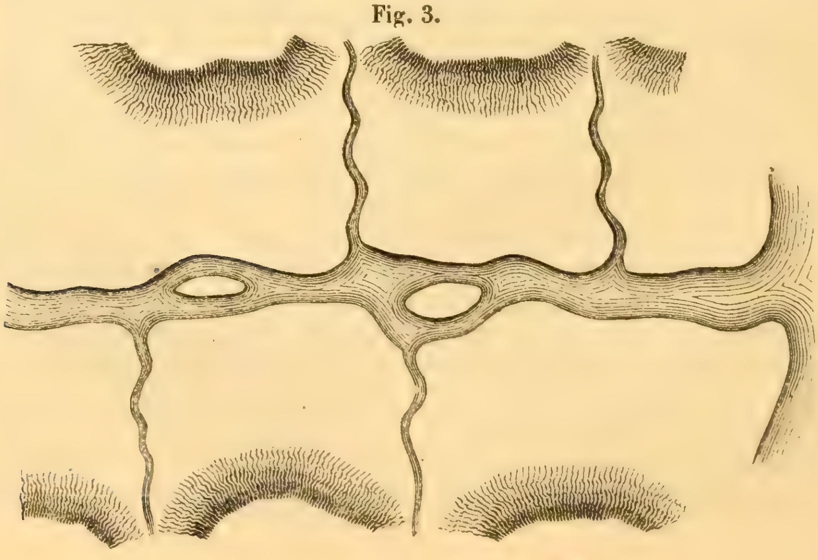


Fig. 4.

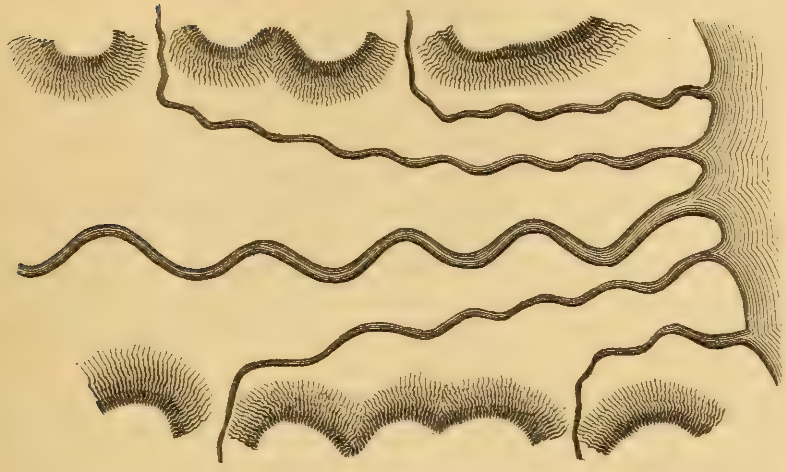


Fig. 5.

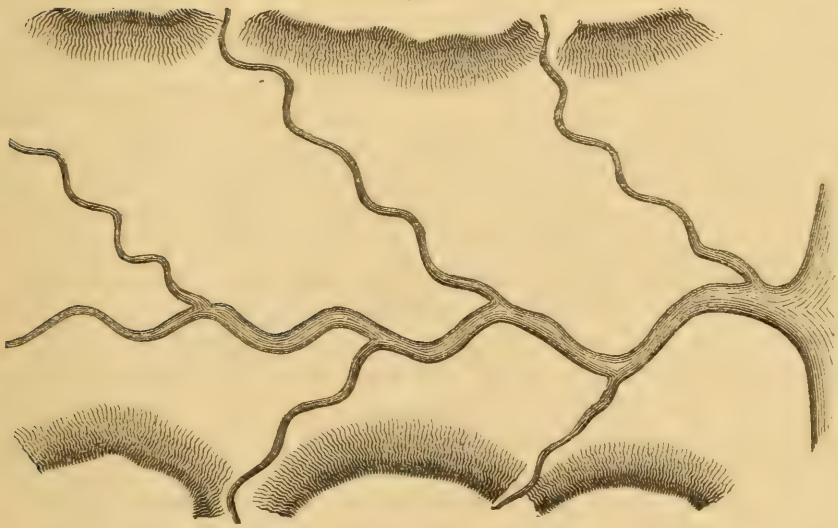
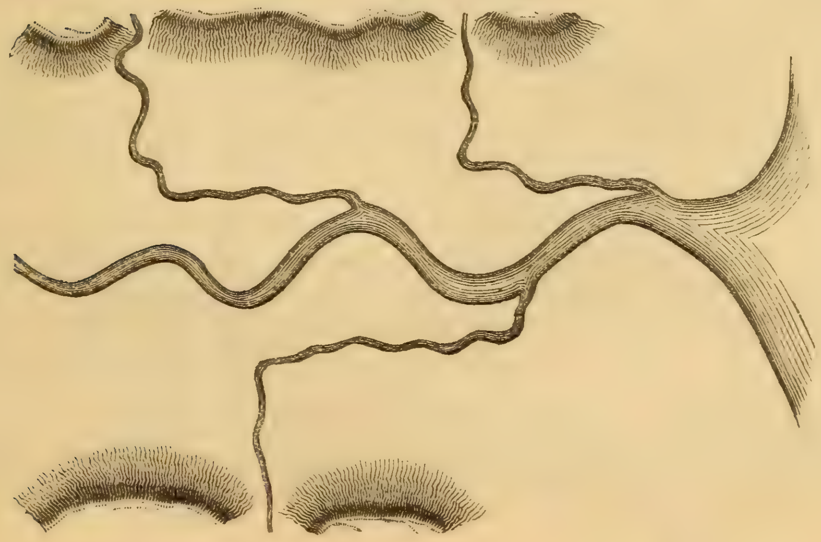


Fig. 6.



tributary streams would join the assumed Ganges-canal at right angles, as shown in the diagram, fig. 3.

For the second hypothesis, let me assume that the sea, or canal, extended from somewhere below Rajmahal to the Himalayas, due north and south, and that the dip of the plain was west and east, say from Cawnpore or Fyzabad to this canal or sea, as shown in fig. 4. It is evident that all the streams, on issuing from the hills, would tend to turn eastward, and to run parallel to the Ganges. Neither of these, of course, truly represents the facts of the case. The valley or the basin of the Ganges, like that of almost all rivers, is compounded of these two plains, varying in slope according to circumstances; and the course of the tributaries is along the diagonal or mean of these two intersecting plains.

Thus, if we assume that when the sea was at Rajmahal the slopes of the two plains were about equal, as shown in fig. 5, all the tributaries would join the main stream at about an angle of 45°; but the extension of the delta has now raised the land about this place to nearly 80 feet above the sea-level. This has been equal to tilting back the valley of the Ganges to that extent, without materially affecting the slopes of the lateral plains, as they are shorter, and start from much higher fixed points at the foot of these hills. The consequence is, that the angle of 45° is always tending to increase, and must eventually reach 90°, or nearly so, in all cases.

There are only slight indications in Bengal of the state of affairs represented in fig. 4, but it can be traced in parts. The upper part of the valley of the Ganges, from Allahabad to the mouth of the Gogra, is in the state represented in fig. 5, with a tendency rather towards that shown in fig. 4. The lower part is fast assuming the form represented in fig. 3. But there is still a fourth form which the rivers must all ultimately assume, and which more resembles fig. 4 than any of the other diagrams. It is this: as soon as the slope of the principal stream has been so reduced by the elevation or extension of the delta, or other causes, that it becomes a depositing river, it will then so raise the level of its plain above the surrounding country that the tributaries cannot flow directly into it.

The form they will then take is shown in fig. 6: having been reduced to joining the main river at right angles, as in fig. 3, they will be turned at right angles on reaching the edge of its plain, and, flowing parallel to it, join it at some point lower down, where the tributary may have acquired sufficient elevation to force its way into the bed of the great river.

We have already examples of this in the way the Soorma was deflected by the Brahmapootra, the Damooda by the Hoogly, the Attree by the Poddah, and all the minor South Behar streams by the Ganges. The Coosy too is fast assuming this shape, and eventually it will become the normal condition of all the tributaries of the Ganges.

The first river to feel the effect of the tilting backward of the plane of the Ganges, by the elevation of the land at Rajmahal, was the Coosy, as the nearest to the delta. The consequence is, that when Rennell surveyed Purneah, he saw, and recorded in his memoir in the 'Philosophical Transactions' *, as well as in his Atlas, that the Coosy had at no distant date flowed past the station at Purneah, and joined the Ganges forty-five miles further down than its present junction. Buchanan Hamilton not only confirms this, but adds:—"This tradition is not only supported by the above-mentioned appearance, but by the opinion of the Pundits, or natives of learning, who inhabit its banks. These, indeed, go still further, and allege that in times of remote antiquity the Coosy passed south-east by where Tajpore now is situated, and thence towards the east till it joined the Brahmapootra, having no connexion with the Ganges;" and he adds, "this opinion seems highly probable" †. Indeed, an attentive study of the successive changes that have taken place renders this almost certain; and it is probable that the Oorasagur is the mouth by which the combined waters of the Coosy, the Mahanuddee, and the Attree were originally discharged into the Assam river.

Were it possible, it would be extremely interesting to know when this was the case. We may certainly assert that it was before the Madoopore jungle was upheaved—and when, consequently, the course of the Brahmapootra was very nearly what it now is—and also at a time when the tide, or at least very low land, extended to Pubna or thereabouts; and that this should have occurred within the very limited range of the traditions of Lower Bengal induces me to suppose that the beginning of the Christian era is the highest antiquity that can be ascribed to such a state of things. It may be much later.

The present course of the Coosy is so nearly perpendicular to that of the Ganges, that its direct junction can hardly travel more than a mile or two further up stream. The first result of any further rise in the level of the Ganges will be that of decreasing the radii of its curves, making it more winding, and converting it into a depositing stream, which it hardly is at present

The rising of the deltaic plain has already produced another effect since Rennell's survey was made, the middle, or the belly, of the river having travelled westward some four or five miles throughout the greater part of its course; and it shows a great tendency to go further in this direction—in fact, to emulate the example of its old confluent, the Mahanuddee, which forms a curve extending thirty-five miles to the westward of the straight line in which we may reasonably suppose it reached the Ganges at no very distant date.

As just mentioned, its junction with the Ganges tends to assume the rectangular form explained in fig. 6; and though its main course is steadily travelling westward, its mouth may travel eastward; and, before many years are over, it probably will again join the Ganges as low down as it did when its main stream flowed past the station of Purneah.

The principal river of the Tirhoot district is the Bogmutty, which presents exactly the same phenomena as those last described. It has an old bed to the eastward, much more perpendicular to the

* Vol. lxxi. p. 87. † Martin, vol. iii. p. 15.

course of the Ganges than that it now occupies. It has now been deflected so far westward that it joins the old bed of the Gunduck, and, in our careless nomenclature, actually gives its name to the lower part of that stream, and in Rennell's maps is so called at its junction with the Ganges opposite Monghyr.

The next river to feel the effect of these changes was the Gunduck. In this instance the evidence is as clear as could be desired. A river marked on our maps as the Little Gunduck—sometimes, but very improperly, as just mentioned, called the Bogmutty, from the name of its principal tributary—joins the Ganges opposite Monghyr; and there can be little or no doubt that it was what it is styled in the maps of the recent Survey, the *Boor* Gunduck, or old bed of that river.

Judging from the height of its banks and that of the land in its neighbourhood, and the extreme sinuosity of its course, this old river must long ago have ceased to flow with any vigour. A date might possibly be found for the time when this was the principal river; but, with the information at present available, all we can say is that it was so at a time when the country was sufficiently inhabited for the nomenclature of the rivers to be fixed.

At the earliest period to which anything like authentic history reaches, this river seems to have been distant from its present channel about twenty-two miles to the north of its present mouth, near Bakhra, or the site of the famous city of Vaisali, celebrated as the place where the second convocation of the Buddhists was held, 300 years before Christ, and to have joined the Ganges some thirty-three miles further down than at present. It is now so nearly perpendicular, that it will probably be a long time before it travels much farther westward.

Proceeding upwards, the next river of any importance we meet is the Soane. Here, fortunately, we have more precise information. Arrian, Strabo, and Pliny—or rather Megasthenes—tell us that Palibothra, the great capital of this country, was situated at the junction of the Erranaboas and the Ganges. Recent antiquarian discoveries have left no doubt that Patna—" Palibothra "— is the city designated, and that the Hyranya Bahu—the Golden-armed, or, popularly, the Sona, or Golden—is the river; and, fortunately, an old branch of the Soane can still be traced, from a spot about twelve miles up the stream to near the west end of the present city. In Rennell's time the Soane joined the Ganges at Moneah, twenty-two miles further west, by a single mouth. Since his survey it has formed a delta, and the upper mouth is the more important; so that, practically, it may be said to have receded four miles since that time. If in eighty years it has progressed so much, in 2000 it ought to have gone back 110 miles, instead of only twenty-five or twenty-six; the probability consequently is, that the delta was not then sufficiently extended or raised to affect rivers so far up the stream ; indeed, it may have been 1000 or more years after the fact was notified to us that the elevation of the delta was first felt so high up as Patna; and, if so, we may expect that the retrocession will now go on at a rapidly increasing rate. Whether our railway-works and bridge may be able to prevent this or not remains to be seen. If they do so, it can only be at an enormous annual expenditure for embanking and repairs. In fact, had the engineers been aware of this physical fact, they would probably have placed their bridge very much further up the stream than they have done. But be this as it may, it will be extremely interesting to watch now the progress of the stream; and having two surveys, separated by an interval of eighty years, and the old indications of the Greek geographers, we may from these data obtain a tolerable index by which to measure the progress of the delta seawards, or its progressive elevation above the sea-level at Rajmahal.

The next stream that ought to be affected is the Sarjoo, or Gogra. It does not, however, seem to have been affected at all; indeed, at first sight, it seems to have been moved downwards since Rennell's survey. This arises, however, only from the Ganges having cut off a sharp bend at this point of its course, and the river Gogra flowing through the arm thus left unoccupied. It does not appear probable, however, that it can remain much longer uninfluenced by these changes; but, until it is so, it may be taken as the fixed point beyond which the extension of the delta has not in recent times affected the slope of the bed of the Ganges.

The only indication I have been able to obtain of the Gogra, or Ghagra, having travelled westward, in historical times, is the following:—

There is an old bed of an old river which leaves the present Gunduck at a point somewhere between Bakhra and Lalgunge, and joins the Ganges opposite Bar. This branch, I have just stated, was probably an old bed of the Gunduck; but it still bears the name of Ghagra; and those who know how permanent Indian names are will hardly hesitate to believe that it may have been an old channel of that river. The evidence cannot be considered as conclusive, however, as I have been unable to trace the course of that river across Sarun. Nothing can be more probable than that, when the Gunduck joined the Ganges opposite Monghyr, the Ghagra should have joined opposite Bar; or that the Gunduck should have cut across that stream at Bakhra and occupied its lower portion, just as the Bogmutty has cut into the old Gunduck and occupied its lower portion; and, lastly, that the new Gunduck should have broken through and sought an independent opening into the parent stream. The Bogmutty will certainly do this one day; at present it is too small and weak a stream to act with the energy of the Coosy or Gunduck, but it must eventually come to this.

The next move must be that the Ghagra will seek a junction with the Tonse, and join the Ganges either through its bed or further west. I am not aware, however, that any tendency in that direction has yet been observed.

§ III. *Historical Evidence of Changes in the Delta of the Ganges.*

Having now run through all the principal phenomena to which I wished to call attention, describing them from a topographical point of view, allow me to recapitulate, as briefly as I can, the historical events connected with them, in order that their approximate dates may be judged of; for as all the events to which I have alluded appear to me to have occurred within historical times, and after the rivers had received their names from the Aryan races inhabiting their banks, we may, without difficulty, connect history with topography in this instance at least.

With the first dawn of history or tradition, about 3000 years B.C., we find the immigrating Aryan Hindoos traversing the Punjaub, and settling, so far as India is concerned, exclusively in the tract of country between the Sutledge and the Jumna. Their rivers were the Sareswati, the Caggar, and the Markandya, which must then have been far more important streams than they are now. Whether their decay arose from neglect of cultivation, after breaking up the soil, or from their raising their beds so as to spill towards the Jumna, or from what other cause, is by no means clear. The last-specified, however, is the most probable. The bed of the Sareswati, at a distance of twenty-four miles from the Jumna, is thirty feet higher than that river. The Caggar, at a distance of fifty miles, is ten feet higher than the last; and the country gradually slopes upwards till it reaches a height of fifty feet, close to the Sutledge, whose waters at Loodiana are at the same level as those of the Jumna at Kurnal*.

This tract, though not quite a desert now, is nearly so. Its rivers are insignificant streams, and lose themselves in the desert; and Thaneswara and Samana, the old classical cities of Arya-Varuta, are now nearly deserted.

The next capitals of this race were Delhi, on the extreme northern spur of a range of hills on the right bank of the Jumna, and Muttra, about eighty miles further down, but still on the elevated right bank. The first cities really in the plain were Hastinapora, on the Ganges, about fifty miles from the hills, and Ayodya, on the Gogra, at about sixty miles from the Himalayas, the last occupying the same position with reference to the valley of the Ganges that Sudya does to Assam; and it seems to have been one of India's most important cities between 2000 and 1000 years B.C. About the last-named date it appears to have been superseded by Cannouge, on the Ganges, this time 120 miles from the hills, being the farthest advance into the plains before the Christian era. Allahabad and Benares next rose into importance.

In the fifth or sixth century before Christ, when we become tolerably familiar with the geography of India, from the events of Buddha's life, we find, in the south, Rajagriha on the hills, and Gya close by, the most important cities of the central portion of the

* These levels are taken from a survey by Lieut. (now Col.) Baker, Journ. Asiat. Soc. Bengal, vol. ix. p. 688.

Gangetic plain ; these were superseded about three centuries later, or in Alexander's time, by Palibothra, or Patna, which was the most important city of India at the time of Alexander's conquests*. On the north of the valley we first find Janakpore, in the Terai, between the Bogmutty and the Coosy, figuring as the capital of Bengal at the time when Ayodya was practically the capital of India ; then Sravasti, Kapilavasti, and Kucinagara, all nestling under the hills close to the Terai, and the remains of ruined cities of this epoch within its now pestiferous limits,—showing that from the greater steepness of the slope, or some such local cause, this was then the most habitable part of the valley of the lower Ganges.

It is not till six or ten centuries after our era that we find any more important cities eastward of Patna ; but, about the last-named period, Gour, opposite Rajmahal, became the capital of Bengal, to be superseded by Dacca, founded in 1604, and Moorshedabad, which only rose into importance in 1704.

For a century after 1634, when our ships were permitted to enter the Ganges, Satgong or Hoogly was the port of Bengal, and continued to be so till superseded by Calcutta.

The ships of those earliest days were no doubt much smaller than those afterwards introduced ; but no sea-going vessel could well now get so far up the river. And it may also be remarked that when Admiral Watson attacked Chandernagore in 1757, he took up to that city what were then called line-of-battle ships, vessels of 60 and 64 guns, which, whatever their tonnage may have been, would with difficulty reach Calcutta now without the aid of steam.

It would be tedious, as it would be out of place here, to attempt to explain the data on which these historical conclusions rest, and pedantic to assert that they are more than approximate inductions from imperfect data. But I may state, generally, that long local study has left the conviction strongly impressed on my mind, that 3000 years B.C. the only practically habitable part of the alluvial plains of the province of Bengal was the portion between the Sutledge and the Jumna ; that even 1000 years later it was only here and there, on the banks of some minor streams, that the country was in a state to support a large population, and to possess considerable cities ; that nearly up to the Christian era it was only on the southern hills, or at the foot of the Himalayas (what is now the Terai), that cities could be placed, because the central parts of the plain eastward of the Gogra were still unfit for human habitation ; that it was not till 1000 years afterwards that the plain of the Ganges was sufficiently desiccated to admit of such a city as Gour rising to importance, so far from the hills ; and not till the Mahometan conquest in the 14th century that the Delta, properly so called, became fit for extensive occupation.

So far as can be judged from the rapid rate at which changes have taken place, and the immense quantity of land which has been

* The circumstance of four of the largest rivers in India—the Gogra, the Gunduck, the Soane, and the Ganges—meeting at one spot has so raised the country in the neighbourhood of Patna, that it must early have been a habitable tract.

redeemed from jungle and swamps, during the last century, there seems nothing to contradict this theory of the very modern origin of the present configuration of the valley of the Ganges.

It is not, of course, meant to be asserted that the valley of the Ganges was filled up, geologically speaking, within that period, but only that it became fit for man's occupation within the limits of the historical period, as hundreds of square miles of the Delta have become since Rennell's survey was made.

The greater part of the valley of Assam still remains—what the plains of Bengal may be conceived to have been 2000 or 3000 years ago—uninhabitable swamps, with occasional spots where cities have existed or do now stand. But if the principles enunciated above are to be depended upon, the recent changes in the course of the Brahmapootra ought rapidly to affect the level of the land in that valley; and it cannot possibly require a thousand, or half that number of years, before the swamps opposite Goalparah and Goahuttee become as dry and as habitable as the plains of Purneah in Tirhoot.

§ IV. *Increase of the Delta seaward.*

1. *Silt held in suspension in Ganges' Water.*—It will have been observed that, in the previous part of this paper, I have said nothing about the quantity of silt contained in the water of the rivers I have been describing, nor attempted to calculate its influence either in extending the delta seaward, or in raising it upwards. I have refrained from alluding to this simply because I know of no data on which any reliance can be placed.

To base any calculation on this agent, the experiments ought to be continued for, at the very least, one whole year, on some one at least of the larger rivers. But this has not yet been done; and, even if it were done for the Ganges, it must be nearly useless unless we had the same knowledge as regards the Brahmapootra, which I believe to be an infinitely more important stream in this respect than the Ganges itself. And we ought also to know what is brought down by the Mahanuddee, and the group of Natore streams debouching through the Oorasagur.

The latter rivers run through so low a country that they probably deposit most of their silt *en route*; but the Mahanuddee and its tributaries are swift, and strongly embanked. The Sylhet rivers may probably be disregarded; they never possess much silt, and what little they have they deposit at home, so they contribute little or nothing to the delta. Supposing, however, all this were ascertained for every river just as it enters the delta, another very important question arises—How much is deposited on the plains of the delta, and how much carried to sea? During the cold weather, when the rivers are low, almost all their silt will be carried to sea; but then the quantity of water is small, and that little comparatively clear. At the height of the inundation, when the river is overflowing its banks, at least one-half is deposited inland. As the rivers fall, the greater part will again be carried away; but as the force of the current slackens, there is a great tendency for rivers to deposit their mud in their own beds, and to heal the wounds that have been made in their banks; so that even during that period it is doubtful if more than half is carried off. For instance, careful simultaneous experiments were made, two years ago, as to the quantity of solid particles held in suspension in the waters of the Matabangah,—first, at leaving the Ganges, when it was found to be 1 in 294 parts, while nearly at its junction with the Hoogly the quantity was only 1 in 884, proving that two-thirds had been deposited *en route* in that short distance*.

Sometimes an acre or two of a bank will fall in in a single night, and, consequently, the stream will be unusually turbid for the next twenty-four hours; but, in such an abnormal instance, one-half at least probably never leaves the local stream, but is deposited again a few miles further down; and, in fact, every stream and every locality has its peculiar regimen in this respect, and until they are more carefully examined than they have hitherto been, it will be safer to look to such indications as history affords us, and to our charts. These last show that little or no change or extension seawards has taken place, during the last 100 years, between the Hoogly and the Horringotta, or about halfway across the seaward face of the delta. But the eastern half is in a state of rapid change, having remained behind, I believe, principally in consequence of the absorption of the Brahmapootra's silt by the Sylhet Jheels; but probably in little more than a century or two from this time the gap may be repaired, and the Sunderbuns bounded by a nearly straight line east and west.

As regards the elevation of the delta, by far the safest test is the progress of the junction of the tributary streams, such as the Soane and Gogra. If the former be carefully surveyed from time to time, and the retrocession of the tributaries carefully noted, we shall gather far more satisfactory evidence of the gradual elevation of the delta than can be obtained by dipping tumblers from the sides of 'Budgerows,' which operation has hitherto been supposed to be sufficient to gauge the growth of continents.

2. *Swatch of "No Ground."*—There is still one other phenomenon which it is necessary to allude to, in order to understand the present or prospective condition of the seaward face of the delta of Bengal. This is the existence of a great depression, or hole, in the middle of the Bay of Bengal, known in the charts as the "Swatch of No Ground." Its exact position is shown on the map accompanying this paper (Plate XII.), and its sides are so steep and well defined that it affords mariners the best possible sea-mark—the lead suddenly dropping, especially on its western face, from 5 and 10 to 200 and even 300 fathoms, with "no ground."

It seems quite impossible to ascribe this sinking to volcanic action, inasmuch as we know that no such violent convulsion has taken place in Lower Bengal, during the last 200 years, as could have caused such a chasm; and it is not conceivable that so large

* 'The Ganges and the Hoogly,' by F. Prestage. Calcutta, 1861.

and so sharply defined a depression could have existed in so muddy a sea for even a fraction of that time without being obliterated or smoothed over, unless there was some tidal or fluviatile action always at work tending to keep it open; nor does it appear difficult to explain where this action is.

If we turn to the authorized chart of the mouths of the Hoogly, we find the following description of the action of the tides in that side of the delta. "The tides in the channels have a rotary movement with the sun, first quarter-flood W.N.W., round by N. to the last quarter E.N.E., to first quarter-ebb E.S.E., round by S. to the last quarter W.S.W."

The same description applies to those on the other side, with the difference that the larger portion of the tidal wave comes from the eastward—following the course of the sun. The circle there is considerably larger, as shown in the two black circles on the map. The action is, in fact, strictly analogous to that of the phenomenon known as the "Bore," which exists, to a greater or less extent, in all funnel-shaped tidal estuaries. The flood-tide, coming up the contracting bay from the southward, is accelerated on the shelving shore on either hand, and reaching the face of the delta at its eastern and western extremities before it touches the centre, this rotary motion ensues. The consequence seems to be that the two circular tides, meeting somewhere in the centre of the bay, must do one of two things—either they must throw up a bar or spit between them, or they must scoop out a depression. The first would be the action of two rivers, the velocity of whose currents was diminished or stopped by contact with the ocean. The latter seems the probable action of two tides whose motion is continuous and uniform.

It is quite reasonable to assume that the action of these tides might not have sufficient force to scoop out such a canal as this, if they found the delta perfectly formed and uniform across the whole head of the bay; but, as the tides certainly existed before the delta had been formed by the deposit of the silt of the rivers, there is no reason for doubting that their daily action is quite sufficient to sweep out and keep clear any channel which may be necessary for the efflux of these waters; and such, I feel convinced, is the true explanation of the phenomenon. It must also be borne in mind that there is every reason to suppose that the action of these tides has been constant and uniform ever since the Bay of Bengal took its present shape, and, consequently, it is probable that there may have always existed a bar or spit on the neutral line between the oceanic and river forces, somewhere not far from where the Sunderbuns now are. If this were the case, the deltaic plains would then have been, as hinted above, a great lagoon or inland sea—a circumstance which would tend very considerably to accelerate the deposition of mud in them, and thus to account for the rapidity of some of the changes, which might otherwise seem strange.

As the case now stands, the western tidal wave has had sufficient strength to sweep out the Balasore Roads, and to keep open the estuary of the Hoogly, known as Saugur Roads. Thence turning eastward towards the Swatch, it seems to have sufficient force to fix the seaward limit of the western Sunderbuns as certainly as the current that passes eastward has fixed the seaward boundary of the Delta of the Nile.

The eastern half of the delta is by no means so fixed in its regimen, principally, I am convinced, owing to the cause pointed out in a previous part of this paper—in consequence of the Brahmapootra being diverted into the Sylhet Jheels, in which its waters were filtered, and its consequently bringing no silt seaward. We learn, however, from Lloyd's survey, made in 1836, that great progress had been made in filling up the gap since the beginning of the century; and if we had a new survey now, we might prophesy approximately how long it would be before the eastern face of the delta would assume a form as fixed as the western half.

The true base of the delta to seaward is the neutral ground between the 5- and 20-fathom lines, which there is no reason to suppose has altered, or will alter, in any time of which we can take cognizance; for, the whole of the silt brought down by the ebb being swept away to the depths of the ocean through the Swatch, there is no reason to suppose that any sufficient portion of it is brought back by the flood to alter so marked a boundary in any appreciable degree.

Inland there is another neutral line parallel to this, in the tract of high land extending from Calcutta to Bakirgunge, and when the delta is complete it will reach Seetacond; this marks the boundary where the tidal forces are stopped by the river's action, and where, consequently, a certain deposit takes place. Behind this inland barrier there still exists an immense tract of jheel-country, in the districts of Jessore and Fureedpore; but, judging from the extraordinary changes which have taken place since Rennell's survey was made, there seems no reason to doubt that, in the course of another century, if the rivers are left alone, there will be very little jheel-country left in the western half of the delta; and the task of the Ganges will then be completed, with the exception of a little smoothing and filling here and there. But it will take several centuries before the Brahmapootra will have rendered its domains, especially in Assam and Sylhet, as habitable and as fertile as the whole of the valley of the Ganges is, even at the present day.

§ V. Appendix.

The following Table, though constructed on the best available data, can only be regarded as an approximation to the truth, no surveys having been undertaken with reference to the objects in view; and though certain levels may be absolutely correct, they do not give either the average height of the land or of the water, or they give that only at exceptional periods.

The first two are from Col. Cautley's survey for the Ganges-canal; the next three from that for the East Indian Railway, and may be depended upon except as regards the correct representation of the true level of the mean high water or of the land at the places mentioned. The remaining levels are from the survey for the Eastern Bengal Railway, and may be depended upon within fractional quantities, both as regards accuracy and levels of water.

The whole is based on the assumption that the highest level of the floods represents the highest level of the land, and that this datum at Calcutta is 27 feet above the Howrah Dock Sill.

	Height, in feet.	Distance, direct.	Slope per mile.
Hurdwar	974	miles.	inches.
Cawnpore	402	350	19·3
Allahabad	269	122	13·
Patna Moneah	161	200	6·5
Rajmahal	68	185	6·
Calcutta	0	168	4·8
Kooshtee	27	100	3·2
Serajgunge	30	54	·8
Dacca and Naraingunge	4	76	4·1

This last would make the level of high water and of the land at Goahuttee about 100 feet, at a distance of 350 feet from the sea, which accords very tolerably with that of 70 feet given by Schlagintweit for the low-water-level above mean sea-level.

April 22, 1863.

Nicholas Kendall, Esq., M.P., Member of the Royal Commission of Mines, Pelyn, Cornwall; Major F. J. Rickard, Inspector-General of Mines in the Argentine Republic, 21 A Hanover Square, W.; and Charles Easton Spooner, Esq., Bron-y-Garth, Port Madoc, North Wales, were elected Fellows.

M. A. Favre, Professor of Geology in the Academy of Geneva; Franz Ritter von Hauer, k.-k. Bergrath, and of the Imperial Geological Institute of Vienna; M. Hébert, Professor of Geology to the Faculty of Sciences at Paris; M. E. Beyrich, Professor of Geology in the University of Berlin; and Dr. F. Sandberger, Professor of Mineralogy at Carlsruhe, were elected Foreign Correspondents.

The following communications were read:—

1. *On the* Gneiss *and other* Azoic Rocks, *and on the superjacent* Palæozoic Formations, *of* Bavaria *and* Bohemia. By Sir Roderick I. Murchison, K.C.B., D.C.L., LL.D., F.R.S., F.G.S., &c.

Introduction.—In my last journey to Bohemia, I had no sooner reached Darmstadt than I was gratified to find that, in two of the most recently published geological maps of Germany, M. Ludwig had marked the Palæozoic subdivisions as Silurian, Devonian, Carboniferous, and Permian*.

Thus, in travelling to the baths of Marienbad, I perceived that on the western flank of the crystalline rocks of Eastern Bohemia and the Erzgebirge the author had thus named and delineated the *three* oldest of these groups in the tract around Hof, where, when I first explored it, "grauwacke" only was applied to the whole region by German authorities.

It was, indeed, in the year 1839 that Professor Sedgwick and myself began to make the subdivision, by pointing out the existence of both Devonian and Carboniferous limestones near Hof. In subsequent years, with the good maps of Naumann, I tracked Silurian rocks, with Graptolites, as separated from Devonian limestones, extending from the Frankenwald into the Thüringerwald, where certain meagre representatives of the Upper Carboniferous rocks are surmounted by a full Permian series.

Proceeding from Eisenach on the north-west, where the great Palæozoic promontory of the Thüringerwald terminates in a point, we see, in advancing to the south-east, that these Palæozoic rocks gradually expand, until, in the latitude of Hof, they occupy a great width, and are succeeded on the south-east by the inferior azoic and crystalline rocks of the Fichtelgebirge and the broad tracts of eastern Bohemia.

To the south-east of Hof, M. Gümbel, of Munich, has recently made a most important discovery. In schists overlying primary clay-slate, and underlying Silurian rocks with Graptolites, he found a peculiar fossiliferous band, the Trilobites of which, having been transmitted to M. Barrande, were determined by his authority to be *Conocephali*, *Oleni*, and *Ellipsocephali*, associated with *Cystideæ*, *Orthis*, *Discina*, and *Pugiunculus*. Hence it was clear that M. Gümbel had discovered in Bavaria an equivalent of the Primordial zone of the Silurian series, of which M. Barrande had been the discoverer in his Silurian basin of Prague. We thus learn that the Silurian rocks of Bavaria, however less rich in fossils in their central and upper members than those of the Bohemian basin of Prague, have the same Trilobite-bearing base as the latter.

Having myself passed over the tract occupied by the older rocks which separate those two Palæozoic tracts, I became very desirous of obtaining from M. Gümbel some account of the exact order, as well as of the dimensions, of those inferior rocks on which the Palæozoic rocks repose. As he has been so kind as to send me a sketch-map of all the region (fig. 1), as well as a transverse section (figs. 2 & 3), showing the succession from the Carboniferous Limestone of Hof, down to the gneiss and granite of the Fichtelgebirge near Selb, I

* See Ludwig's 'Deutschland,' 1860, and 'Deutschland und das Alpen-Gebiet,' and compare them with von Dechen's Geological Map of Germany, published in 1838, in which the vast tracts now so subdivided were, as regards the three lower formations, as well as the inferior clay-slate, all grouped under one colour and with the name of 'Grauwacke.'

Fig. 1.—*Geological Sketch-map of a Part of Bavaria and Bohemia* (after Gümbel).

1. Granite.
2. } Gneissose series.
3. }
4. Mica-schist.
5. Clay-slate.
6. Silurian Primordial Zone.
7. Silurian (except the Primordial Zone).
8. Devonian.
9. Upper Carboniferous.
10. Carboniferous.
11. Rothliegende.
12. Tertiary.

A. } Basalt.
B. }
C. Pfahl.

will presently dilate upon these important contributions, which constitute, in fact, a main part of this communication*.

Gneiss of Bavaria and Bohemia.—One of my great objects in exploring this region was to satisfy myself, if possible, as to the existence of a fundamental gneiss of as high antiquity as the Laurentian rocks of Canada, and those of the north-west Highlands of Scotland, which I had described. For this purpose, besides traversing the country from Marienbad to Pilsen, and thence to Prague and Pardowitz on the east, I repassed from Pilsen by Furth to Regensburg, and afterwards examined the huge masses of gneiss and granite which form the southern wall of the chain of the Böhmerwaldgebirge between Passau and Linz, on the banks of the Danube. I was unable, in my partial examination, to satisfy myself that the true gneiss of any one part of this vast crystalline region overlies another or more ancient gneiss. But M. Gümbel in Bavaria, and M. Crejci in Bohemia, believe in the existence of an older and a younger gneiss. As, however, I am not aware that an order of superposition has anywhere been seen, I am the more disposed to consider all the gneissose rocks which underlie the micaceous schists and primary clay-slate as belonging to one great fundamental group, though eventually these rocks may be separated by proofs worked out by local observers.

In order to convey to me his own ideas on this subject, M. Gümbel has kindly transmitted to me a sketch-map (fig. 1) as condensed from his long and laborious surveys, executed upon maps of a very large scale. Dividing the gneiss into older and younger (2 and 3 of the map), he distinguishes the first as a highly granitoid and reddish rock, like the gneiss of the Erzgebirge, and containing 75 per cent. of silex, and as being both intermixed with and penetrated by granite. The younger or grey group of this gneiss contains courses of hornblende, slaty greenstone, syenite, granulite, and serpentine. The elder of these gneissose groups is roughly estimated by M. Gümbel to have a thickness of about 50,000 French feet, and the younger group to be about 35,000 French feet thick; so that, as a whole, the gneiss of Bavaria and Bohemia, according to this author, has a maximum thickness of not less than 90,000 English feet!

Unable, as I have said, to see any order of superposition between these two varieties of gneiss, I afterwards found that the same variety of gneiss changed its direction so greatly in its range through different tracts, that no inference respecting the age of the deposit could be drawn from the strike of the strata.

This is, indeed, clearly demonstrated by M. Gümbel's map (fig. 1), by which it is seen that both the older and younger gneiss of that author assume in some tracts the same strike, *i. e.* E.S.E. to W.N.W., while in others they both change to a direction perpendicular or rectangular to the above, or from S.W. and W.S.W. to N.E. and E.N.E.

* The detailed labours of M. Gümbel are not to be judged of by this little sketch-map. He has, in fact, so closely examined the various rocks of granite and gneiss and all the superjacent rocks, as to have laid them down on the huge cadastral map of Bohemia which is called the "Feuer Cadaster."

Thus, on the eastern flank of the Silurian basin of Prague, M. Gümbel's younger member of the gneiss, after conforming, with a north-easterly strike, to the superjacent clay-slate and Silurian rocks, folds round by devious bends until it reaches the southern end of the mountainous wooded region called the Böhmerwaldgebirge. There, where the gneiss-rocks are associated with vast masses of granite, the longer axes of which are directed from W.S.W. to E.N.E., both the older and younger gneiss have a coincident strike, and they both range at a right angle to the dominant direction of the strata in those parts of the region where they flank the fossiliferous Silurian rocks.

I examined in some detail the gneiss-strata on the banks of the Danube, between Linz and Passau, which form the southern fringe of the Böhmerwaldgebirge; and, judging from their strike, which diverged from that of all those beds of gneiss with which I was acquainted to the S.E. of Prague, I thought that they might represent the older gneiss. Again, judging from their very siliceous character, and led by the analogy of their structure and their having the same direction as the older gneiss of the West Highlands of Scotland, I at first inferred that they were probably inferior to other gneiss-rocks lying to the N.E., as well as to those near Furth.

In these rocks of the Danube, whether at Passau or Linz, I saw no trace of micaceous schists or serpentines, or any of those associations which M. Gümbel assigns to the upper gneiss. On the contrary, I found the grey gneiss, particularly at Linz, to be so eminently quartzose and siliceous, that the fine white layers of quartz and felspar constituted the dominant feature, as contrasted with the dark layers of black mica. Such opinions, however, were necessarily modified by the information kindly offered to me by M. Gümbel, and as laid down in his little sketch-map. Thus, to the N.W. of Cham, the older gneiss of that author, first ranging to the N.W., then bends to the N.E., and is followed by the younger gneiss. The latter, folding round large masses of granite, after several contortions, passes away with a normal north-easterly strike, as it extends to the south of Marienbad and Karlsbad.

Again, as M. Gümbel shows in his map, the gneiss which he believes to be the younger is that which ranges by Passau, and occupies the gorges of the Danube—the very rock which I had supposed to be of older date. Now, as he marks these, his younger rocks, as dipping to the N.E., so as to seem to pass under his newer beds, he was naturally struck with the anomaly. He supposes, indeed, that this anomaly may be accounted for by a grand inversion similar to the numerous cases of overthrow in the Alps, which he, as well as others, has described. But, from what I saw, I cannot as yet coincide with him in this view, inasmuch as the grand buttresses of gneiss and granite which occupy the banks of the Danube between Passau and Linz, and which are presumed by him to be the younger gneiss, occupy a very low country, with no mountain-chain nor igneous rock to the S.E. or at the back of them, by which we might account for their upheaval, and yet they all incline rapidly to the N.

and N.E., and seem fairly to pass under the other gneiss. My impression, therefore, is that, on the Danube, the masses of gneiss are in their normal position, and form simply one of the lower members of the great gneissic series of Bohemia, the diversified mineral structure of which requires no detailed description by me.

M. Gümbel shows that a remarkable band of quartz-rock, seventeen German miles in length, called the "Pfahl" (C, fig. 1), is associated with his lower gneiss. But, again, this rock, as well as the gneiss to which it is subordinate, strikes from E.S.E. to W.N.W., and is perfectly parallel to the associated gneiss of the Danube.

I am the more disposed to view all the gneissose rocks of Bohemia and Bavaria as belonging to one great series, by examining M. Gümbel's sketch-map, by which it appears that, where his older gneiss folds round and strikes to the north, there are signs of great distortion of the strike where the strata meet the southern end of the granitic masses of the Fichtelgebirge. There, both his varieties of gneiss bend round with very devious strikes, but each more or less conforming to the granitic nucleus. It appears to me, therefore, that the older and newer gneiss of this region form, as before said, one great series only, and are not to be distinguished, like the fundamental or Laurentian gneiss and the younger or micaceous gneiss of the Highlands of Scotland, by a total unconformity, and by being separated from each other by a great intervening deposit, as is the case in Scotland. In point of fact, the so-called younger gneiss of Scotland is simply altered Silurian, whilst in Bohemia and Bavaria the one gneiss is followed by another gneiss without any separating deposit.

In Bohemia and Bavaria we have, as before shown, many proofs that the age of the old slaty and crystalline rocks cannot be determined by any partial examination of their strike; for in one tract we find the very same rocks ranging N.W. to S.E., and in another trending from N.E. to S.W.

In viewing these gneiss-rocks for the present as one great series, I do so with some hesitation, and with every respect for the labours of M. Gümbel, who has with infinite pains followed these crystalline rocks into all their sinuosities, and may have better reason than myself for distinguishing the lower or, what he calls, the Bavarian gneiss from that named by him Hercynian gneiss. I must also here remark, that if all the true gneissic rocks of Bavaria be united, they may well, from their colossal dimensions, stand in the place of the Laurentian gneiss of Canada and of the north-west of Scotland. The clear evidence which exists of the interpolation of a vast thickness of sedimentary formations in which no fossils have been found, between the great gneissose series and the lowest Silurian rock, is a good reason for believing that the gneiss of Bohemia and Bavaria is truly the representative of the Laurentian or fundamental gneiss.

General ascending order of the Rocks.—A clear illustration of the inference previously arrived at as regards the fundamental gneiss is afforded, indeed, by the regular ascending series of rocks from the gneiss of the Fichtelgebirge at Selb to Hof in Bavaria, as drawn by M. Gümbel in the annexed instructive sections. One of these sec-

Fig. 2.—*Section from the Labyrinth-Berg, near Hof, to Selb* (from 7 to 8 miles).

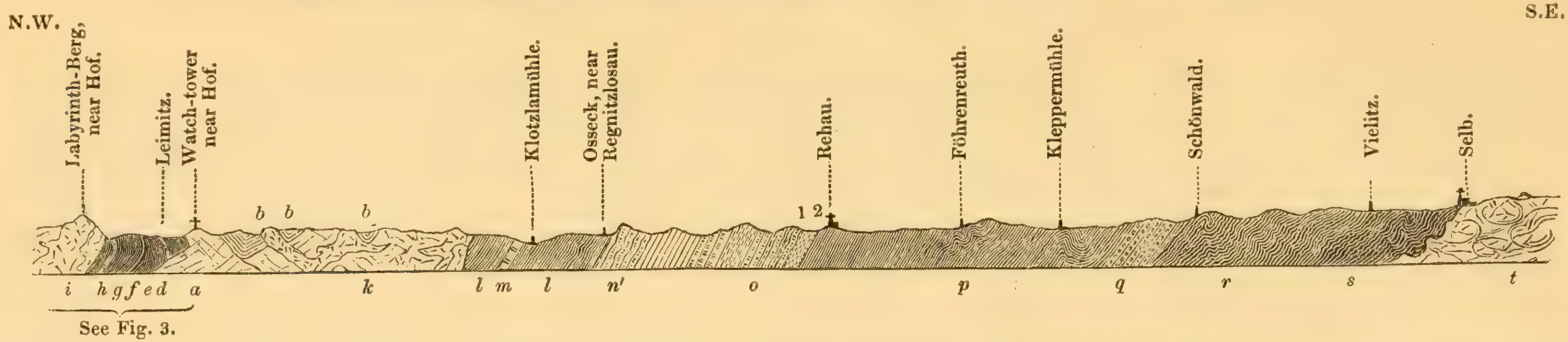


Fig. 3.—*Detailed Section from the Labyrinth-Berg to the Watch-tower.*

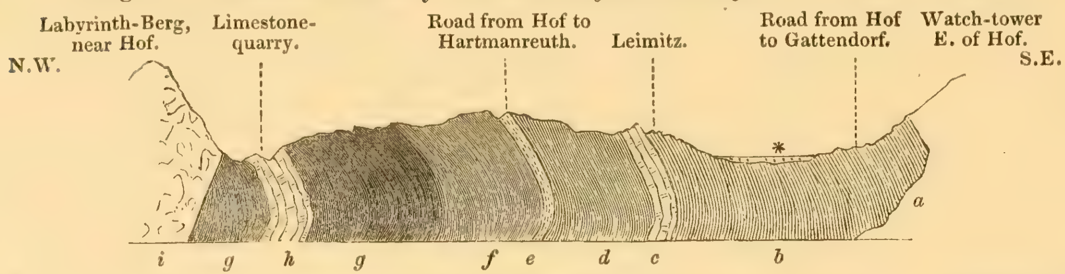


Fig. 2.

	feet.
t. Granite.	
s. Gneiss	3,000
r. Mica-schist	6,000
q. Chlorite-schist with quartz . .	3,000
p. Primary clay-slate	9,000
1. Silurian Primordial zone . . .	50
o, 2. Silurian	5,000
n, *n'*. Devonian	5,000
m. Mountain-limestone, with many species of *Productus* . . .	70
l. Carboniferous	9,500

Fig. 2 (*continued*).

	feet.
k. Diabase-rocks with tuff, breccia, and altered clay-slate . . .	15,000

Figs. 2 & 3.

	feet.	
i. Diabase, tuff, and breccia.		
h. Cypridina-limestone	250	Devonian.
g. Greyish-white clay-slate, alternating with lydite, the uppermost portion being the Nereites- and Pentamerus-beds, more than	1,000	Devonian.

Figs. 2 & 3 (*continued*).

	feet.	
f. Siliceous slate and lydite, full of Graptolites	270	Silurian.
e. Primordial zone	60	Silurian.
d. Blackish-grey laminated clay-slate and lydite	450	Silurian.
c. Black crystalline limestone . .	180	Silurian.
b. Grey, red, and yellow clay-slate, micaceous and talcose above .	950	Silurian.
a. Chlorite-, hornblende-, and diorite-slate.		

tions, fig. 2, exhibits, in the space of about 7 or 8 miles, the following ascending order of strata, arranged in conformable superposition:—

Gneiss (*s*) resting against granite (*t*), and, in this spot, near Selb, having a superficial width of 3000 metres only, or about 10,000 English feet, though in Bohemia this thickness, as before stated, is enormously increased. These strata of gneiss pass upwards into

Mica-slate (*r*), occupying a surface of about 20,000 feet wide, and all at very high angles of inclination. These beds, after one or two undulations, plunge at an angle of 45° under

Chloritic, quartzose, concretionary masses (*q*), which form the natural base of the vast thickness of the great mudstone series to which the Germans assign the name of Urthon-Schiefer (*p*), and which, with the underlying chloritic beds, has here (to the S.E. of Rehau) a thickness of 36,000 French feet.

It is this grand and massive accumulation of primary clay-slate (in which no fossils have yet been found, and to which M. Gümbel assigns, in other tracts, a thickness of about 80,000 English feet) which, with the underlying and more metamorphosed portions of it, may be viewed as the German equivalent of the Cambrian rocks of North Wales, as laid down in the maps executed by my predecessor Sir Henry De la Beche and his associates. In some places this great series of the "roches azoïques" of Barrande is a micaceous greywacke, in others it contains quartzose and even pebbly beds, and is often charged with lead-veins in quartzose matrices. In traversing the wide tract around the town of Mies* in Bohemia, which is occupied by this Thon-Schiefer, I was so much struck with its resemblance to those ordinary Silurian mudstones, or "rotch" of South Wales, which have been affected by an imperfect cleavage, that I could not avoid the reflection that, if fossils are ever to be found in the strata which underlie the Primordial Silurian zone of Barrande, this is a tract singularly favourable for an endeavour to find them; for I can assert that much of this Urthon-Schiefer is less altered or crystalline than many Silurian rocks of younger age, which are charged with fossils†. Not wishing, however, to dogmatize on this point, or to adhere blindly to my title-page of 'Siluria,' in calling attention to what I still consider to be unassailed, "the oldest fossiliferous rocks and their foundations," I simply invite all those who sustain theories against facts, hitherto uncontradicted, to travel into the region now described, and many others to which I could refer them, and try to discover fossils in these quasi unaltered primary strata of mudstone. If they succeed,

* This tract was described, in 1791, by Lindacher (see Barrande, Système Silurien du Centre de la Bohême, vol. i. p. 10).

† On this head see a valuable memoir by Dr. Bigsby, "On the Organic Contents of the Older Metamorphic Rocks," Edin. New Phil. Journ., April 1863. The author, citing well-known authorities, refers to sixty-four cases where organic remains have been observed in altered Palæozoic rocks of different countries.

and detect recognizable fossils, why then my datum-line as to the first appearance of invertebrate animals will of course be lowered, and I shall bow, as I have always hitherto done, to palæontological facts.

But to return to the ascending section of M. Gümbel. The summit of the primary clay-slate, here reddish and chloritic, passes up into quartzites, about 300 feet thick (2), containing Fucoids; these are followed by black siliceous roofing-slate (lydianstone or lydite), in which fossils of the Primordial zone (1) occur, and among which M. Barrande has detected the genera before mentioned. According to M. Barrande, who examined them when I was at Prague, they consist of *Conocephali* and *Oleni*, and also some species of *Lingula, Orthis, Discina, Pugiunculus*, and fragments of *Cystideæ*.

In answer to a recent letter from myself, M. Barrande writes as follows:—"This fauna (from the environs of Hof) presents evidently Primordial characters by the predominance and the forms of its Trilobites, which are accompanied by a small number only of the usual Lower Silurian genera, *i. e. Lingula* and *Discina*, the Pteropod *Pugiunculus*, and a Cystidean.

"The Trilobites predominate, indeed, over the other fossils, both in the number of species and in the relative quantity of individuals. I recognized eight to ten species of *Conocephalus* and *Olenus*, all new, as well as another type which also seemed to me to be new. With these Primordial Trilobites are also associated two or three forms which everywhere characterize the Second Silurian fauna (Llandeilo and Caradoc), *i. e. Calymene* and *Cheirurus*.

"The coexistence of these different types is evident, since I found them in the same piece of rock not larger than my hand.

"The occurrence of the genus *Olenus*, which is entirely absent in Bohemia, and the appearances which the species of it present, indicate that the fauna of the environs of Hof has more relation to the English and northern zone than to the central zone of Europe. There was, therefore, (of old) a gneissic barrier, more or less elevated, between Bohemia and Bavaria, such as that which we now see.

"I was drawing up an interesting parallel between these two Palæozoic basins; but just as I was about to complete it, I was obliged to quit Prague; and since then I have been absorbed in very different occupations.

"You will observe that the partial coexistence of the Primordial and Second faunas on the frontier of Bohemia comes in very *à propos* to aid us in the conception of the partial coexistence of the Second and Third faunas in Bohemia, or, in other words, of my 'Colonies.'"

May I not add to this important notice of M. Barrande, that this discovery near Hof links together, in a remarkable manner, the lowest to the next succeeding member of the Silurian, and that this band forms the natural base of that first great Trilobite-bearing series, below which no recognizable Crustacean has yet ever been found? This Primordial zone is followed upwards by black siliceous schists, 10,000 feet thick, all symmetrically and compactly arranged conformably to the slates below and to the beds above, and which, being loaded with Graptolites, are unquestionably Silurian (*o*).

The Graptolite-bearing schists are next surmounted, also in perfect conformity, by a micaceous, glossy, waved, and uneven-bedded siliceous clay-slate, representing the Nereites-flags of the Thüringerwald. These strata, standing for a portion of the Devonian rocks (*n*), and occupying a thickness of about 15,000 feet, are surmounted by the concretionary Cypridina-limestone (*n'*), so well known near Saalfeld and other places in the Thüringerwald. This is the Upper Devonian, or Clymenia-limestone, of Münster, which is characterized by the Plants described by Richter and Unger*.

Ascending from the Cypridinæ- and plant-bed, M. Gümbel assigns a thickness of about 14,000 or 15,000 feet to the conformably overlying schists, clay-slate, and grauwacke (*l*), which, containing the *Calamites transitionis* and other plants of the Lower Carboniferous group, pass regularly upwards into a zone of limestone (*m*) about 220 feet thick. This limestone is charged with numerous *Producti*, of species well known in the Mountain-limestone of Britain and France, several of which were collected by Professor Sedgwick and myself in the year 1839. This true carboniferous limestone, which is intercalated in a great expansion of schistose 'grauwacke,' was shown by my associate and myself to have been elevated with and to be parallel to the underlying Devonian rocks, and to be quite unconformable to the horizontal, upper Coal-formations of Bohemia.

This last-mentioned great break in the geological succession occurs in France as well as in Germany, and will be again alluded to in the sequel.

In the remainder, or north-western part of M. Gümbel's section, which bringsus up to the town of Hof, we see a good example of the dislocation and inversion to which the strata have been subjected where they have been affected by various igneous rocks.

Here, in the detailed section across the country from the Labyrinth Hill, near Hof, by the village of Leimitz, to the hill of the Watch-tower, east of Hof, as drawn by M. Gümbel (fig. 3), all the strata are inverted. The crystalline chloritic and hornblendic rocks (*a*) of the Watch-tower overlie parts of yellow, red, and grey micaceous clay-slate dipping to the S.E., and, after passing over a depression occupied by alluvium, other beds of grey clay-slate, with lydianstone and slate, lie upon black granular dolomite-limestone (*c*), nearly 200 feet thick, which lies on a considerable thickness of lydianstone and clay-slate (*d*). It was in the next band (*e*) where M. Gümbel first found those fossils which M. Barrande pronounced as belonging to the Primordial Silurian fauna, mingled with some forms indicating a transition into the Second Silurian fauna of that

* See 'Siluria,' 2nd edit. p. 408. These plants are very peculiar; and, according to Unger, besides forms intermediate between Ferns and Equisetaceæ, others seem to be the *primitive* forms of Cycads and Conifers. In the environs of Saalfeld there is a most perfect and gradual transition from the Devonian Plant-beds into the overlying strata charged with Lower Carboniferous Plants of entirely different forms.

author, or what I call the Lower Llandeilo series. This Primordial zone is overlain by dark flinty slate and lydianstone (f), full of Graptolites; and in the Eichelberg these again underlie glossy clay-slates of greenish-grey colour (g), with Nereites and Tentaculites. Finally, the true Devonian limestones (h) (the concretionary Cypridina-limestones, so well seen in the environs of Saalfeld, *i.e.* the Clymenia-limestone of Münster, or this younger formation) underlie all the older Silurian series.

With this highly-inverted region around Hof I was already acquainted in previous years. In fact, I had abandoned all idea of eliciting the order of superposition, and of assigning to the beds their proper places in the succession by the fossils they respectively contained. My associates may therefore well imagine what great value I attach to the investigations of M. Gümbel, who has so effectually cleared away the remainder of the obscurity in which this tract was shrouded, and has given to the fossiliferous deposits such clear base-lines.

The Silurian Rocks of Bohemia.—Having now described the regular ascending succession of the Palæozoic rocks of Bavaria, in the environs of Hof, as well as their inversion, let us traverse the great region of crystalline rocks which separates them from that celebrated Silurian basin of Bohemia, so well described by M. Barrande in his truly classical work.

I have already alluded to the wide extension of the so-called Urthon-Schiefer, or primary clay-slate, which subtends this basin on the west; and M. Barrande has, indeed, clearly shown how in other parts, particularly near Przibram, the fossiliferous primary zone is equally supported by unfossiliferous schists and grauwacke, and his still older "roches azoïques."

Knowing that the Austrian Surveyors had prepared, and were about to issue, their geological maps of this region, the eastern parts of which only I had several times visited, in company with my friend M. Barrande, I naturally felt a great desire to see how the lower members of his series were related to the still older rocks on the western flank of the basin—a tract which I had never seen. I also knew that from this western side a new railroad had been cut, which, in proceeding from Pilsen to Prague, laid open several of the Silurian rocks. In sending to me the new Austrian maps at Marienbad, M. Haidinger also stated that he had requested M. Lipold, who had coloured the sheets in question, to meet me at Pilsen. I had, indeed, previously made the acquaintance in London of a very intelligent Bohemian naturalist and palæontologist, Dr. Anton Fritsch, the Curator of the Natural History Museum at Prague, who attended the recent International Exhibition in London, and this gentleman (M. Barrande being then absent from Prague) agreed to meet me at Pilsen, accompanied by M. Lipold, the Austrian Surveyor.

Aware that the subject of the "Colonies" had been so criticised as to cause my eminent friend to bring out replies in defence of his views, I explicitly told the gentlemen who accompanied me in my rapid journey from Pilsen to Prague, that the subject of the "Colonies" could form no part of my observations, stating truly that from want of time, I had no power to sift the question at issue, and I therefore resolved not to examine any one of the sections of M. Lipold or of M. Crejci, which had been brought forward in antagonism to M. Barrande. My main object, I stated, was to see how the lower part only of the great deposit of grauwacke-slate, in parts alum-slate, in parts flinty-slate, which overlies the Thon-Schiefer, exhibits here and there only the Primordial fossils discovered by Barrande, and how from that Primordial zone the transition into the overlying schists, with fossils of Llandeilo age, was to be best seen.

And here I must do M. Lipold and Dr. Fritsch the justice to say, that, far from undervaluing the original and masterly labours of M. Barrande, they had adopted all his formations, as base-lines, though they had assigned local names to subformations, as synonyms of his alphabetic classification. Thus, his lowest fossiliferous or Primordial zone of C was their Przibram beds, and so on with all the overlying divisions. As such, indeed, they appear in the accompanying map of the Austrian Survey, and with their references to the stages of Barrande.

I must also here state, that, before I left London, Mr. Salter had come to the conclusion, from Bohemian fossils which he had examined, that the zone D′ of Barrande, or the next division above the Primordial (C), was a true equivalent of the Llandeilo beds. Again, from a comparison of their fossils, M. Barrande had previously properly compared other overlying beds of his great group D with my Caradoc sandstone. In his great work he had, however, simply divided, as I did in my first classification, the Silurian system into upper and lower.

In elaborating the British fossils of what was formerly called Upper Caradoc, and particularly through the labours of Mr. Salter, it was found, however, that an intermediate group ought to be established, which I called Llandovery rocks, the lower member of which had strong affinities with the Caradoc formation, whilst the upper member was as clearly connected by its fossils with the Welsh strata.

To the possible intercalation of the Llandovery rocks in the Bohemian series of Barrande I will presently advert.

I now beg to call attention to the Austrian Geological Map of the Silurian basin of Bohemia, and of the subtending and overlying rocks, by the Imperial Surveyors, which my old friend M. Haidinger, the Director of that Survey, has transmitted to me. He has obligingly attended to my request, and has had all the strata coloured on the same principle which regulates the colouring of the Silurian rocks in the British Survey. The only deviations from the base-colours of dull and brighter grey and purple are where the Loess covers certain lower tracts, or where the Upper Coal-strata are represented, as they range unconformably over the Silurian rocks.

In directing attention to the table of colours accompanying this elaborate map, I must say that much closer analyses and comparisons of palæontologists will be required before the subordinate parts of the Bohemian series can be placed in such exact correlation with our British local details as is here given. In fact, I do not believe that a much closer analogy between the Silurian series of Bohemia and Britain can be set up than that which M. Barrande has established by a very good general identification of his rocks with my Upper and Lower Silurians. And although, as before said, I think that, in Bohemia, the Llandeilo zone can be distinguished from the Caradoc zone, it will be impracticable so to define other details as to say that any one bed of the Bohemian series is the equivalent of one of our British Lower Silurian subformations.

Again, in the Upper Silurian rocks, though the limestones or upper portion of the 'E' of Barrande are clearly identifiable with the Wenlock limestone, it does not follow that the shale beneath it is equal to the Wenlock shale, merely because the mineral character of the two rocks and the order of superposition agree. Judging from the organic remains, M. Barrande may, I think, possibly be induced to form a new group, and unite this shale with his D^5, or next underlying bed, and thus represent our Llandovery rocks.

On this point I am disposed to be guided by the opinion of Mr. Salter, who has taken great interest in the question of the Colonies; and he thus wrote, in June 1860, to Sir Charles Lyell:—"I regard at present the Colonies, with the beds called Lower Silurian over them, and the base of Étage E (Graptolite-bearing schists and trappean beds), as equivalent to the Llandovery rocks, under an aspect different from that which they present in Scandinavia and Britain." This view, which Mr. Salter still maintains, he strengthens by assuring me that the fauna of the Colonies consists chiefly of about 65 species (Barrande), of which 5 are peculiar, 2 are common to D^4, or Caradoc and Wenlock, and 58 are Wenlock forms.*

In the uppermost Silurian rocks a few Ludlow types only are mixed with many forms quite peculiar. It is therefore impracticable to define the Bohemian subdivisions into Lower Ludlow, Aymestry Limestone, Upper Ludlow, and Passage-beds, as attempted in the

* On this head Mr. Salter has furnished me with the range of certain striking Bohemian genera and species, as they occur in Britain:—

	Bohemia.	Britain.
Trilobites.	Cheirurus insignis	Very like the Wenlock *C. bimucronatus*, but long known as a species in the Caradoc of Bohemia.
Trilobites.	Cyphaspis	The genus in England—Wenlock.
Trilobites.	Lichas	The genus in England—Wenlock.
Trilobites.	Sphærexochus mirus	Lower Silurian to Upper Silurian.
	Orthoceras originale	Upper Silurian.
	——, 7 species.	
	Cyrtoceras	Genus in England—Upper Silurian.
	Terebratula obovata	Upper Silurian.
	—— reticularis?	Lower Llandovery to Upper Silurian.
	Spirifer togatus	Species not yet recognized.
	Leptæna euglypha	Lower Llandovery to Upper Silurian.
	Cardiola, 4 species.	
	—— interrupta	Lower Silurian? to Upper Silurian.
	Favosites Gothlandica	Lower Silurian to Upper Silurian.
	Graptolithus priodon	Lower and Upper Silurian.
	—— Nilssoni	Lower Silurian.
	—— Becki	Lower Silurian.

new Austrian map, and we must be content in the meantime with those broad divisions of Lower and Upper Silurian into which M. Barrande divided them, with the possible establishment of a Middle Silurian; whilst we can certainly affirm that our Lingula-flags, Llandeilo, Caradoc, and Wenlock formations are palæontologically well represented, with a full equivalent in time, by some fossils of the Ludlow rocks.

The total absence of Devonian rocks in the environs of Prague shows how very different a development of Palæozoic life took place on this the south-eastern side of the old crystalline rocks from that which occurred at a short distance on their north-western flank, nearer Hof, where, as already noted, the Silurian rocks, though infinitely less rich in fossils and containing no limestones, have still a vast formation of clay-slate and a clear Primordial zone. From that horizon, however, upwards, we have a marked difference. Instead of the rich Lower and Upper Silurian, with their numerous limestones and abundance of fossils, as seen in Bohemia, the system above the Primordial zone in Bavaria is simply represented by grauwacke schists with Graptolites, which pass upwards into true Devonian rocks with many fossils. The latter again are there surmounted conformably, as previously shown, by Carboniferous limestones with many *Producti*. There are no Upper Carboniferous strata in that neighbourhood. In Bohemia, on the contrary, with a very full Silurian series, there is no Devonian nor Lower Carboniferous rock, whilst there is an abundant Upper Carboniferous deposit with coal, the sandstones and shales of which rest quite transgressively upon different members of the Silurian system. The differences in the fauna and flora of the Lower and Upper Carboniferous formations, and between which there is such a manifest break throughout Germany and France, have been ably pointed out in Saxony by Dr. Geinitz.

Our President, Professor Ramsay, in his recent Anniversary Address, opened out a highly interesting and important inquiry, and has clearly shown that in Britain there have been ten breaks or dislocations in the older Palæozoic times. Let this inquiry be followed in other countries. From my experience I am led to believe that the breaks he has enumerated as common to Britain are essentially local, and are rarely to be paralleled even in the adjacent continent of Europe, where the solutions of continuity are often of very different age from those common to our land.

Thus, I have long known that the great disseverance between Lower and Upper Carboniferous, so strongly marked all over Germany and France, has apparently no existence in Britain, whilst, as shown in the preceding consecutive section of M. Gümbel, there still exists in Bavaria an unbroken and conformable ascending order, from the older stratified rocks, through the Silurian and Devonian, up into the Lower Carboniferous—a striking contrast to the Silurian derangements in Wales, as cited by Professor Ramsay.

In the endeavour to grapple with such great questions as the amount of time which may have occurred whilst the breaks and overlaps of the various formations were in course of production, as broached by Professor Ramsay, it seems to me to be still more important to draw special attention to the gradual transitions or passages between two formations, or, in other words, from the quiet burial-grounds of one epoch of life into those of another. For if, through the patient accumulation of well-compared data, derived from different and distant regions, we can ultimately succeed in showing that, though the geological record is locally broken, yet all such gaps in one country can be filled up by putting together the local sequences in other and numerous tracts, we shall be in a much fitter condition to reason upon the hypothesis suggested by Mr. Charles Darwin, as to the probability of finding, in those enormous deposits of former ages (which could indeed only have been formed in very long periods), any forms of life which link on one group of animals to another. As a stratigraphical geologist, who has convinced himself that the particular break of one region is often well filled up by the unbroken sequences of strata in another, I will only observe, that I am acquainted with many examples of such true physical transitions from one formation into another, in which there is not a trace of disturbance. Thus, in addition to the examples given by M. Gümbel, I would refer to the tract near Saalfeld, where the Upper Devonian, with its very peculiar Plants, is gradually linked on to the Lower Carboniferous, containing very different plants.

Again, in those well-known quiet transitional deposits which occur in Britain between the great natural divisions, the Silurian and the Devonian *, and again between the latter and the Carboniferous, it is an undoubted fact that, in ascending from the lower to the higher beds, we ever find different genera and species of animals. On the other hand, we have never found in such united strata an animal representing a link between two great divisions of the animal kingdom. Yet, if such links, which have not yet been found in existing nature, are to be detected in the ancient crusts of the earth, it is in such transitional unbroken bands as these that they must be specially sought for; and as they have been very sedulously examined without affording a trace of the requisite evidence, I contend that the geological record yields no support whatever to the transmutation-theory, if that theory be restricted to the examination of true natural species, and be not based on those varieties which man has educed by his own efforts and perseverance.

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2. *Notice of a* Section *at* Mocktree. By R. Lightbody, Esq.

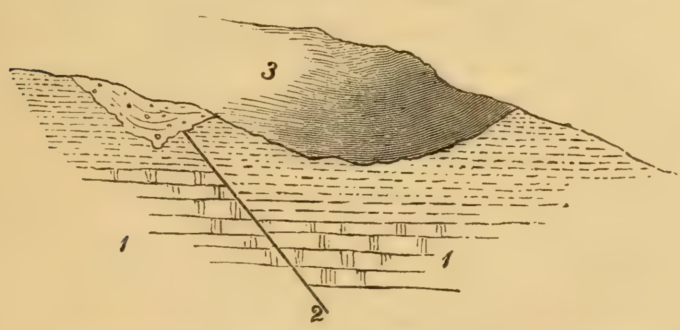
[Communicated by J. W. Salter, Esq., F.G.S.]

A remarkable section having been recently noticed in the Aymestry Limestone at Mocktree, near Leintwardine, it may be interesting to record a few particulars in reference to it.

* See Silurian System, 1839 (*passim*), Siluria, 2nd edit. p. 149 *et seq.*, and Memoirs published in the Quarterly Journal of the Geological Society.

The section in question is in the upper quarry of Aymestry Limestone, on the north side of the turnpike-road from Ludlow, and about 1¾ mile from Leintwardine, on the right-hand side on entering the quarry. The rock has been cut down about thirty feet in a perpendicular face through the Aymestry Limestone, where it yields a few examples of *Pentamerus Knightii*; the upper beds consisting of what has hitherto been considered to be Upper Ludlow rock, but which I shall presently endeavour to show ought to be classed with the Aymestry Limestone. This upper part is composed of thin beds, chiefly argillaceo-arenaceous, with interposed occasional calcareous bands. The argillaceous limestone in the lower two-thirds of the section (1) contains *Pentamerus Knightii* and *Atrypa reticularis*, though not abundantly, and exhibits the characteristic lines of honeycomb-structure peculiar to the Aymestry Limestone. In the upper part of this rock may be seen a hollow, some ten or twelve yards in diameter at the top, but rounded at the bottom, and four to five feet deep; it appears to have been a channel cut through the honeycombed beds by the action of water. This has been again filled in with thin arenaceo-argillaceous beds (3), which are deposited at the bottom of it, in an inverted arc, quite unconformable to the beds on which they rest, but corresponding to the hollow of the trough. This bent character gradually disappears, until, at some little distance above the edges of the trough, the beds again dip conformably, or nearly so, to the honeycombed beds, and in straight lines, at a moderate angle towards the south-east. These beds are here from three to four yards thick.

Section in the Aymestry Limestone at Mocktree.



1. Aymestry Limestone. 2. Fault. 3. Starfish-bed.

There appears to be an oblique fault (2), dipping south, a little to the left of the trough, but which has been covered by the thin beds. These thin beds, which fill the trough, though not quite so hard, correspond very much with the Lower Ludlow beds in the Church-Hill quarry, where the Starfish are so abundant, and contain, together with other fossils,—such as *Lingula lata*, *Ceratiocaris* (two species), *Pterygotus punctatus*, *Entomis tuberosa*, *Calymene Blumenbachii*, and *Encrinurus punctatus*,—one or two species of Starfish, but only very rarely, and very indifferently preserved.

To Mr. Alfred Marston, of Ludlow, is due the credit of making the discovery of Starfish here; and he has also found them in a similar bed, three feet thick, in a quarry about a quarter of a mile north of this one, on the west side of the old road to Leintwardine, but having this peculiarity—that it lies conformably on a bed full of *Pentamerus Knightii*, at least nine feet thick, and is covered by another Pentamerus-bed eighteen inches thick, so that it is unquestionably enveloped in the Aymestry Limestone. This neighbourhood is traversed by many faults, and it has been suggested that the occurrence of these Lower Ludlow beds above the Aymestry Limestone may be due to them and the falling over or reversal of the beds; but in the last-mentioned case, certainly, this would not explain the phenomena, inasmuch as the limestone-beds *overlie*, as well as underlie, these beds containing Lower Ludlow fossils. In the first-mentioned section, too, the circumstances are very peculiar; for there is, apparently, evidence of the action of water, either subaërial or, possibly, an ocean-current, which has cut through the consolidated (but possibly not then indurated) beds of the Aymestry Limestone previous to the cessation of the animal life of the Lower Ludlow period; so that, when circumstances again admitted of it, a deposit took place, nearly similar in nature and contents to that of the Lower Ludlow. Does it not bear some comparison with M. Barrande's "Colonies," only reversed in position?

I now come to the question of classification of the beds overlying the Aymestry Limestone. It is well known that, at the time when the maps of the Geological Survey relating to the Ludlow district were coloured, there was comparatively less weight than at present attached to the palæontology of the Silurian strata in the discrimination of the beds, which was determined more by their lithological character. We may fairly assume, I think, that the Whitcliff at Ludlow was considered the typical section of the Upper Ludlow rock, running downwards as it does from the Downton Sandstone, and the Bone-bed, in apparently unbroken sequence. The surveyor at that time, looking at the nearly identical dips of the beds there, their lithological character, and structure of bedding,—and, moreover, finding certain fossils, such as *Chonetes lata*, *Rhynchonella nucula*, *Goniophora cymbæformis*, and *Orthonota amygdalina*, in both the upper and the lower beds, very naturally believed that they were all part of the same group, and undisturbed. A little closer examination, however, would have shown the existence of two faults, by which a large portion of the middle of the cliff is thrown up, until the beds originally at the bottom of it now form the capping, though the dip is but slightly altered. Again, a closer examination of the fossils would have shown that though some of the fossils pervade the whole series of beds, yet that portion between the faults also contains a number of other species, which I believe are never found in the true Upper Ludlow, and others, abundantly, which are very rare in those beds, while all belong specially to the so-called Aymestry Limestone and the Lower Ludlow. Among the fossils belonging to the lower formation, but found on Whitcliff, I may mention

Strophomena depressa, *S. filosa*, and *Atrypa reticularis*, all abundantly; *Acroculia Haliotis*, *Lingula striata*, *Proëtus Stokesii*, *Encrinurus punctatus*, *E. variolaris*, and *Lichas Bucklandi*. Besides these fossils, however, the character of the rock, if closely examined, testifies to the same effect, as it is much more calcareous than the true Upper Ludlow beds ever are, and shows the honeycombed structure in the joints along the bedding. This is shown also by the whiteness left, on the central parts of the cliff, by the trickling of water, which has given it the name of White Cliff.

The consequence of this oversight has been that the admixture of Aymestry Limestone fossils (most of which run through the Lower Ludlow) with the Upper Ludlow list has rendered it impossible, where the thick calcareous beds do not intervene (as is the case towards the west), to discriminate between the Upper Ludlow and the Lower Ludlow, and they are consequently coloured the same on the maps.

When we consider that all through the strata, from the top of the Aymestry Limestone, there is a constant intercalation of calcareous beds, to the bottom of the Lower Ludlow, of which the Aymestry Limestone is only an exaggeration arising from the casual occurrence of large beds of shells or corals in certain places,—if we further consider the identity of a large proportion of the fossils of the Aymestry Limestone with those of the Lower Ludlow, particularly when we find such local fossils as the Lower Ludlow Star-fish in beds above the whole thickness of the Aymestry workable limestone,—if we consider the impossibility of fixing upon the point where the one formation ends and the other begins,—and, lastly, that the Aymestry or thick limestone does not exist through large tracts of Ludlow rocks, but only where certain fossils are very abundant,—would it not seem better to discontinue the name Aymestry Limestone as a *division* altogether, and to call all the beds between the Upper Ludlow and the Wenlock simply Lower Ludlow, though still colouring the thick calcareous beds as before?

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

May 6, 1863.

William Whitaker Collins, Esq., M.I.C.E., 15 Buckingham Street, Adelphi; Charles Carter Blake, Esq., Honorary Secretary of the Anthropological Society, 1 Mabledon Place, W.C.; and John Martin, Esq., Cambridge House, Portsmouth, and Keydell, Shorndean, Hants, were elected Fellows.

M. F.-J. Pictet, Professor of Zoology and Comparative Anatomy in the Academy of Geneva; Signor Q. Sella, Member of the Italian Parliament, Turin; Herr Credner, Königlicher Bergmeister of Gotha; Dr. J. J. Kaup, Conservator of the Museum of Darmstadt; Signor G. Meneghini, Professor of Palæontology in the University of Pisa; Signor B. Gastaldi, of Turin; and M. A. Morlot, of Berne, were elected Foreign Correspondents.

The following communications were read:—

1. *On the* Brick-pit *at* Lexden, *near* Colchester. By the Rev. O. Fisher, M.A., F.G.S. *With* Notes *on the* Coleoptera; by T. V. Wollaston, Esq., M.A., F.L.S.

Description of the Strata.—The Brick-pit at Lexden is situated on a plateau upon the south side of the valley of the Colne, about a mile west of Colchester. The table-land around Colchester, elevated somewhat more than a hundred feet above the level of the sea, upon the south side of the Colne, consists of thick beds of gravel and sand resting upon London Clay. This gravel is for the most part well rolled, and its stratification is very regular. Its upper and lower portions are stony, while the middle consists principally of false-bedded strata of sand. Fine sections are exposed by the drainage-works now going on at the new cavalry-barracks at Colchester, and in pits in the suburbs. The lowest bed, resting on the London Clay, is a coarse gravel, well seen at Wivenhoe ballast-pit.

I believe this extensive bed of gravel to be the old gravel which elsewhere underlies the Boulder-clay. It crops out towards the southern part of Essex, ranging from Danbury, where it attains a considerable elevation, by Tiptree Heath to Colchester. It is seen near the railway-station at Hadleigh in Suffolk, and in the same county forms an extensive heath near Dunwich.

There is an excavation in the lower portion of this gravel, in the corner of Lexden Brick-pit, close to the kiln, where the following section is exposed:—

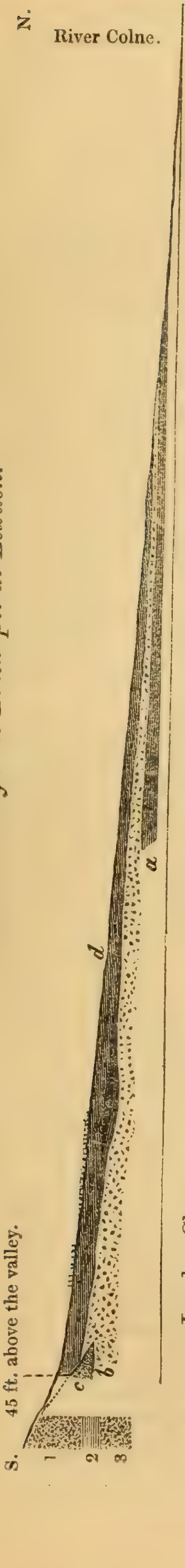
Section in the Brick-pit at Lexden.

		ft.	in.
1.	Gravelly sand, about	16	0
2.	Sand	20	0
	Loamy sand with dark stains	0	6
3.	Coarse gravel with water, not pierced.		

The latter is doubtless the lowest member of the deposit, resting upon the London Clay.

The newer deposits of the Brick-field appear to rest upon a shelf of the London Clay, and to abut against the old gravel above described. The clay which, under the local name of "Strong Clay," is dug at the north-west corner of the field seems to be the London Clay (*a* in section, p. 395). There it has been excavated to the depth of about 12 feet; and at the lowest point ever reached pyrites are said to have been found, and to have been pronounced by the late Mr. J. Brown of Stanway to be "petrified wood," like that found at Walton-on-the-Naze, where such remains *are* found in the London Clay. There is a septarium to be seen in the river-bed just below. I have not been so fortunate as to see this part of the pit in work.

Upon this clay lies a bed of gravel (*b*), largely dug in those parts of the field from which the superincumbent brick-earth has been extracted. It is very different in character from the older gravel above described, although its materials seem to have been for the most part derived from the more ancient deposit. In the course of its re-formation much of the sand has been removed, and a certain proportion of clay incorporated instead, which renders the cementing material more "binding." This gravel also contains a few large, slightly rolled flints; one which I saw must have weighed twenty-five pounds. These flints were probably derived from the Boulder-clay. The thickness of this gravel is about 7 feet; but there are other layers of clay and gravel, beneath the one which is worked, which have not been proved.



Section through the Brick-pit at Lexden.

a. London Clay.
b. Post-pliocene Gravel.
c. Talus of old Gravel (1, 2, 3).
d. Brick-earth.
e. Peat resting on carbonaceous clay.
1, 2, 3. Probable old Gravel.

Occupying a trough about 30 feet wide in this gravel, and running parallel with the southern boundary, where the newer strata abut upon the older gravel, is found a deposit of fine grey clay passing into carbonaceous clay with rootlets, and resting upon it a bed of peat (*e*). In the central and thickest part the peat measures about a foot in depth, and the grey clay 3 feet. The clay extends north and south beyond the edges of the peat, and both are planed off above to one general surface. A thin seam of whitish gravel and yellow clay, and, above that, about a foot of whitish clay, cover these deposits, and pass upwards into the main bed of brown brick-earth (*d*) hereafter to be described.

As far as Palæontology is concerned, the interest of the locality is confined to this remarkable trough, which has formed a perfect cemetery for the pachyderms of the period. *Elephas primigenius* is found abundantly, associated with *Rhinoceros leptorhinus*, of which latter animal some fine jaws were obtained here by Mr. Brown, who placed them in the British Museum. Their bones lie upon the surface of the clay immediately beneath the peat, while their condition shows that they have been affected by contact with it. The peat itself contains an amazing number of fragments of Beetles in a remarkable state of preservation. I collected as many specimens as I could find in the portion of peat that had been dug out during the past winter, and submitted them to the inspection of my friend Mr. Wollaston, and I have appended his highly interesting description of them to this paper.

The peat has almost thinned out at the point which the excavations have reached towards the east; but what remains of it seems unaltered in character, as if it were the remaining portion of a thicker mass, of which the upper part has been removed by denudation.

In digging the brick-earth, the workmen are now stopped at the south end of the pit by a bank of sandy gravel (*c*), with a slope of about 30°. This I concluded to be a talus of the ancient bank of the valley; and accordingly, upon digging into it, I found that its materials were identical in substance and colour with those of the old glacial gravel, but that it was wholly unstratified; whereas that gravel, when *in situ*, is notably bedded. I had, therefore, a pit dug following the face of this talus until stopped by water. I found that the basement gravel of the newer deposits runs underneath the talus, while a sandy layer resting upon it, but markedly distinct, has the end of the talus intercalated with it. All the beds above this rest against the face of the talus, and have their ends slightly bent upwards against it. A few pebbles lie upon the face of the talus, as if they had rolled down it while the upper beds which abut upon it were being deposited.

Passing upwards from the denuded surface of the peat, we next meet with a deposit of sandy brown brick-earth (*d*), about 9 feet thick. It differs entirely from all the beds below it, and was evidently deposited by a comparatively quiet action against the face of the old talus, which is wholly undisturbed by it, while its lines of stratification bend upwards where they abut upon it. In this brick-earth are a few very thin beds of pebbles. There are also, as already noticed, a few pebbles where it joins the talus. In the former position was found a singular red stone, which seems to have been baked in fire *. In character the brick-earth seems like a silt derived from the weathered surface of London Clay, abundant in the neighbourhood. A similar bed of brick-earth occurs in some pits near the Colchester railway-station, where it is nearly 20 feet thick. I have obtained from it the teeth of Deer.

The next deposit in ascending order is the capping of soil, or "heading," passing upwards into the vegetable mould. Of this deposit I believe less is known than of almost any other, while its importance as containing the records of the latest geological changes exceeds perhaps that of many of the older strata. In the present locality there seems to be sufficient evidence that it is a *drift*. Its line of junction with the brick-earth is, as usual, extremely irregular; and its lower portion is here, as elsewhere, studded with small subangular flints. Small flints occur only sparingly in the brick-earth on which it rests. There is at present to be seen, intercalated in the deposit, a thin wedge-shaped drift of sandy gravel, evidently washed down from the old gravel forming the hillside above. At the brick-pit near the Colchester station this drift in patches has almost the character of a gravel, while the brick-earth on which it rests is nearly devoid of pebbles. It seems impossible that the one can have been derived by any subaërial action from the other.

There is also at Lexden a section of a natural bank, beneath which the surface of the brick-earth is seen to follow the form of the superficial surface, with this overlying drift wrapping round it.

Mode of Formation of the Strata.—In endeavouring to understand the causes which have led to the phenomena just described, I have been much assisted by noticing the present condition of the locality, and have little doubt that the state of things during the period when the Elephant lived here was only an older edition of the present.

* Deposited in the Society's Museum. Mr. Prestwich has indicated Lexden as a probable locality for "Flint Implements," Phil. Trans. 1860, part 2, p. 308.

At present the River Colne meanders through flat meadow-land, whose surface it is raising by the deposit of inundation-mud, so that old trees are becoming buried over their butts. The bed of the river reveals a layer of coarse gravel as the subsoil. On the right bank and a little above the Brick-pit, a short cliff has been excavated in the valley-side, where the course of the stream makes its most southern elbow. A talus has been formed in the curve of the cliff, and is covered with vegetation. A mere inspection of the place shows that the area in which the Brick-pit is situated is simply a similar curve in the boundary of the more ancient river-valley, where an elbow of the stream which then occupied it may have encroached upon the valley-side,—the bed of gravel which forms the base of the Post-pliocene deposits being the former equivalent of the gravel now to be seen 40 feet lower in the present bed of the stream, while the old talus answers to the present one. But the points of similarity do not cease here; for along the base of the present cliff are some small springs issuing from the junction of the old gravel and the London Clay, which, trickling down the face of the bank, have been received in a deep hole, and have formed a thick bed of peat with a soft quaggy surface. A short time ago a horse got mired here, and would have perished but for timely aid. It is obvious that the ancient bed of peat was formed in a similar manner by springs issuing from the same junction of the old gravel and London Clay, which yields water abundantly throughout the pit; and that the Elephants got mired and perished there, as the horse would have done without rescue the other day. This explains why so many individuals have left their remains in so small a space, and also accounts for the bones of the feet of an Elephant being found in juxtaposition in the clay at the base of the peat*.

I am doubtful whether the modern cliff is the result of an undermining action of the stream. Such cliffs are very noticeable when they occur, but are rare in the sides of valleys among soft strata; and when they are met with, they usually present springs at their bases. I believe their formation to be due to the erosive action of the springs, aided by the slipping away of peat as it becomes gradually too heavy to remain where it was formed; and the ordinary proximity of an elbow of the stream to such cliffs seems to be an effect rather than a cause. Nevertheless such a rule need not be general, and there appears to be evidence, in the gravel underlying the talus, that the torrential action which brought it there had at least its share in causing the ancient cliff in the valley-side.

Both the ancient and the recent deposits of peat contain much sand and gravel on the side nearest to the bank. This may have been brought here on the feet of birds or other animals, or by stones rolling and sand being blown down from the bank above. Both peats seem to have had the effect of discharging all ferruginous colour from the gravel immediately beneath them, by rendering the colouring material soluble through the evolution of carbonic acid. The pebbles of flint in actual contact with the peat are stained black. The ancient peat

* These bones are now in the Museum of Practical Geology, in Jermyn Street, London.

seems to have been formed entirely by succulent plants, and to contain no wood, whilst the modern peat is full of sticks and boughs.

I have expressed an opinion in a former paper* that the valleys in this neighbourhood are not due to causes such as we now see in operation, but have been excavated and re-excavated by a powerful and comparatively transient action. I see, then, in the gravel at the base of the Brick-field the débris of a former period of denudation, during which the current swept in an eddy against the hillside forming the ancient cliff, and deposited gravel against its base. This action would leave a hole at a short distance from the bank, such as every angler knows to exist in the elbow of a stream. When the force of the current abated, that hole would become partially filled with mud, and afterwards with a rank growth of marsh-plants, which were continually kept moist and converted into peat by the springs that rose close by. Here the Phytophagous Insects disported themselves, and here the Elephants were lured to their destruction.

We now come to the consideration of the brick-earth which covers the peat. I have stated that the surface of the peat seems to have been denuded. The denudation has not, however, been of large amount, but has merely produced channels which appear to run parallel with the old bank, and are filled with clay. In places there is a thin bed of shingle above the peat. The denudation may have been caused by the shifting of the river-course, causing the water to flow at some period or other over the peat; and the brick-earth may be nothing more than the silt deposited by the stream in periods of flood.

It is also possible that the brick-earth may be an estuarine deposit, for its height above the sea cannot exceed 60 feet; the tide now reaches to within less than two miles of the spot. Such a rise in the sea-level would be nothing remarkable in the Post-pliocene period, during which, as is well known, there was in many parts a subsidence of the land to the depth of about 40 feet †.

Organic Remains.—The facts as yet observed at Lexden do not add to the evidence now relied upon for the association of Man with extinct Mammalia. Mr. Prestwich has indicated the locality as one in which Flint Implements are likely to be found, but they have not yet been observed. There is, however, a bed of gravel still lower than that which is dug; and it is very probable that, if Flint Implements do occur in the pit, that is their position.

When I submitted the Insect-remains to Mr. Wollaston for his examination, I requested him particularly to give me his opinion as to the climate which they appeared to indicate; and also to notice especially whether they agreed specifically with the *Coleoptera* at present inhabiting Britain. In reply he writes:—"One thing I feel pretty certain about, namely, that none of those few species, the portions of which I have yet examined, are specifically identical with any of the existing British forms, unless, indeed, it be No. 1 ‡,

* Quart. Journ. Geol. Soc. vol. xvii. p. 1.

† Smith's 'Newer Pliocene Geology,' p. 19.

‡ See the specimens, which are in the Society's Museum.

which may *possibly* belong to an ordinary *Coccinella*. Generically perhaps some of them may be, though at least two, unless I am much mistaken, cannot be referred to any genus now inhabiting the British Isles. I say two; but I believe that, even of the few I have seen, the number is greater. Without more data it would be scarcely safe to speculate much as to the climate which such species would indicate. But so far as I am able to judge, if there were any difference from that which now obtains, I should be inclined to suppose it to have been warmer, and not the reverse. Thus *Cossyphus* (and I can scarcely be mistaken as to that Insect) does not now occur in England at all, indeed not even I believe in Central Europe, but in Mediterranean latitudes. The existence, in abundance, of a large metallic *Curculio*, or anything else so gorgeously cyaneous as to have transmitted even a respectable tint to our times, is certainly more suggestive of a warm climate than of a cold one. I do not think there can be much doubt that a warmer temperature than what at present obtains is indicated by these few forms; though at the same time I am well aware that it is possible to be mistaken as to this, because some of the Alpine (and therefore Boreal) species assume the brilliant metallic hues and somewhat large size of insects of more southern latitudes. Still I do not believe such to be the explanation in the present case, but exactly the reverse; more particularly if I am not mistaken in the genus *Cossyphus*, which I imagine will hardly be met with now-a-days north of the Pyrenees."

Mr. Wollaston's opinion seems, at any rate, to lead to the conclusion that there was a higher summer-temperature than we now have in England; and if, as is generally believed, our Island was at that period annexed to the Continent, such a circumstance, together with more rigorous winters, would be natural. But the facts, as interpreted by him, seem to suggest that the cosmical cooling of the glacial age had passed away *.

Mr. Wollaston's opinion as to the diversity of the Lexden Insects from recent British species is singularly in contrast to the statement that the Insects of the Forest-bed of Norfolk, and also those of Mundesley, are of recent British species. A change of climate from the already cold preglacial era to a warmer summer-temperature might cause the introduction of more southern types, and might account for the insect-forms of the Forest-bed coming nearer to those of the present day. But this would not explain the case of Mundesley, where the deposit is supposed to be of the same age as that of Hoxne, and probably of Lexden. However, I may be permitted to remark that, apart from Mr. Wollaston's high authority in any question of this kind, it must be remembered that it is much safer for an entomologist to pronounce that a portion of an Insect is unlike anything

* Captain Godwin-Austen's account of the former extension of Glaciers in the Himalaya (if that extension was contemporary with our Glacial Period) seems to prove that the phenomenon was general, at least in the northern hemisphere. See Report of the British Association Meeting at Cambridge, 1862, Transactions of the Sections, p. 67. Dr. Hooker's observation that the cedars of Lebanon grow on old moraines confirms this view; see Tyndall's 'Heat considered as a mode of motion,' p. 191.

with which he is acquainted, than, from the fragmentary remains of a geological deposit, to pronounce definitely upon the species to which those fragments may have belonged.

Note on the Remains *of* Coleoptera *from the* Peat *of* Lexden Brick-pit. By T. V. Wollaston, Esq., M.A., F.L.S.

Although each specimen of peat is one mass, apparently, of organic matter, I have been unable to detect much of an entomological kind, except elytra. In one specimen*, No. 4, there is part of a prothorax, and the scutellum is traceable; but the insect is much covered, and I cannot be sure that its margins are sufficiently flattened for it to be regarded as a *Cassida*. Also in another case, No. 5 (perhaps the most interesting and significant of the whole), a prothorax of such an unmistakeable nature is exposed, that I feel almost sure it can be nothing but the heteromerous genus *Cossyphus*.

The enclosed memorandum will show you that I am satisfied that there are certainly eleven well-defined species,—probably many more; but the fragments of the rest are too small and unsatisfactory to dogmatize upon. I can discern no limbs, though the other portions come out very clean and decipherable by brushing them over with benzine collas †.

But how to generalize satisfactorily from such fragments I cannot say; for elytra are the most unsatisfactory parts of Insects for determining their affinities. A few points perhaps may be ventured upon.

Imprimis, with the exception of two species, Nos. 6 and 7, both apparently scarce, and which may be Carabideous (though I will not be positive of this), all the remainder seem to be Phytophagous; and as one or two of these, for instance No. 3, seem to have been extremely abundant, this fact is the more significant. The *Chrysomelidæ*, *Curculionidæ*, and *Cassididæ*, I suspect, embrace the prevailing forms. Bright metallic tints seem to have been the prevailing ones, such as one finds in many of the marsh-insects of our own times; and there is no evidence of anything very extraordinary either in size or structure ‡; though I do not think that any, unless it be one or two, could be referred to actual species now existing in England. If any of the species had been fossorial, I imagine that their strongly developed corneous anterior legs, which are often wide and externally dentate, could not fail to have been preserved.

Description of the Fragments of Coleoptera.

1. A small, short, and rounded elytron, with a strong outer rim, uneven, and almost without sculpture, though coarsely coriaceous under a high power: perhaps a *Cassida*, or more probably a mutilated *Coccinella*.

2. A larger and extremely wrinkled elytron, most *densely* and

* The specimens are in the Museum of the Geological Society.

† The same difficulty in identifying limbs occurs among the fossil Insects of the Purbeck beds.—O. F.

‡ I have reason to think, from the report of the intelligent manager of the pit Mr. Steward, that much larger Insects occur than any that I have seen.—O. F.

minutely punctulated all over, but not striated: possibly one of the *Chrysomelidæ* (such as *Oreina*).

3. A large uneven elytron, of a bright cyaneous blue, deeply punctate-striated, and coarsely wrinkled transversely: possibly, from its colour, a *Chrysomela*, though more probably, from its sculpture, a large metallic *Curculio*; apparently a common species.

4. Elytron, scutellum, and prothorax, all partly visible. Elytra gibbous, shining, sparingly punctured, but not striated, of the same breadth at the base as the prothorax, but divided from it by a sharp narrow suture; scutellum very minute and triangular; prothorax more opaque, most closely and minutely alutaceous, with a longitudinal depression on either side at its base: a small and rounded Insect, like a very minute *Cassida*.

5. A prothorax very evident, with an extremely broad, flattened, and perhaps tubercled margin. The Insect is clearly elongate-oblong and flat, though more convex and carinated down its central region: either *Cossyphus* or *Cassida*; I think decidedly the former.

6. A large, bright, and more flattened elytron, finely, but simply, or at the utmost subcrenately striated; with the interstices most minutely and sparingly punctured, and a little wrinkled. I think Carabideous; possibly a *Licinus* (or an allied genus).

7. A large, uneven, but rather flattened elytron, distinctly crenate-striated, and with the interstices most closely and coarsely rugulose transversely, but not punctulated. Probably Carabideous.

8. A long, rather narrow, and bright elytron, with the striæ excessively deep, sulciform, and impunctate; the interstices almost unsculptured, though most minutely alutaceous under a high power. Apparently a rather large Insect. *Possibly* one of the *Buprestidæ*.

9. A bright cyaneous elytron, coarsely seriate-punctate, the punctures large and remote, and with the interstices minutely rugulose: most likely a *Chrysomela*.

10. A small portion of an elytron, most coarsely, regularly, and thickly tubercled or shagreened, but apparently without any other sculpture.

11. A large convex and polished elytron, most densely, regularly, and minutely punctulated all over, but without any other sculpture: I believe a Water-beetle.

12. Possibly the fractured underside of No. 11.—T. V. W.

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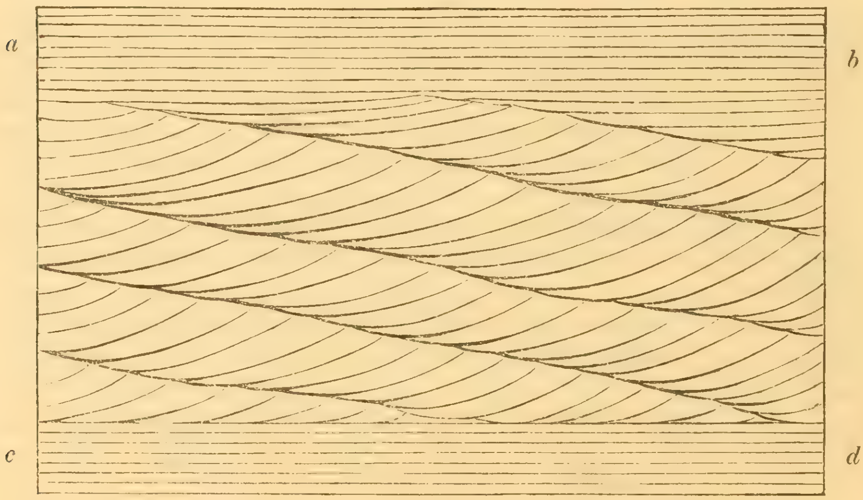
2. *On the* Original Nature *and* Subsequent Alteration *of* Mica-schist. By H. C. Sorby, Esq., F.R.S., F.G.S.

That micaceous schists were originally deposited as sand and mud, and that their present mineralogical and mechanical structure is due to subsequent metamorphic action, may appear to some geologists so thoroughly established as to make further proof needless. Since, however, some geologists in our own country and on the Continent have, within the last few years, argued that the bands of varying mineral character do not represent original stratification, but were due to causes similar to those which have produced thin-bedded and almost laminar trachytes, or to some little-understood force of polarity, it appears to me far from superfluous to describe certain facts very completely establishing the sedimentary and metamorphic origin of the schistose rocks of the localities mentioned in the sequel. That the mere repetition of layers of different mineral character is of itself no absolute proof of sedimentary formation is sufficiently apparent from what is often seen in well-known igneous rocks; but mica-schist sometimes possesses other peculiarities, to which I beg to call attention.

In very many stratified rocks the ripple-marks are extremely characteristic of deposition under the influence of a current; but, if these were found in bent and contorted schists, it would, I think, be rash to base any important conclusion on them, since mere mechanical bendings might so readily mislead an observer. There is, however, a structure generated when ripples are formed whilst material is being deposited and permanently accumulated, which has such well-defined peculiarities that it appears to me almost impossible to confound it with any structure produced by other means. I here allude to what, in the various papers I have published on the subject*, I have called "ripple-drift," the most important characters of which will be better understood from the following drawing:—

Fig. 1.—*Thin bed of "Ripple-drift" in unaltered sandstone* (nat. size).



Frequently there are quite horizontal beds below and above (*a b*, *c d*), and between are beds inclined to them at an angle *a d c*, which are themselves made up of smaller beds or stratula dipping in the opposite direction, namely from *b* towards *c*. Such bands often occur in the green slates of Langdale in Westmoreland, the cleavage cutting them at a considerable angle; and when the slates are ground smooth and slightly varnished, the peculiar structure may

* Edin. New Phil. Journ., new ser. vols. iii. p. 112, iv. p. 317, v. p. 275, vii. p. 226; 'Geologist,' 1859, p. 137.

generally be seen very distinctly. The existence of this "ripple-drift" appears to me to prove most conclusively the sedimentary origin of the rock in which it occurs. Its various peculiarities are so characteristic that it could not, I think, be confounded with any structure known in any unstratified rock; and therefore, since I find that it is by no means rare in the mica-schist of the Highlands of Scotland, I contend that it is a most convincing proof of the material having been originally deposited from water, whilst other facts prove quite as conclusively that the present schistose condition was produced by subsequent crystallization. That these conclusions are also borne out by the relations of the rocks on a large scale is shown in the interesting paper by Murchison and Geikie, published in the Society's Journal, vol. xvii. p. 232. The localities in which I have more especially met with this ripple-drift are in the neighbourhood of Arroquhar and of Aberdeen. Along the coast between the latter place and Stonehaven I have seen some most excellent examples with all the characteristic peculiarities, but the rocks are often so much contorted that very complicated appearances have been produced. Such structures are also very well seen in a small quarry between Arroquhar and Tarbat; and were it not that the most complicated cases gradually pass into others sufficiently simple, one might sometimes be induced to abandon all hope of a satisfactory explanation. I must here remark that it is often almost impossible to make out the true structure by examining the rock in its natural state. It should be ground down to a smooth, flat surface, and slightly varnished, when the structure is revealed in a most striking manner. The contortion and compression of the beds have produced very various and curious results. In some cases the small stratula have been greatly contorted, whilst the oblique beds have been but little affected. In others the latter have been much disturbed, and the stratula forced together, so as to be nearly all parallel; but so various and complicated are the relations, that possibly I cannot explain them better than by saying that nearly all the results are met with that could be produced by bending and squeezing bands of ripple-drift in all sorts of positions.

Though specimens ground flat and varnished show the general structure to very great advantage, yet many, more minute particulars can only be learned by preparing thin transparent sections for microscopical examination,—some facts being best seen by using a Wenham's parabolic condenser, and others by reflected or by transmitted light, with or without polarizing apparatus. When the coarser varieties of clay-slate are thus examined, the separate grains of sand, composed of quartz, felspar, or of compound rocks, can be distinctly seen; but very commonly no such grains are visible in the typical varieties of mica-schist. In them the quartz exists as masses of smaller or larger crystals, not bounded by crystalline planes, but mutually interfering, so as to give rise to a very different structure from that of quartzose slates. However, I have lately met with many specimens of typical mica-schist in which the original grains of sand may be distinctly seen, even although the rock has been greatly altered and is quite crystalline. In some cases their being now visible is due to the nature of the surrounding material, which is so slightly quartzose that their outline is well defined; but in other cases it is due to the character of the quartz of the grains of sand being different from that of the quartz subsequently developed in the rock. Thus it often happens that, whilst the quartz of the schist itself is clear and transparent, that of the grains of sand contains many fluid-cavities and minute acicular crystals, and is milk-white or brownish, so that, when seen with a Wenham's condenser, each of the grains has a distinct outline, though surrounded by the clear quartz which has been deposited on them in crystalline continuity. The grains of felspar-sand are in a similar manner surrounded by quartz, near the junction containing granules due to the decomposition of the felspar, which occasionally appears to have been itself metamorphosed into a fine-grained mica-schist. Some of these facts are seen to great advantage in the sericite slate (a kind of green mica-schist), which occurs near Wiesbaden in Germany, and also in the mica-schist of the Highlands of Scotland; and since I first observed them last autumn, I have been surprised to find how frequently they may be seen, when carefully looked for. I scarcely need say that their occurrence in metamorphic rocks is a very important fact, for they show most clearly that mica-schist originally contained grains of sand, and that there has been a subsequent crystallization of quartz throughout the whole rock; whilst other facts prove that there was a crystallization of mica, garnets, felspar, and other minerals, so as to completely alter its original character, and form what we call a metamorphic schist. It appears to me that nothing establishes this more conclusively than the structure of those varieties of mica-schist which possess what I have described as "cleavage-foliation" in papers read before the British Association (Report, Trans. Sects. 1855, p. 96, and 1856, p. 78). I will especially call attention to a thin microscopical section which I have lately prepared of a mica-schist from Muchuls, about ten miles south of Aberdeen, which contains in itself proof of all the leading facts connected with metamorphism. It was originally part of a band of ripple-drift, and therefore the material must have been deposited from a gentle current of water, but has since been completely altered into mica-schist with cleavage-foliation. In ripple-drift in fine-grained sandstones of perfectly unaltered rocks, the small stratula of sand are separated by layers of argillaceous matter, and the bands of stratula are also separated by a similar deposit. These facts readily explain the structure of the ripple-drift in mica-schist; for in those parts where in unaltered rocks we find sand or impure clay, in mica-schist occur bands of quartz or mica, the sandy parts corresponding to the quartzose, and the argillaceous to the micaceous. But this is not all; for the stratula have been greatly disturbed by mechanical forces, have been placed at angles at which they could not possibly have been deposited, and have been bent into contortions that show clearly the direction of the pressure, as will be best understood from the following drawing:—

Fig. 2.—*Contorted "Ripple-drift" in Mica-schist from Muchuls, exhibiting "Cleavage-foliation."* (Magnified 3 diameters.)

The micaceous parts possess a well-marked cleavage-foliation: the crystals of black mica do not lie in the line of the stratula (*b c*), nor in that of the compound bands (*a b, c d*), but have one prevailing direction, as shown in the drawing. Judging from the small contortions, and from the alteration of the inclination of the stratula to the compound bands, which originally cannot have been more than 30°, but is now often as much as 90°, this direction is perpendicular to that of the pressure which produced the disturbance, and, no doubt, developed slaty cleavage in the rock; so that, when subsequently metamorphosed, the crystals of mica were formed with their flat surfaces and cleavage in the plane of the slaty cleavage. In mica-schist which has been contorted since it was metamorphosed and possesses only stratification-foliation, the crystals of mica lie with their flat surfaces in the plane of deposition of each part of the ripple-drift, so that it might be argued that they had been mechanically deposited in that position. In the case of the specimen I am now describing this explanation is, however, quite inadmissible; for the crystals of mica could not possibly have derived their present arrangement from deposition and subsequent mere mechanical disturbance, and must, I contend, have been formed in the midst of the rock by chemical and crystalline action. Hence this one thin section does by itself afford most complete proof of original deposition as a stratified rock, of subsequent compression and the development of slaty cleavage, and of the final alteration into a crystalline schist. As throwing light on this last change, I may here state that I have recently prepared a thin section of mica-schist from the same locality as that just described, which, on the whole, is extremely altered and crystalline. Some parts are solid, clear quartz, and others a mixture of black, green, and white mica and of pink garnets; but mixed up with these highly crystalline portions are others of much finer grain, which, though not having the structure of clay-slate, properly so called, are such a very fine-grained mixture of mica and quartz, that to the naked eye a rock of such a nature might, and perhaps would, be looked upon by many as a clay-slate—at all events it would be extremely analogous to some clay-slates slightly altered by contact with granite. These portions are not small beds interstratified with the very crystalline, but pass into them irregularly along the plane of bedding, just as if the very crystalline parts had been formed out of the fine-grained material which here and there has remained in a comparatively unaltered condition.

From the facts thus briefly described we may, I think, unhesitatingly draw the following general conclusions:—

1. The existence of ripple-drift proves that the material from which the schists were formed was mechanically deposited from water.

2. This material originally contained grains of sand, and was probably a deposit of more or less pure sand and clay.

3. Whatever may have been their original nature, the present highly crystalline structure of the schists was developed after deposition; in some cases, indeed, after mechanical movements had produced complicated contortions and given rise to slaty cleavage.

4. The bands of different minerals represent the planes of original deposition, rendered very distinct by the alteration of thin strata (which in unaltered rocks often differ more in chemical composition than in appearance) into layers of minerals having entirely different physical characters.

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3. *On the* Fossil Corals *of the* West Indian Islands.—Part I.

By P. Martin Duncan, M.B. Lond., F.G.S., &c.

[Plates XIII.–XVI.]

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A. *Preliminary Remarks.*

I. *Introduction.*—This communication was intended to be a description of the Antiguan Fossil Corals in the Collection of the Geological Society; but it has been found necessary to include a notice of those from other West Indian Islands, especially from San Domingo, Montserrat, Jamaica, Barbadoes, Guadaloupe, Barbuda, and Trinidad.

The silicified Corals of Antigua have been well known to the lapidary for many years, and they were brought under the notice of this Society by Dr. Nugent in 1819. His description of the geology of Antigua was accompanied by a beautiful collection of the rocks and fossils of the island; but although it produced some correspondence, and Mr. Guilding forwarded specimens in after-years, no attempt was made to describe or classify the organic remains. Dr. Nugent's gift included some fossil Shells; and as most of them were evidently either of recent or very late Tertiary species, the rest and the *Zoantharia* were unfortunately determined by some good authorities to be specifically identical with the forms now existing in the reefs around the island.

A very superficial examination of the Corals sufficed to prove the fallacy of this view, and by their careful study it was discovered that, as a whole, they had not even a West Indian facies. It thus became necessary to extend the scope of the investigation, and to endeavour to connect the apparently anomalous distribution of the fossil Corals in Antigua with the fossil Coral-fauna of islands whose geology was better known.

The collection of Corals from the limestone and Nivajè shale of San Domingo, which was examined, in 1850, by Mr. Lonsdale, contains forms the study of which resolved the apparent anomaly, as those strata are said to be of the Miocene period.

The admirable papers by Messrs. Moore, Morris, Lonsdale, and Heneken, on the Heneken collection, contain interesting notices of some of the genera of the fossil Corals of San Domingo; but Mr. Lonsdale had not time to devote to their complete study and description; the whole of the specimens, therefore, are described in this communication.

The later Tertiary Corals of Jamaica and San Domingo have also been examined, and will form the subject of a future communication; but the earlier or mid-tertiary specimens, from the hard inclined limestone-beds of Jamaica, which were described years ago by De la Beche, will be noticed now, as well as the few species in the Geological Society's collection from Barbadoes, Barbuda, and Montserrat.

The literature of the fossil Corals of the West Indies is remarkably scanty; and, excepting the results of the Survey of Trinidad by Messrs. Wall and Sawkins*, the papers by Sir Henry De la Beche †

* Report on the Geology of Trinidad; or, Part I. of the West Indian Survey. By G. P. Wall and J. G. Sawkins. 8vo, London, 1860.

† "Remarks on the Geology of Jamaica," Trans. Geol. Soc. 2nd ser. vol. ii. p. 143.

and Mr. Barrett* on Jamaica, and Capt. Nelson's well-known communications†, our exact knowledge of the geology of the islands is equally limited. Mr. Lonsdale's brief notice‡ of the genera of the Nivajè Corals (admitted by himself to be incomplete), Mr. Etheridge's short list of the Trinidad forms §, the notice by MM. Duchassaing and Michelotti of a few species from St. Thomas, Guadaloupe, and St. Croix ||, and the scanty collection of descriptions by MM. Milne-Edwards and Haime¶ include the whole of what has been done amongst these formations, second to none in their interest and great geological importance. A notice of the species already named will be added to those now described for the first time. Amongst the many reasons which might be adduced as explanatory of the neglect of the Corals of these formations, the unsatisfactory state of the classification and nomenclature of the *Zoantharia* stands prominently forward. The paucity of careful descriptions of recent West Indian Corals has evidently rendered unsatisfactory and uncertain their comparison with the forms found in the raised beds; and the condition in which the fossil and semifossil specimens occur renders their identification difficult and, without a careful study of their various forms of silicification, impossible. Both Mr. Parkinson and Dr. Nugent experienced this difficulty, and they warned those who might interest themselves in the description of the Barbadian and Antiguan Corals that the details of their structure were so altered by the peculiarities of their fossilization as to render their specific identification difficult; they both, however, left the matter as they found it. Messrs. Wall, Sawkins, and Etheridge bear testimony to these difficulties, and to the general absence of information about the palæontology of the West Indies.

In investigating the Antiguan Corals, especially, I found it absolutely necessary to study the various methods of their silicification, together with the alterations the specimens had undergone during the process, before I attempted to define the species. Many of the determinations of the structural differences depend upon the correct appreciation of the effects of prefossil wear and tear, and of the results of mineralization. This part of the subject, with a description of the West Indian Tertiaries, I have postponed until the next session, on account of the length of this paper. It is necessary, however, to introduce at once an abstract of, and a few remarks on, Dr. Nugent's "Description of the Geology of Antigua"**.

II. *Geology of Antigua.*—The oldest calcareous formation in Antigua

* "On some Cretaceous Rocks in the South-Eastern Portion of Jamaica," Quart. Journ. Geol. Soc. vol. xvi. p. 324.

† "On the Geology of the Bermudas," Trans. Geol. Soc. 2nd series, vol. v. p. 103; "On the Geology of the Bahamas, and on Coral Formations generally," Quart. Journ. Geol. Soc. vol. ix. p. 200.

‡ "On some Tertiary Deposits in San Domingo, by T. S. Heneken, Esq.; with Notes on the Fossil Shells, by Mr. J. C. Moore; and on the Fossil Corals, by Mr. W. Lonsdale," Quart. Journ. Geol. Soc. vol. ix. p. 115.

§ Report on the Geology of Trinidad, *ut cit.*

|| Mem. Acad. Turin, 2nd series, vol. xix. p. 279, 1861.

¶ Hist. Nat. des Coralliaires. 8vo, Paris, 1857–60.

** Trans. Geol. Soc. 1st series, vol. v. p. 459, 1821.

rests upon a trap-formation about 1400 feet high; it forms hills which are precipitous towards the trap, but have a gradual slope in the opposite direction. It is stratified, and the beds, which dip at a very considerable angle, consist of clays, limestones, and freestones; they are yellow in the last case, and green from the presence of chlorite in the second. The clays contain crystals of felspar; and masses of porphyry, lava, greenstone, and amygdaloid are found throughout the strata generally.

The organic remains consist of Woods, Corals, and Shells, either silicified and fragmentary or, in the case of some Corals, converted into chert-like masses. Two formations rest unconformably on the Inclined Strata, namely, a deep Marl, whose surface is undulating like our chalk-downs, and which forms the superficial structure of the greater part of the Island; and a Chert subordinate to the lowest part of the Marl. The Chert does not rest conformably on the oldest formation, is limited in extent, and has evidently suffered from various wearing causes during the deposition of the Marl. It consists of hard, opaque, white limestone-rock, mixed with portions of coloured stone, and, from its position and organic remains, appears to be an old coral-reef fringing the Inclined Strata. The specimens of Corals occurring in it are siliceous and chert-like in appearance, and the Woods are like those found in the more ancient strata. It is characterized by the presence of extraordinary quantities of "*Cerithia*," which are rarely found in the Marl or in the Inclined Strata*.

The Marl (the third formation), although its surface has suffered greatly from denudation, reaches, nevertheless, to the height of nearly 400 feet above the level of the sea, and consists of various more or less compact limestones, white and yellow marls, and freestone, and contains vast quantities of Corals in different conditions of fossilization. No fossil Wood is found in it, and the little chert with *Cerithia*, occasionally met with, has evidently been broken off the chert-rock and become intermixed. Agates, flints in great variety of form and colour, calcareous concretions, and silicified Shells and their casts are very common, and three or four kinds of *Helix* also. Moreover, there are traces of bitumen. The depth of the Marl, below the sea-level, is not known; but recent coral-reefs fringe the low cliffs and outliers.

The specimens in the Collection of the Society are derived from

1. The Inclined Strata, or Conglomerate; 2. The Chert; 3. The lower, middle, and upper parts of the Marl.

Both the Inclined Strata and the Chert contain extraordinary quantities of silicified Wood; and their Corals, which are also silicified, are often more or less rolled, and are found as agate mixed with crystalline quartz, or are turned into opal; they present imperfect calicular surfaces, but often consist of siliceous casts. The compound Corals are all of great beauty, and Dr. Nugent identified them invariably by their small patterns and chert-like appearance.

The Marl contains no Wood, and its Mollusca are not identical with those of the Chert; and many species of *Zoantharia* also occur in it

* The so-called "*Cerithia*" probably belong to the genus *Melania*.

in the same state of preservation as the Shells sent over by Dr. Nugent. Those which I have examined are principally gigantic Astræans, covered with casts of their calices, and presenting every variety of fossilization, from perfect universal silicification to imperfect silicification of the original hard tissues and filling up of the interstices with granular carbonate of lime. They are less perfectly silicified than in the other strata, are usually of a yellow-ochre colour externally, and are remarkable for their luxuriant growth. Some terrestrial Shells are found in the Marl, and the Corals, generally, are more or less affected by the matrix in which they were imbedded. The Inclined Strata appear to have been Coral-formations of no very great luxuriance; and their partial and irregular upheaval by the trap was previous to the formation of the unconformable Chert, which is in the exact position of a fringing reef. The Chert, as far as can be determined from the Corals, was formed under external circumstances not very different from those under which the Inclined Beds were deposited; both contain fossil Woods in great quantity. The Marl, formed as a reef around the Inclined Beds during times of considerable variation of level, quite surrounds the Chert, and is found above, below, and outside it. Fragments of the Chert are found in the Marl, which has also suffered greatly from denudation. There is no Wood in the latter formation, and the Corals are luxuriant and gigantic. Here there are evidences of a change in the external circumstances which affect coral-growth—probably the absence of the current which carried down the trees whose fragments, often many feet long, are found mixed with the Corals of the older beds.

The Corals of the Marl are closely allied to some of those in the older beds. Here are three consecutive coral-formations, furnishing the support for the growth of existing reefs, and evidently developed according to the same processes now in action in the surrounding sea.

B. *Enumeration of the Species.*

I. From Antigua.

a. *From the Marl.*

1*a*. Astræa crassolamellata, sp. nov.
1*b*. —— ——, var. magnetica.
1*c*. —— ——, var. pulchella.
1*d*. —— ——, var. nobilis.
1*e*. —— ——, var. minor.
1*f*. —— ——, var. Nugenti.
1*g*. —— ——, var. magnifica.
3. —— Antiguensis, sp. nov.
4. —— endothecata, sp. nov.†, varr. 1, 2, 3.
6. Astræa tenuis, sp. nov.
7. —— Barbadensis**, sp. nov.
8. —— radiata, *Lamarck*, var. intermedia.
9. —— costata, sp. nov.
20. Rhodaræa irregularis, sp. nov.
21*a*. Alveopora Dædalæa, *Blainville*, var. regularis*.
22. —— microscopica, sp. nov.
23. —— fenestrata, *Dana*†.

* Common to the Chert and the Marl.
† Common to St. Domingo and Antigua.
** Common to Barbadoes and Antigua.

b. *From the Chert.*

2 *b*. Astræa cellulosa, var. curvata, sp. nov.
5. —— megalaxona, sp. nov.
10. Solenastræa Turonensis, *Michelin.*
11. Isastræa conferta, sp. nov.
12. —— turbinata, sp. nov.
13. Stephanocœnia tenuis, sp. nov.‡
15. Cœloria dens-elephantis, sp. nov.
16. Astroria polygonalis, sp. nov.
17. —— affinis, sp. nov.
18. —— Antiguensis, sp. nov.
19. Astrocœnia ornata, *Edwards & Haime.*
21 *a*. Alveopora Dædalæa, *Blainville*, var. regularis *§.
21 *b*. —— ——, var. minor.

c. *From the Inclined Beds, or the Conglomerate.*

2 *a*. Astræa cellulosa, sp. nov.
13. Stephanocœnia tenuis, sp. nov.‡
14. Meandrina, sp.

II. From the Nivaje Shale, superficial Limestone, Postrero and Esperanza Shales of San Domingo.

1. Brachycyathus Henekeni, sp. nov.
2. Placocyathus Barretti, sp. nov.‖, varr. 1, 2.
3. Trochocyathus cornucopia, *Edwards & Haime.*
4. Placotrochus Lonsdalei, sp. nov.
5. Flabellum dubium, sp. nov.
6. ——, sp. nov.
7. Thysanus corbicula, gen. et sp. nov.
8. Barysmilia intermedia, sp. nov.
9. Dichocœnia tuberosa, sp. nov.
10. Stephanocœnia dendroidea, *Edwards & Haime.*
11. Phyllocœnia sculpta, *Edwards & Haime*, var. tegula.
12. —— limbata, sp. nov.
13. Montlivaltia ponderosa, *Edwards & Haime.*
14. Mæandrina filograna, *Lamarck.*
15. Astræa (Heliastræa, *Edwards*) endothecata†, sp. nov.
16. —— (Heliastræa, *Edwards*) cylindrica, sp. nov.
17. Siderastræa crenulata, *Blainville*, var. Antillarum.
18. Cyphastræa costata, sp. nov.¶
19*a*. Stylophora affinis, sp. nov.
19*b*. —— ——, var. minor.
20. Agaricia agaricites, *Lamarck.*
21. —— undata, *Lamarck*, var.
22. Alveopora fenestrata, *Dana*†.
23. Porites Collegniana, *Michelin.*

III. From the Jamaica Tertiary Limestones.

1. Placocyathus Barretti, sp. nov.‖
2. Placotrochus alveolus, sp. nov.
3. Thysanus excentricus, sp. nov.
4. Astrocœnia decaphylla, *Edwards & Haime.*
5. Siderastræa grandis, sp. nov.
6. Cyphastræa costata, sp. nov.¶
7. Montlivaltia ponderosa ‖, *Edwards & Haime.*
8. Astræinæ dendroidæ.
9. Alveopora Dædalæa, *Blainville*, var. regularis §.
10. Porites, sp.

IV. Montserrat.

1. Astræa Antillarum, sp. nov.

V. Barbuda.

1. Cyphastræa costata¶, sp. nov.

VI. Barbadoes.

1. Astræa Barbadensis**, sp. nov.
2. Oculina, sp.
3. Madrepora, sp.

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‡ Common to the Conglomerate and the Chert.
§ Common to Jamaica and Antigua.
‖ Common to San Domingo and Jamaica.
¶ Common to San Domingo, Jamaica, and Barbuda.
** Common to Barbadoes and Antigua.

VII. Trinidad (Etheridge) *.

1. Turbinolia, two species.
2. Astræa (Orbicella, *Dana*) Argus, *Lam.*
3. —— radiata, *Lam.*
4. Orbicella coronata, *Dana.*
5. —— stelligera, *Dana.*
6. —— Pleiades, *Dana.*

VIII. Guadaloupe, St. Thomas, St. Croix.

1. Cyathina Guadalupensis, *Edwards & Haime.*
2. Paterocyathus Guadalupensis, *Duchassaing & Michelotti.*
3. Trochosmilia Laurenti, *Duchassaing & Michelotti.*
4. —— gracilis, *Duchassaing & Michelotti.*
5. Parasmilia nutans, *Duchassaing & Michelotti.*
6. Montlivaltia ponderosa, *Edwards & Haime.*
7. Solenastræa Ellisii ?, *Duchassaing & Michelotti.*
8. Favosites Dietzi, (St. Croix,) *Duchassaing & Michelotti.*

C. *Description of the Species.*

I. Antigua.

1. Astræa crassolamellata, spec. nov. † Pl. XIII. figs. 1–7.

General Description.—A group of forms from the Marl presents the following structural characteristics : — Corallum very massive and large, with an irregular upper surface, which is convex in some parts, almost flat in others, and more or less largely gibbous in all ; intercalicular groove very decided. Corallites usually very large, and never very small. Wall very delicate and indistinct ; costæ small ; columella large. Septa variable in cyclical arrangement, the larger excessively developed at the wall and linear within. Endotheca abundant, but not in excess, vesicular. Exotheca not well developed, but decided and plentiful. Calices invariably found as casts : impressions prove them to have been shallow. Cœnenchyma well developed.

These characters, common to many forms, are more or less varied in intensity in different specimens. The septal number varies in individuals of the same corallum, in one series of forms to a remarkable extent, although the corallites thus differing are nearly equal in diameter, and are nearly, if not quite, as advanced in development. In other forms it is fixed to four cycles in six systems ;

* The fossil Corals from the newer Parian Formation of Trinidad were described under the above names, by Mr. Etheridge, in Wall & Sawkins's 'Geology of Trinidad.' They were all greatly altered by fossilization.

† The genus *Astræa* of Lamarck contained forms subsequently referred to *Siderastræa* by Blainville, as well as those included in the genus *Astræa* by Milne-Edwards & Haime in their earlier contributions to the Académie des Sciences Naturelles, and in the "Introduction to the Classification of the *Zoantharia*," prefixed to their 'British Fossil Corals,' published by the Palæontographical Society. In the 'Histoire Naturelle des Coralliaires' by Milne-Edwards & Haime (1857), their genus *Astræa* appears as *Heliastræa*, and Blainville's genus *Siderastræa* as *Astræa*. I have retained the nomenclature recognized amongst British palæontologists, feeling assured that MM. Milne-Edwards & Haime have so influenced the successful study of Corals by their earlier works that their original generic terms will remain in use. Also, instead of their new application of the generic term *Caryophyllia* to *Cyathina*, I retain the latter as they originally gave it.

whilst in some there are three cycles in some systems, and only two in others, the corallum being large.

The form which I consider typical of the species has four perfect cycles in six systems; but in some corallites the rudimentary sixth and seventh orders of a fifth cycle exist. The specific characteristics—the thick and great development of the septal laminæ at their wall-end, and the more or less linear, but entire, condition of their internal parts—are seen in all these forms, in the primary, secondary, and tertiary septa, according to the relative septal arrangements. In some corallites with a low septal number, the primary septa alone are thus characterized; and as the higher cycles are seen, so the secondary and tertiary septa become enlarged and resemble the primary. The septa of the higher orders are either linear throughout or slightly enlarged at the wall; and as they approach the tertiary or quaternary, as the case may be, they are seen to become more equal to them in size. In examining these forms allowance must be made for their fossil condition; and attention must be given, in examining transverse sections of corallites, that they are quite at right angles to the corallite, for any obliquity will, of course, diminish the peculiar spear-shape or mace-shape of the septa, and render them more like a paddle, or a leaf with the stalk attached.

The tendency of the higher orders of septa to become linear throughout, or to be less decidedly large at one end and thin elsewhere—that is, more or less uniformly thick, but in a less degree than is usual at the wall,—is seen throughout the species; and in a gigantic variety, where the fully developed corallites have twelve or fourteen septa in every system, the whole of the septa are less decidedly thick at the wall, and are either more or less so throughout, or present the usual form of the septa in a modified degree.

This species is found throughout the great Marl-formation, and presents every variety of siliceous fossilization, from that characterized by silicification of the sclerenchyma and infiltration of the interspaces by granular carbonate of lime, to that where all is siliceous and capable of polish. Destructive silicification almost invariably exists in a greater or less degree; and as the sections preserved were made, as a rule, for ornament or amusement, I have seldom seen accurately transverse and longitudinal views of the corallites.

All the specimens, with the specific peculiarities mentioned, may be ranged in seven groups: that which contains the detailed characters in their greatest intensity, generally, may be considered the typical form.

a. Astræa crassolamellata, typical form. Pl. XIII. figs. 1 *a*–1 *c*.

Corallum large, irregularly convex above. Corallites tall, large, crowded here and there, but not so much so higher up or at the surface. Calices circular, but more or less elliptical when on an irregularity of the surface; very large, and separated from each other by well-marked, furrow-shaped, polygonal tracts; tracts marked by costal elevations and by granules*. Calices crateriform, not much

* As none of the specimens exhibit perfect calices, many of these characters have, of necessity, been taken from casts.

elevated above the surface. Wall thin, and rendered insignificant by the great development of the septa at the margin. Fossa not deep. Costæ numerous, and, considering the diameter of the septa at the wall, very small; they project but little, and are, as a rule, alternately large and small, not dentate, and often incline one to the other at their free edge. The larger costæ present regular enlargements

Analysis of the Species.

	Intercalicular furrow.	Septa.	Cycles.	Diameter of corallites.
a. Astræa crassolamellata (type).	well marked	very thick at wall	4, in some 5	$\frac{3}{4}$–$\frac{4}{5}$ inch
b. ——— ———, var. magnetica ...	well marked		4	$\frac{1}{2}$ inch
c. ——— ———, var. pulchella ...			variable	$\frac{1}{3}$–$\frac{1}{2}$ inch
d. ——— ———, var. nobilis	less well marked	very large at wall	variable	variable
e. ——— ———, var. minor		very thick at wall	2 and 3	small, variable
f. ——— ———, var. Nugenti	less marked			
g. ——— ———, var. magnifica ...	well marked	less thick and more linear	4–6	$\frac{1}{3}$ inch 1 inch and more

where the cross-tissue (dissepiments) of the exotheca joins them: when there are more than four cycles of septa, the smaller costæ are irregular as regards their appearance and development. Columella large, of lax laminæ, parietal; it does not project much at the bottom of the fossa, and occupies a large space in the corallite. Septa numerous, generally characterized by great enlargement at the wall, and linear appearance in the rest of their course, the higher orders being nearly linear at the wall also. The number of cycles varies with the stage of development of the corallite.

In young corallites there are six systems of three cycles. As growth proceeds, the other orders of the fourth and sometimes of the fifth cycle are gradually added. Some systems are defective in certain orders, while others possess them. The largest corallites have four perfect cycles, and a fifth in two or three systems; the ninth order being usually wanting. It is difficult, in the larger corallites, to distinguish the systems on account of the resemblance of the primary, secondary, and tertiary septa to each other.

The primary septa are very thick externally, but delicate and linear elsewhere; the linear part joins the rest suddenly, like the staff of a big-headed spear; at the junction the thick corners of the enlargement give off a lateral spine, like a piece of endotheca; near the costal end of the septa there are delicate lateral spines. The space between the sets of lateral spines is more or less square. The secondary septa are very like the primary.

When there are more orders in the system than five, that is, when there are six, seven, eight, and nine, the tertiary septa equal the primary and secondary, the blunt end terminating in the linear portion a little nearer the wall. When there are four cycles, the tertiary septa are smaller than the primary and secondary; and when there are only three cycles, as in young corallites, the tertiary septa are linear throughout. The quaternary septa are linear and very slightly developed; when there are more septa than those of the fourth cycle, the quaternary resemble small tertiary septa. The remaining septa are very small and linear, and reach a very little way from the wall; they are apt to curve towards the septa nearest them. In examining the shape of the septa in this and in all the allied forms, particular attention must be paid that the section is quite transverse, as any obliquity will more or less alter the shape of the larger end.

As regards the endotheca, the dissepiments are frequent and delicate, and not very much developed. The exotheca is tolerably well developed, but not in proportion to the size of the corallites. Its dissepiments form square cells. The free surface between the costæ and calices has a few granules. Increase by extra-calicular gemmation.

Marl-formation of Antigua. Coll. Geol. Soc.

Measurements.—Diameter of the calices in six specimens $\frac{3}{4}$ inch, in seven others $\frac{4}{5}$ inch, and in some from $\frac{1}{2}$ to $\frac{1}{4}$ inch. The elliptical calices (situated on the sides of the corallum) are about $1\frac{1}{10}$ inch in longest diameter. The greatest thickness of the septa at the wall is $\frac{1}{10}$ inch. Columella $\frac{1}{5}$ inch in diameter.

No recent specimens of this species have as yet been found, and its alliances are with *Astræa Lifolensis*, Edwards and Haime*, and *Astræa Guettardi*, Edwards and Haime†. The latter species includes also the *Astræa nobilis*, Edwards and Haime; it has a polygonal furrow around the calices, shallow fossæ, septa excessively thick at the wall, and indistinct walls. It has also smaller corallites than the type of the new species, but larger than some of the varieties; but its costæ being strong, very close, and alternately very thick and thin, constitutes a specific distinction.

A specimen of *Astræa Lifolensis* (Jurassic) in the British Museum has stronger resemblances to the West Indian forms than has *A. Guettardi* (Miocene). The general form of the fourth variety (var. *nobilis*) differs much from that of *A. Lifolensis*, although there is a great resemblance in their details. The costæ furnish, however, a specific difference; still the alliance is extremely close.

b. Var. MAGNETICA. Pl. XIII. figs. 4 *a*, 4 *b*.

A magnificent Astræan, resembling the typical form, but having no more than four cycles of septa. The septa are very marked, very large at the wall, and resemble the printed radii on a mariner's compass-card. Cœnenchyma greatly developed. The diameter of the corallites is from $\frac{1}{3}$ to $\frac{1}{2}$ inch, being very variable.

Marl-formation of Antigua. Coll. Geol. Soc.

c. Var. PULCHELLA.

Corallum large, convex, irregular in superficial outline. Corallites tall, varying in diameter on account of the mode of growth, rather crowded at the surface, circular in transverse section, with abundant cœnenchyma. Costæ wide apart. Calices rather crowded, and the

* Polyp. Foss. des Terr. Palæoz., 1851, p. 98. † *Op. cit.* p. 97.

intercalicular furrow not so distinct as in the typical form of the species. Diameter from $\frac{1}{3}$ to $\frac{1}{2}$ inch. Septa large at the margin, more or less thin elsewhere; in six systems with a very irregular septal distribution. In young corallites there are two cycles, and a third in two systems (eight large septa). In larger corallites there are three cycles in four systems, and two in the rest (ten large septa). In the largest there are three cycles in all systems but one (eleven large septa). In some large corallites a fourth cycle evidently existed near the calicular margin.

In some specimens the marginal enlargement of the septa is rendered less distinct by rather thick and not very linear septal development internally. The corallum is too large to admit of all the corallites being badly developed, except those with four cycles; and the expression of its septal number must be three cycles, the third being occasionally wanting in some systems, and four cycles being the extreme range. The variability in the septal number is very characteristic of this variety. The exothecal dissepiments are abundant, and bifurcate here and there.

Marl-formation of Antigua. Coll. Geol. Soc.

d. Var. NOBILIS. Pl. XIII. figs. 2 *a*, 2 *b*.

Corallum large, irregularly convex, and gibbous above. Corallites distinct, circular in transverse section, varying in size; cœnenchyma well developed. Septa very large at the wall, linear within, number of large-headed septa remarkable; primary, secondary, and tertiary septa often equally large. Calices varying in size. Septal number from three to four cycles. This form is between the varieties *magnetica* and *pulchella*. Coll. Geol. Soc.

e. Var. MINOR. Pl. XIII. fig. 6.

Corallites tall, slender, crowded, distinct; walls circular, not thick. Calices circular, somewhat variable in size; the largest is $\frac{3}{10}$ inch in diameter. The larger septa are spear-shaped, the smaller linear; they are in six systems of two cycles; rarely three cycles in two systems in some corallites. Primary septa much larger than the secondary, but nearly equalling them when there is a third cycle. Columella large.

The alternate large and small, spear-shaped and linear septa are very well seen in this form. The same details as in this form are found in several specimens with larger corallites.

Marl-formation of Antigua. Coll. Geol. Soc., and Mr. W. W. Jones's Coll.

f. Var. NUGENTI. Pl. XIII. fig. 5.

The specimen upon which this variety is founded has no calices, but the transverse views of the corallites are very distinct.

Corallites $\frac{1}{3}$ inch in diameter, not crowded. Septa in six systems, two cycles in four systems and three in the other two. The tertiary orders are small, and often join the secondary near the columella. The primary septa are square and large at the wall, and not very linear, but staff-shaped within; their width at the margin is $\frac{1}{15}$ inch. The secondary septa are very much smaller and thinner than the primary, but nearly as large when the tertiary orders are present.

Costæ wide apart. Exothecal cells scalariform, wider than high; from $\frac{1}{30}$ to $\frac{1}{60}$ inch high, and $\frac{1}{15}$ inch long. Endotheca abundant.

This form has squarer-headed septa, longer exothecal cells, costæ wider apart, and a lower septal number than many of the forms of the species; and differs from the forms with three more or less incomplete septal cycles in the greater thickness of the inner part of the septal laminæ, the broad exothecal cells, and in the disposition of the tertiary septa to join the secondary.

From the lithological character of the specimen thus described (Coll. Geol. Soc.), it is either from the Chert-formation of Antigua or from the lower part of the Marl.

g. Var. MAGNIFICA. Pl. XIII. fig. 3.

In the smaller corallites of this variety the spear-shaped septa are seen; but in the larger, where there are from twelve to fourteen septa in a system, the primary, secondary, and tertiary orders are nearly equal in size. They have lost the extreme relative thickness between their extremities, and, although still very thin at the columella, they are not greatly developed at the wall. In some corallites the septa, in transverse view, are not straight, but form curving radii*; and in all, the relation which the septa bear to the interseptal spaces and to the wall is very much exaggerated.

Corallites circular in transverse section; they vary much in diameter, and are now and then crowded, but generally have much cœnenchyma between them. The diameters of five corallites are as follows:—$\frac{5}{6}$ inch, $\frac{2}{3}$ inch, 1 inch, $1\frac{1}{10}$ inch, $\frac{1}{2}$ inch. Walls very indistinct. Costæ small, and appearing to be appended to all the septa. Exotheca is present, and connects the costæ. Septa numerous, especially in large corallites, where the cycles, which are small and rudimentary in the lesser, become well developed. In the smallest corallites there are six systems of four cycles, the fourth and eighth orders being very small. In medium-sized corallites there are six systems, four cycles in five systems, and in the sixth there are the rudimentary sixth, seventh, and eighth orders. The first, second, and third orders are nearly equal in size. In the largest there are six systems, and from twelve to fourteen septa in every system. Lateral teeth exist on all the primary septa at the place of greatest width. The higher orders in every system are very linear. Endotheca abundant, but not in excess. Columella large, well developed, and spongy. Cœnenchyma formed of cells produced by the costæ and the exothecal dissepiments.

This is the largest form of compound Astræan yet described, and when in mass must present a very striking appearance; unfortunately no calices have been discovered as yet. Reproduction by extra-calicular budding.

Marl-formation of Antigua. Coll. Geol. Soc., Mus. Pract. Geol., and British Museum.

2 *a*. ASTRÆA CELLULOSA, spec. nov., typical form. Pl. XIII. fig. 10.

Corallum tall, and, judging from the disposition of the corallites,

* See a specimen in the Mus. Pract. Geol. Lond.

subplane above. Corallites very numerous, tall, slender, crowded, but distinct; usually cylindrical, but sometimes more or less prismatic from mutual pressure; varying in size. The transverse section of the corallites is generally circular, now and then deformed. Septa crowded, linear; the primary are the largest, but often the secondary are nearly as large. The primary septa are of nearly the same thickness at the wall and throughout. There are six systems of four cycles; in imperfectly developed systems the fourth cycle is wanting, but the persistence of this cycle throughout all the systems is very generally decided. The fourth and fifth orders are very small, and when there are only three cycles, the third order is small; the septa are generally straight. Columella small and slightly developed. The wall appears to be stout. Costæ attached to every septum, subequal, and not very greatly developed. Endotheca vesicular, greatly developed. There are often four dissepiments dividing each interseptal space. Exotheca cellular and highly developed; exothecal cells small, more rectangular and larger than the endothecal cells. The reproduction is by extra-calicular gemmation; the smallest buds visible have three perfect cycles of septa.

From the Conglomerate of Antigua. Coll. Geol. Soc.

Dimensions.—Height of corallum several inches. Diameter of corallites from 1–2 lines.

The minute details of the structure of this Coral have disappeared; but the brilliant porcellanous silica which fills up the interseptal loculi and the exothecal cells is so easily distinguished from the dull colourless remains of the septa, dissepiments, and walls, that the characters described are easily seen in the specimens. In some parts of the specimens the sclerenchyma is whitish grey, and the interspaces are filled with dark homogeneous silica, just reversing the arrangement generally observed.

The intimate relation between this form and one from a later formation (the Chert) is very interesting. The latter (var. *curvata*) has the teeth on the septa preserved; and the septa of the third order curve towards those of the second near the columella. It has all the other structural peculiarities of the older form, and is clearly a variety; for here and there, amongst the numerous individuals of the masses from the Inclined Strata, the septa of the third order are now and then seen to curve towards those of the second.

2 *b*. Var. CURVATA.

Corallites slender, long, close, sometimes compressed; circular in transverse section, except when compressed. Walls thin and delicate. Costæ delicate, unequal, narrow at the base, tapering externally. Septa well developed, in six systems of four complete cycles. The primary septa are large, toothed on either side, not larger at any one point than at another. The secondary septa are smaller than the primary, and have a tooth near the columella. The tertiary are smaller than the secondary, vary much in size, often extend nearly up to the columella, and curve there towards the latter; they have lateral teeth, and a larger tooth at the end; or they reach only halfway, being either straight or curved. The quaternary septa have wedge-shaped bases and spike-like prolongations, extend one-quarter the distance to the columella, and sometimes curve towards the tertiary. Columella lax and parietal. Endotheca greatly developed, subdividing the septal loculi by transverse bars. Exotheca distinct, cells small.

Dimensions.—Diameter of the corallites $\frac{1}{5}$ inch; a bud 1 line in diameter has three cycles.

Chert-formation of Antigua. Coll. Geol. Soc. As a rule, this variety is curiously fossilized.

3. Astræa Antiguensis, spec. nov. Pl. XIII. fig. 8.

Corallum large, turbinate, convex and gibbous above, with a very small base. Corallites long, close, rather crowded, but distinct and radiating from the narrow base. Walls well developed, moderately thick. Costæ moderately developed, projecting more than the width of their base; they are plain where seen superficially, very nearly equal, and are not spined or toothed. In some corallites the fourth cycle of costæ is wanting, but not in those that are fully developed. Calices circular, slightly raised, appearing as truncated cones, sometimes compressed (at the side of the corallum they are distorted), unequal in size; margin thin. Fossa not deep, but variable. Columella well developed, projecting at the bottom of the fossa; its component tissue is laminar and folded, and it is rounded above. Septa straight, very slightly exsert, delicate throughout, not larger at any point decidedly; but the largest are more delicate midway between the walls and the columella; they are arranged in six systems of four cycles. The primary and secondary septa are equal; the tertiary a little smaller; those of the fourth order are very small, and barely developed in some calices, but they exist in all. The primary and secondary septa have a tooth near the columella. Endotheca tolerably developed. Exotheca well developed, forming large and small cells, both square, though often divided by dissepiments. Reproduction by extra-calicular gemmation. There is no epitheca.

Dimensions.—Height of corallum several inches; diameter of calices from a little less than 3 lines to 4; thickness of septa $\frac{1}{60}$ inch. The dimensions of the elliptical calices are—length $3\frac{1}{2}$ lines, breadth $2\frac{1}{2}$ lines, depth of fossa $\frac{2}{3}$ line. Exothecal cells from $\frac{1}{4}$ to $\frac{1}{2}$ line. The lateral calices are very irregular, and the younger corallites have three cycles of septa.

Fossilization.—Calices, as a rule, not filled up. Sclerenchyma light-brown in colour, opaque, and siliceous, the central portions of the corallum evidently consisting of dark homogeneous flint, the sclerenchyma having been destroyed in the process of silicification.

From the Marl-formation of Antigua. Coll. Geol. Soc.

4. Astræa endothecata, spec. nov.*, var. 1. Pl. XIV. fig. 9.

Corallum tall, without radiating corallites, subplane above. Coral-

* See also p. 434, amongst the Corals from San Domingo.

lites crowded, cylindrical, distinct, very long. Costæ subequal, large; those of the fourth order sometimes wanting. Calices circular, from $\frac{3}{10}$ to $\frac{4}{10}$ inch in diameter. Septa very delicate, very crowded, nearly linear, granular. Endotheca greatly developed, vesicular, with from three to four dissepiments between the septa, dividing the loculi into compartments. The fourth cycle of septa appears often to reach one of these dissepiments, and to end by touching it. Columella well developed.

From the lower part of the Marl-formation of Antigua. Coll. Geol. Soc.

This is a variety characterized by a larger amount of endotheca and a smaller amount of exotheca than in the typical form.

Var. 2.

A variety with the specific details of the typical form, and in addition an increased amount of exotheca, whose cells are broader than high, the dissepiments being well developed.

From the lower part of the Marl-formation of Antigua. Coll. Geol. Soc.

Var. 3.

A variety with smaller corallites, longer and more crowded delicate septa, with the endotheca greatly developed, the dessepiments being very stout.

From the calcareous beds in the lower part of the Marl-formation of Antigua. Coll. Geol. Soc.

5. Astræa megalaxona, spec. nov. Pl. XIII. figs. 12 *a*, 12 *b*.

Corallum large. Corallites very numerous, crowded, very variable in breadth, long and slender; they have suffered much from mutual pressure, and although the walls are distinct, yet the corallites are often more or less polygonal; diameter from $\frac{1}{8}$ to $\frac{1}{5}$ inch. Walls thin. Costæ small. Septa very delicate, a little thicker at the wall than elsewhere, and very thin towards the columella; in six systems, the cycles varying greatly; thus, in many corallites there are two cycles, in others two cycles and a third in one or more systems. Three perfect cycles are seen in large corallites, and two additional septa in some (in the whole corallite). The primary septa have a tooth near the wall; the secondary are a little smaller than the primary. Columella lax, parietal, occupying a very large space.

The details can be made out in only one corallite, which has escaped the ruinous but remarkable fossilization that has destroyed them in most of the specimens. The details have nearly all disappeared in the mass, and the interseptal loculi look like blunt, thick septa. In some specimens the large space occupied by the columella is filled with silica of a white or of a black colour, giving them a very curious appearance.

There are many corallites which appear to have been undergoing fissiparous growth, but it is evident that extra-calicular gemmation also occurred. There are few details left for a diagnosis of the species. The recent *Astræa Pleiades*, a Pacific form, is the only known species with a low septal number and fissiparous growth; it differs from that just described in its costal arrangement, but is more closely allied to it than to any other Coral.

From the Chert-formation of Antigua. Coll. Geol. Soc.

6. Astræa tenuis, spec. nov. Pl. XIII. fig. 11.

Corallites close, generally cylindrical, but sometimes deformed by pressure. Walls slender, distinct. Costæ distinct, small, subequal, well separated, sometimes inclined laterally; edges sharp. Columella lax, badly developed, formed of trabeculæ passing from the ends of the septa. Septa thin, close, slender, a little thicker at the wall than elsewhere, and a little larger at the columella than in the middle; they appear to have had a large tooth near the columella, and are arranged in six systems, the cycles being very variable. Unfortunately I have not seen any calices, and fully developed corallites are also wanting. The following are the arrangements of the septa in the corallites I have seen:—In one corallite there are thirty septa, or three cycles, in four systems, a fourth cycle in one system, and fourth and fifth orders in half a system; in a second corallite the same; in a third, with thirty-two septa, there are three cycles in four systems, and four cycles in the other two. In a fourth corallite there are thirty-four septa, or three cycles in three systems, four cycles in two, and fourth and fifth orders in half a system. The primary septa are slightly thicker and more toothed than the secondary; and the latter are more developed than the tertiary, which are rudimentary except when there is a fourth cycle, and then they are as large as the secondary. The fourth and fifth orders often curve towards the third. Doubtless, in well-developed corallites, the fourth cycle is perfect in all the systems, being now and then wanting in the half of certain systems. Endotheca absorbed during fossilization. Exotheca exists as cells between the costæ.

From the Marl-formation of Antigua. Coll. Geol. Soc. Diameter of the corallites about 2 lines, a little more or less.

7. Astræa Barbadensis*, spec. nov. Pl. XV. figs. 6 *a*, 6 *b*.

This Astræan is found in the Marl-formation of Antigua, greatly altered by fossilization; the calicular surface is subplane, and the calices are seen as prominent columnar casts. Coll. Geol. Soc.

8. Astræa radiata, Lamarck, var. intermedia.

To this variety I refer certain corals presenting the specific distinctions of *Astræa radiata*, but having the third cycle of septa complete, and a little excess of vesicular endotheca. The specimens are remarkable for their varieties of fossilization, the presence of crystalline quartz, as well as homogeneous flint, being common inside the corallites. The variety forms a link between the great Astræans of the Miocene of the Antilles and the existing *Astræa radiata* of the Caribbean Sea, *Astræa Antillarum* being closely allied to it.

* See also the Barbadian Corals, pp. 444 & 445.

From the Upper Parian of Trinidad (Wall & Sawkins's Coll.), and the Marl-formation of Antigua. Coll. Geol. Soc.

9. Astræa costata, spec. nov. Pl. XIII. fig. 9.

The specimens of this species which I have examined present polished longitudinal and transverse sections of corallites, but I have seen no calices. Corallites long, parallel, sometimes deformed, generally circular in transverse outline, not crowded, but close, varying in size. Intercorallite spaces very distinct. Walls thin, not thicker than the delicate septa. Costæ large alternately, both sizes equally produced; wedge-shaped at the wall, pointed, and often bent at the free end. Septa all delicate and linear near the columella and in the middle; at the wall their base is narrower than that of the costæ. They are arranged in six systems, the cycles being very irregular. In three systems there are three cycles, and in the rest an incomplete fourth; rarely there are two systems with four complete cycles; the fourth and fifth orders often curve towards the third order. Lamellæ rather cribriform, joining the columella by oblique processes. Columella lax, small, and formed by dissepiments from the septa and a central spongy mass. Endotheca very abundant, vesicular, and horizontal, with four or five dissepiments in $\frac{1}{10}$ inch. Exotheca abundant, nearly equal to the endotheca. Reproduction by extra-calicular budding. Diameter of the corallites from $\frac{3}{10}$ to $\frac{7}{20}$ inch.

This species is closely allied to the Astræans with great endothecal development, and especially to *Astræa vesiculosa*, Edwards and Haime, from Dax, as well as to *A. Antillarum*, nob., and *A. endothecata*, nob.

10. Solenastræa Turonensis, Michelin.

Some imperfect specimens of this species from Antigua are contained in the collection of the Geological Society, but they add nothing to our knowledge of the species.

11. Isastræa conferta, spec. nov. Pl. XIV. fig. 2.

Corallites very close, tall, slender, straight, and prismatic; a transverse section shows the wall to be very thin. The breadth of the corallites varies from $\frac{3}{10}$ to $\frac{1}{10}$ inch. Septa very numerous, linear; the primary extend to the centre of the corallite, the secondary less so, and the others join the larger septa at a very acute angle; all are very slender and excessively crowded. There are eighty-two septa in the larger corallites, sixty in the smaller. The septa of one corallite do not join those of the next, but end sharply at the wall. Endotheca plainly exists, linear, appearing, in transverse section, to divide the interseptal loculi into several cells. The reproduction is by submarginal budding. The sclerenchyma has been replaced by dark homogeneous silica, and the interspaces by porcellanous and opaline silica.

From the Chert-formation of Antigua. Coll. Geol. Soc.

This is a very remarkable form. Unfortunately no calices exist;

but the transverse view of the corallites is excellent. If the specimen had been found in Oolitic rocks, it would have passed for a small variety of *Isastræa tenuistriata.*

12. Isastræa turbinata, spec. nov. Pl. XIV. figs. 1 *a*–1 *c*.

Corallum 7 inches high, subplane and irregularly convex above, broad and gibbous at the sides, small and conical at the base, whence the corallites radiate; upper surface ridged with the elevated margins of more or less polygonal, close calices. Corallites very long, slender, and prismatic, excessively crowded. Walls united, simple throughout. Calices very numerous, irregularly pentagonal, not deep, and not packed geometrically. Margins existing as sharp ridges, not marked by the septa, but faintly ragged; united, crowded, not deep. Septa small, not exsert, not arched, but slanting irregularly downwards and inwards, except the primary, which stand up in the fossa, and are easily seen; they are laminar, delicate, and crowded, slightly toothed near the internal end, ragged above, and granular on the sides. The primary septa sometimes meet by their inner ends; the secondary and tertiary are subequal when there are others. They are disposed in six systems. In fully developed calices there are four cycles in four systems, and three in the rest; in other calices three cycles with an occasional fourth order; the fourth cycle is very small. Septa straight, not crenulate, but slightly ragged; no external spines. Endotheca tolerably developed. From the condition of the base, which has been rolled, no epitheca can be seen. Reproduction by submarginal (close to the wall) gemmation. Diameter of the calices from 2 lines to $3\frac{1}{2}$ lines.

From the Chert-formation of Antigua. Coll. Geol. Soc.

Fossilization very like that of *Isastræa oblonga* in the British Portland Oolite.

The affinities of these two Corals with the *Isastrææ* are not to be mistaken; and their occurring in the Chert of Antigua, where they are associated with the Miocene *Astrocœnia ornata*, is very remarkable.

13. Stephanocœnia tenuis, spec. nov. Pl. XIV. figs. 3 *a*, 3 *b*.

Corallites very long, slender, nearly straight, prismatic, and closely approximated; sometimes less prismatic than cylindrical. Walls thin. Calices wanting; but there are several polished sections of the corallites which show a pentagonal or hexagonal outline; occasionally a circular outline is seen. Columella obscurely preserved, but well enough to be recognized as styliform. Pali long, distinct, like prolongations of the septa to the columella; opposed to all the primary septa, and to the secondary where the third cycle is complete. Septa delicate, straight, very little thicker at the wall than elsewhere; slightly granular, and not crowded. They are disposed in three cycles, the third being often wanting in some systems, or in some half-systems, in imperfectly developed corallites. The primary and secondary septa are nearly equal when the third cycle is complete; the tertiary do not reach halfway to the columella, and are straight. Reproduction by marginal budding.

Dimensions.—Diameter of the corallites from 1 line to 2 lines; height several inches.

This species of *Stephanocœnia* differs widely from the form from San Domingo; and its distinct, thin, linear pali distinguish it from all others. It has no other than a generic affinity with the depicted, but not described, *Stephanocœnia tenuisepta* of the late M. Haime.

From the Inclined Beds and the Chert of Antigua. Coll. Geol. Soc.

14. Mæandrina, sp.

One specimen from the lower formation of Antigua is a semi-polished silicified fossil, greatly affected by the destructive form of silicification. A few transverse views of "series" enable me to classify it with the *Mœandrinœ*, but it presents structural peculiarities which remove it from the recent forms and connect it with those described as fossil. It does not come within the diagnosis of any species as yet described.

Valleys moderately long, very flexuous, repeatedly branching at nearly right angles. Columella sublamellar, deficient here and there for a very slight interval. Septa alternately large and small, the first extending close to the columella, presenting occasionally a slight transverse enlargement at the end; all delicate and straight, there being seven in a length of 1 line. Mural elevations (collines) small and delicate. Breadth of the valleys $\frac{1}{10}$ inch.

The recent *Mœandrinœ* have a well-developed spongy columella, but in the fossil forms that organ has a lamellar structure and is more or less defective. The breadth of the valleys is, as a rule, smaller in the fossil than in the recent species.

From the defective state of the fossil above described (Coll. Geol. Soc.), no specific determination is possible, but its characters relate to fossil more than to recent forms.

15. Cœloria dens-elephantis, spec. nov. Pl. XIV. fig. 8.

Valleys long, very much disposed to be nearly straight, branching rarely, and then at an acute angle, parallel, varying greatly in width. The resemblance of transverse sections to the dental laminæ of *Elephas* is most remarkable. Length 1 inch; breadth from 2 to 3 lines. A columella is present as a few laminæ, occasionally continuous with the septa. Septa alternately thick and thin, without pali or transverse enlargement, four or five to $\frac{1}{10}$ inch. Endotheca abundant and at right angles to the septa. The mural elevations, so far as can be judged from a section, are small and delicate.

The specimen is an example of the variety of siliceous fossilization where the interspaces are filled with porcellanous and opaline silica, the sclerenchyma having lost much of its details and being turned into homogeneous dark flint.

From the Chert-formation of Antigua. Coll. Geol. Soc.

16. Astroria polygonalis, spec. nov.* Pl. XIV. fig. 6.

Walls bearing a very small proportion to the size of the corallite (in

* In the Hist. Nat. des Corall., by Edwards and Haime, the genus *Cœloria*

transverse section). Calices polygonal, varying in size; many form short series, but the simple corallite is in excess. Columella very rudimentary. Septa long, thin, alternately large and small; they are generally numerous, but in a small corallite they are few, and resemble those of an *Astræa* with a low septal number. A small undeveloped corallite gives six systems, two cycles in some and three in other systems. Length of each series $9\frac{1}{2}$ lines; three septa to $\frac{1}{10}$ inch; the width varies, from the ends of the series being pointed. Width of the largest corallites not forming series $\frac{1}{2}$ inch, of the smallest $\frac{1}{4}$ inch. Endotheca abundant and subvesicular.

From the Chert-formation of Antigua. Coll. Geol. Soc.

The lithological character of this specimen is very interesting, the interspaces being filled with opalescent and opaque-white silica.

17. Astroria affinis, spec. nov.

Corallites crowded. Walls very thin indeed. Transverse section of corallites polygonal, rarely forming short series. Columella slightly but decidedly developed. Septa alternately large and very small, linear, a little larger externally, with at least four cycles in six systems. Breadth of the calices 4 lines; five septa to 1 line. Endotheca abundant.

From the Chert-formation of Antigua. Coll. Geol. Soc.

The greater independence of the calices and the rare fissiparity connect this species very closely with the Astræans. In some particulars it is allied to *A. astræiformis* (a recent species inhabiting the Red Sea); but that species has a rudimentary columella, only three cycles of septa, and smaller corallites. It has greater affinities with the species of *Astroria* just described than with any recent form.

18. Astroria Antiguensis, spec. nov.

Corallites not crowded, but close, tall. Walls rather thin. The transverse section of the corallites is in many cases circular, in others obscurely polygonal; some present short series, but rarely. Columella very indistinct. Septa alternately large and small, in six systems of four cycles, the fourth being occasionally deficient in two systems. Breadth of the corallites from 2 to $3\frac{1}{2}$ lines. Length of the series 6 lines; five septa to a line. Endotheca abundant.

Fossilization like that of the other Astrorians, and rendering the details indistinct. It is closely allied to the other species of *Astroria* from Antigua.

From the Chert-formation of Antigua. Coll. Geol. Soc.

19. Astrocœnia ornata, Edwards & Haime. Pl. XIV. fig. 7.

This well-known Miocene species is found in the Chert-formation of Antigua. The corallum is massive, in some cases most singularly altered by fossilization, and presenting most abundant corallites; the

absorbs *Astroria* (see vol. ii. p. 412). I have, however, retained the latter as a distinct genus, as it certainly forms a connective link between the fissiparous *Astrææ* and the *Cœloriæ*, and a certain number of species group themselves readily within the terms of its definition.

calices are a little smaller than in the European form. There is no specific difference.

Coll. Geol. Soc. and Brit. Mus.

20. Rhodaræa irregularis, spec. nov.

Corallum massive and tall. Corallites long, irregularly prismatic, crowded, distinct; diameter $\frac{1}{6}$ inch. Walls irregularly reticulate, delicate. Septa in six systems of three cycles; sometimes a fourth is seen; they are tolerably well developed and sublamellar. Pali very distinct before the primary and secondary septa. Columella formed by the junction of the pali.

The specimens are much altered by fossilization, but the structural details enumerated above are evident enough. The species is distinguished by the mass of pali and the presence of an incomplete fourth cycle. There are no recent West Indian species of this genus, those known being either Chinese or from New Holland; the fossil form is from Dax (Miocene).

From the Marl-formation of Antigua. Coll. Geol. Soc.

21*a*. Alveopora Dædalæa, Blainville, var. regularis. Pl. XIV. figs. 4 *a*–4 *c*.

Corallites prismatic, in all cases radiating from a small base, and lobed above. Walls very regularly perforated and thin. Calices a little smaller than the transverse sections of the corallites, rather deformed, polygonal; $\frac{1}{2}$ line in diameter. Septa spiculiform, and forming a false columella by their junction with some slight cellular trabeculæ.

From the Chert- and Marl-formations of Antigua. Coll. Geol. Soc.

21*b*. Var. minor.

A small variety from the Chert of Antigua. Coll. Geol. Soc.

22. Alveopora microscopica, spec. nov. Pl. XIV. fig. 5.

Corallites barely $\frac{1}{20}$ inch in diameter, prismatic and hexagonal, tall. Walls with reticulations, rendered less regular and equal than in the above species by the rather wavy track of the large longitudinal sclerenchymatous threads and by their irregular thickness. Septa small, less spiniform than in other species; usually twelve in number.

From the Marl-formation of Antigua. Coll. Geol. Soc.

23. Alveopora fenestrata, Dana.

In fronds. From the Marl-formation of Antigua. Coll. Geol. Soc.

II. San Domingo.

1. Brachycyathus Henekeni, spec. nov. Pl. XV. fig. 1.

The numerous small simple Corals considered to belong to this species are all young, and in examining them allowance must be made for the rapid growth which takes place in their breadth after a certain height has been attained. Corallum simple, straight, with a small circular base, conical below, cylindrical above, with a slight enlargement below the calicular margin: no trace of adherence. Costæ distinct, very slightly prominent, blunt; those of the primary and secondary septa are visible to the base, being most prominent at the calicular margin; at the enlargement they are ragged. The tertiary costæ resemble the primary and secondary when there are higher orders of septa; but when there are not, they only extend a little way from the calice, and are small. The fourth and fifth orders of septa are continuous, with short and very small costæ. Wall very faintly granular. No epitheca nor exotheca. Calice circular; its margins and axes are on even planes; fossa shallow. Columella large, essential, presenting at the free surface numerous small, free, cylindrical, papillary elevations, the largest being external. Pali very indistinct, and feebly developed. Septa crowded, in six systems of four cycles; incomplete. Septa of the fourth and fifth orders wanting in four half-systems; primary and secondary well developed and equal, thin, and not larger at any part than at another; straight, but slightly exsert and arched. Laminæ marked with a few distinct and prominent papillæ. The tertiary septa are larger when the higher orders of septa are present, and resemble the secondary; but when these are absent, they are like the fourth and fifth orders—linear, rarely granular, and often bending laterally.

From the Nivajè shale. Coll. Geol. Soc.

Dimensions.—Height of the largest specimens equal to the breadth; of the smaller greater than the breadth—from $\frac{1}{5}$ to $\frac{1}{4}$ inch. It is evident that, were the septal cycles complete, the breadth would increase still more; and also that the growth of the coral is at first in excess longitudinally, then transversely. The specimens are very hard and calcareous.

One specimen with the larger costæ more decidedly dentate superiorly must be considered to constitute a variety of this species.

From the Nivajè shale. Coll. Geol. Soc.

The twelve specimens of this species which I examined presented the above-mentioned structural details, except one, which was considered a variety. The breadth of the corals in their young stage, their large papillose columella, and their small pali lead to their comparison with *Brachycyathus Orbignyanus*, Edwards & Haime; nevertheless there is only a remote affinity. Their small pali and undecided transverse development must be considered, with the defective fourth cycle, as indicative of immaturity. The new forms do not fall within any other generic definition, and the varying development of the pali in the *Cœnocyathi* must be remembered before a great value is placed on this peculiarity. The genus *Brachycyathus* has hitherto included only one species, which is closely allied to the shorter *Cyathinæ*. Duchassaing and Michelotti have formed the genus *Paterocyathus* to admit a form which differs from *Brachycyathus* in being turbinate, and having the upper part of the wall strongly striated, the pali being in a simple crown. The specimen described* by them came from the Upper Tertiary beds of Guadaloupe. If the

* Mem. Acad. Turin, 2nd series, 1861, vol. xix. p. 336. pl. 5. fig. 11.

turbinate shape does not depend upon the incomplete development of the individual, the necessity for a new genus is evident; but in the other characters this *Paterocyathus Guadalupensis* is closely allied to the genus *Brachycyathus*. There is no reason for separating the San Domingo forms from the genus *Brachycyathus*, but they constitute a group not sufficiently resembling the species *B. Orbignyanus** to be placed in close alliance with it.

2. Placocyathus Barretti, spec. nov. Pl. XVI. figs. 1 *a*–1 *c*.

Var. 1.

A fragment of a simple corallum, with a curved lamellar columella and with the pali destroyed, probably belongs to the same species as the Jamaican form, page 437.

From Postrero. Brit. Mus.

Var. 2.

A variety with more rounded ends, less epitheca, and more distinct costæ than seen in the Jamaican form.

From Postrero. Brit. Mus.

3. Trochocyathus cornucopia, Edwards & Haime (*Turbinolia cornucopia*, Michelin).

A specimen of this species from the San-Domingan shale is in the British Museum. The species is common in the Vienna Basin and at Tortona.

4. Placotrochus Lonsdalei, spec. nov. Pl. XV. figs. 2 *a*, 2 *b*.

Corallum simple, straight, compressed; surrounded by a delicate but complete epitheca, through which the rounded, badly developed costæ can be seen. The epitheca is delicate and pellicular for nearly halfway up the wall, where it presents a slight constriction; it is most dense above and below this constriction, and presents no other folds. Costæ numerous, very indistinct, except the two lateral ones, which have a well-marked crest projecting like the cutwater of a boat, and at first not following the line of the wall, but being carried outwards and downwards, forming an angle, and then following the line of the wall. The costæ are most prominent at the angle, and the crests diminish in width towards the basilar mark, and just above this there is the appearance as if there had been a small spine. The margins of the crests and the basilar mark form an angle quite equal to a right angle. The basilar mark is distinct, but small, and not eroded, though flat. Calice elliptical. The long axis is terminated by the crested costæ, and the widest part of the short axis corresponds to a prominent part of the margin on each side. From this prominent part the margin gradually slopes to the crested costæ. The plane of the long axis is thus lower than the short. The long axis is exactly twice the length of the short one, excluding the salient crests. Width of the calice $\frac{1}{6}$ inch; length $\frac{1}{3}$ inch. Fossa large and moderately deep. Columella essential, long, free to but a slight extent, formed of a thin vertical lamina with a rather arched,

* This species is found in the Neocomian (Hautes Alpes).

not dentate, upper border; it is perfect in a considerable part of the specimen, and the sides of the lamina are finely granular. Septa numerous and crowded, in six unequal systems. There are four cycles in two systems, in two systems five, minus certain orders, and in the remaining systems the fourth and fifth orders are wanting in half of each system.

In 2 systems there are	8 septa	=16
In 2 „ „ „	13 „	=26
In 2 „ „ „	6 „	=12
		54 septa.

The primary, secondary, and tertiary septa are very much alike, and project but little. They are all slightly arched, and rather stouter nearer the wall than internally. They are faintly granular, and their orders may be recognized with care. The septa of the higher orders are very delicate; all correspond to faint costæ, and the primary septa at each extremity correspond with the large costæ. Height $\frac{1}{5}$ inch.

From the Nivajè shale. Coll. Geol. Soc.

As a species of the *Turbinolides* without pali and with an epitheca, this specimen might be considered a *Flabellum* closely allied to *F. avicula* (Turin, Miocene); but the laminar columella places it in the genus *Placotrochus*. Its compressed form, lateral crests, irregular septal arrangement, small basilar spot, and angular calicular margins are very distinctive of the species. The basilar spot is not a concave fracture, but a plane rupture as in *Flabellum spinosum*. The great angle formed by the costæ is equally a peculiarity of the genus *Flabellum*, and, close as *Placotrochus* is to that genus (differing in the important laminar columella), the form from San Domingo connects the two more intimately than the species *Placotrochus lævis* and *Placotrochus Candeanus*, both of which are recent, the first from the Philippines, and the second from the Chinese Seas.

The alar costæ and the small base of *Placotrochus Lonsdalei* distinguish it from *Placotrochus alveolus* (Jamaica, Miocene). I have named this beautiful little form after Mr. Lonsdale, who noticed the existence of the genus in the Heneken Collection, in his brief summary of the San-Domingan fossil Corals already noticed.

5. Flabellum dubium, spec. nov.

Corallum simple, in the form of a slightly compressed cone, straight. Epitheca incomplete, pellicular. Base small and conical. A mark of attachment is visible, there being two fractured appendices on one side of the base, one of which corresponds to the long axis. Costæ not crested, none larger than the majority. The lines of the costæ at the ends of the long axis form less than a right angle, or about 70°, where they join at the base. Long axis about one-third longer than the height of the corallum; length $1\frac{1}{3}$ inch. Length of the short axis 1 inch; its plane is a little higher than that of the long axis. Calice elliptical; fossa shallow at the sides, and deepening in the middle. Septa rather exsert, delicate. Primary, secondary, and tertiary septa of the same size. Laminæ slender and granular. In six systems of five cycles. Some septa appear to be united by their inner extremities. Costæ subequal, although the septa are alternately large and small. Height 1 inch.

From the Nivajè shale.

In shape the corallum resembles that of Michelin's *Turbinolia Japhetii*; but *Flabellum dubium* has not the dense septa of that species, and is furnished with an epitheca. *Flabellum Galapagense* and *Flabellum crassum* have alliances with it, especially the former. Although, from the state of its fossilization, the anatomy of the appendices cannot be made out, still it is clear that there was never any large mark of erosion. The specimen is shorter in relation to the length of the long axis of the calice than is the case in *F. Galapagense*, and the laminar granules are smaller; moreover the ends of the septa are not very thick.

6. Flabellum, sp.

Several casts and portions of a large *Flabellum* are found in the blue shale of San Domingo, but the specimens are all too incomplete for specific determination.

7. Thysanus* corbicula, gen. et spec. nov. Pl. XV. figs. 3 *a*, 3 *b*.

Corallum simple, in the shape of an elliptical dish with a rounded and ovoid base, fringed with granular ribs; apparently it was once attached, but became free by the rupture of a lateral pedicel, the erosion resulting from the separation remaining at one extremity. The base is smooth, and has a central groove. The height is greatest at the end marked by the erosion; and the base, as it recedes, approaches more or less the calicular margin. Epitheca imperfect,—perfect in the lower half, wanting in a circular groove above it, and again present for a small space above the groove on the portion of the wall remote from the erosion,—smooth, not echinulate or granular, raised into slight ridges which are continuous with the costæ. The ridges radiate more or less from the eroded end, and the general growth of the coral appears to start from this point, although the elliptical form is perfect. Groove shallow. Erosion circular, rather deep, ragged at the edges; it is situated above the epitheca, which bounds its lower half, and is deeply grooved for a short space by it. Wall hidden by the epitheca and costæ; its general outline is more convex near the erosion than elsewhere. Costæ very distinct, existing as ridges when beneath the epitheca, and as prominent granulated laminæ in the rest of their course. The ridges pass in curves from the part of the base nearest to the eroded end. The costæ are alternately large and small, those corresponding to the rudimentary septa of the fifth cycle being very slight; but the costæ of the other cycles are very equal. The granulations are very marked, and are very characteristic; at regular intervals they swell out the costæ, a granule being developed on each side of the laminæ and on the free surface. These three irregular growths add to the swellings,

* Θύσανος, *a tassel.* See also *Thysani* from Jamaica, p. 439.

and render the intervals between them delicate and linear. Each costa consists of alternate granular swellings and linear intervals, being thus irregularly moniliform. The smaller costæ present smaller granulations. Intercostal dissepiments wanting. Calice elliptical, margin broad, fossa very deep. Length to breadth as 16 to 10. Length $\frac{1}{2}$ inch and $\frac{1}{30}$; breadth $\frac{1}{3}$ inch. Depth of fossa 2 lines. Marginal surface on one plane. Septa well developed, projecting upwards three-quarters of a line, boldly arched above, ending in costæ externally, but arched and irregularly prominent in the fossa internally. They slope at last to the bottom. All the septa have more or less a tendency to radiate from the eroded end. Primary and secondary septa very much alike; the others are unequal, according to their orders, but the tertiary are a little smaller than the secondary. Free septal margin strongly and regularly granulated; sides of the laminæ marked with rows of granulations with sharp points, each row ending at the septal margin in one of the swellings. Granulations very distinct on broken septa. No pali, endotheca, nor synapticulæ. Septa in six systems of five cycles; in all ninety-six septa. Columella badly developed, parietal, consisting of a lax tissue reaching from the septa to those on each side; it is situated at the bottom of the fossa.

The species under examination is one of the *Turbinolides*, as there are no pali; it is deficient in endotheca, open from the base of the fossa upwards, and has a dense wall; the epitheca is tolerably developed. Coming thus under the division of epithecal *Turbinolides*, it is associated with *Flabellum*, *Rhizotrochus*, *Placotrochus*, and *Blastotrochus*.

Blastotrochus is distinguished from the other genera by its gemmiparous reproduction; it is moreover cylindroid. *Placotrochus* has a laminar columella. *Flabellum* has non-projecting septa, and costæ crested, spined, and covered by epitheca. This last genus only resembles the new form in its species having more or less granular septa, a parietal and badly developed columella, and a high septal number. The elliptical calice of *Rhizotrochus*, as well as the arched and prominent septa and deep fossa of that genus, are found in the new form. Allied thus to *Flabellum* and *Rhizotrochus*, the genus *Thysanus* is distinguished by its lateral erosion, highly granular costæ, incomplete epitheca, grooved base, and elliptical and depressed shape.

From the Nivajè shale. Coll. Geol. Soc.

8. Barysmilia intermedia, spec. nov. Pl. XV. fig. 4.

Corallum with the trunk irregularly cylindrical, the spot of former adhesion being smaller than the diameter of the trunk, which has some undeveloped calices on its surface. Head convex and closely covered with calices, whose long axis is in no definite direction. Calices crowded, tolerably elevated above the surface, elliptical and circular, forming series of not more than three, by fissiparity; lateral margin of some calices higher than others. Fossa tolerably deep. Septa barely exsert, slightly arched inwards, granular on their faces;

in six systems of four cycles, generally incomplete in some half-systems. The primary septa are the largest; the fourth and fifth orders are very small. Columella rudimentary. Costæ very marked, subplane, alternately large and small, reaching down the trunk; near the calices they are marked by a series of distant papillary elevations, with a small and superficial foramen at their apices. Height of corallum 2 inches; small diameter of calices $\frac{3}{5}$ inch.

This species is closely allied to *Barysmilia tuberosa*, Reuss, from Gosau, and the genus has not hitherto been noticed out of the Cretaceous group.

From the shale at Esperanza, San Domingo. Coll. Geol. Soc.

9. Dichocœnia tuberosa, spec. nov. Pl. XV. figs. 5 *a*, 5 *b*.

Corallum tuber-shaped, with a circular or oval eroded base, and a more or less gibbous surface, covered with a delicate epitheca and numerous calices. Calices numerous, rather close, decidedly prominent, the lower edge generally longer than the upper. The calices look generally upwards and outwards; they are either circular and small or elliptical and larger; in the largest form, series of two or three are produced in the process of fissiparous reproduction. The long axes of the calices point in all directions; some small calices are hidden by the epitheca. Costæ well marked on the calice, but becoming granular and slightly spined on the surface of the Coral: a shagreen-looking epitheca, which, when broken, shows linear costæ beneath, separates the calices. The costal markings on the epitheca are now and then continuous from one calice to another, and from calices to the base. Septa in six systems; four cycles in some systems, three in others; the fourth orders are often wanting. They are delicate, a little larger at the wall than elsewhere, and faintly granular. Columella laminar, parietal, or spongy in different calices. Pali exist very irregularly; they are placed very constantly before the secondary septa, but are often not seen at all. Calicular fossæ tolerably deep. Diameter of the calices $\frac{3}{10}$, $\frac{2}{5}$, to $\frac{2}{3}$ inch. The Coral is generally some inches high, and bulky.

No fossil species of this genus have been described, except a doubtful form, to which Milne-Edwards gives a Lower Cretaceous age.

From the Nivajè shale and tufaceous limestone of San Domingo. Coll. Geol. Soc. and Brit. Mus.

10. Stephanocœnia dendroidea, Edwards & Haime, Hist. Nat. des Polyp. &c., p. 169.

Edwards and Haime give no habitat for this form; but the ramose species of *Stephanocœnia*, common in the Miocene of San Domingo, is evidently the same.

11. Phyllocœnia sculpta, Edwards & Haime, var. tegula.

Astræa sculpta, Michelin.

A thin, flat, tile-shaped Coral from San Domingo corresponds with the *Astræa sculpta*, Michelin (the *Phyllocœnia sculpta*, Edwards & Haime), in the majority of its details. The costæ are not so decidedly granular, the septa less equal, and the calices not quite so elevated (little as they are) as in the form depicted by Michelin (Zooph. pl. 71. fig. 3) and described by Edwards and Haime (Recherches, p. 304). There is not, however, a specific difference between the San-Domingan form and that from Martigues. It is with doubt that Edwards and Haime call this a *Phyllocœnia,* and certainly the San-Domingan form has some very strong Eusmilian features, and one very indecisive Astræan peculiarity. Diameter of the calices hardly $\frac{1}{5}$ inch. Height of the coral from $\frac{2}{3}$ to $\frac{5}{6}$ inch.

From the Nivajè shale. Coll. Geol. Soc.

12. PHYLLOCŒNIA LIMBATA, spec. nov.

Corallum in the shape of *Stylina limbata,* Edwards & Haime. Stem large and cylindrical. Corallites numerous, irregularly placed. Calices separated by much cœnenchyma, circular and but slightly elevated. Costæ covering much surface, slightly dentate where they approach, and turning aside from those of other calices; they are not continuous, not very prominent, and slightly granular. Septa not projecting far inwards, laminæ granular; their upper margin is neither incised nor dentate; in six systems of generally three cycles, though occasionally of four. Primary septa largest. Columella rudimentary. Endotheca abundant. Diameter of calice, with costæ, $\frac{1}{5}$ inch.

The deficient columella is the only point in which this species differs from *Madrepora limbata,* Goldfuss, which has been determined by Milne-Edwards to be a *Stylina.*

From the yellow shale of San Domingo. Coll. Geol. Soc.

13. MONTLIVALTIA PONDEROSA, Edwards & Haime. Pl. XVI. figs. 6*a*, 6*b*.

Thecophyllia ponderosa, Edwards & Haime.
Turbinolia Deucalionis, Duchassaing.

From the shales of St. Domingo. Brit. Mus. Guadaloupe and Jamaica; also Travancore in Southern India. Coll. Geol. Soc.

The description of this great Coral, whose synonyms have arisen from the description of defective specimens, is given with the Jamaican Corals, p. 441. It is to be noticed that the San-Domingan specimens are young, but are better preserved than that drawn by Milne-Edwards in the plates of the 'Hist. Nat. des Corall.' I have also examined a specimen from Travancore.

14. MÆANDRINA FILOGRANA, Lamarck.

A figure of this Coral was given by Michelin (Zooph. pl. 14. fig. 7), and described as a Supracretaceous fossil. Milne-Edwards and Haime add to the above notice that the specimen is not a fossil. The species is East Indian; and if the *Madrepora filograna* (Esper, Pflanz. t. i. p. 139, pl. 22, 1791) be received as a *Mæandrina,* there is proof of a West Indian habitat.

From the San-Domingan shale (Coll. Geol. Soc.); recent in the East Indian and American seas.

15. Astræa endothecata, spec. nov. Pl. XV. figs. 7 *a*, 7 *b*.

An Astræan, characterized by large corallites, great development of the costæ and exotheca, as well as of the endotheca, and by the delicate and numerous septa. Varieties are found in the Lower Calcareous beds (Marl) of Antigua very closely allied to this form.

Corallum tall, subplane above. Corallites tall, stout, cylindrical; a little wavy in their course, slightly enlarged here and there; close, but not crowded, separated occasionally by buds, which speedily become as large as the parent corallite. Wall well developed, strong. Calices rather irregular in size, irregular in their mutual distances, and unequally elevated above the surface; not much elevated, but still decidedly so, like truncated cones; margin thin; external surface of the calices inclined, and marked by the costæ and oblique dissepiments. These dissepiments have often a granular tooth, and, when broken through, a corresponding dissepiment with a tooth is seen below. Septa delicate, barely exsert, straight, granular; in six systems of four cycles, the higher orders being but slightly developed. Costæ largely developed, those belonging to the fourth and fifth orders of septa being smaller, and hidden between the large costæ on each side; they have, moreover, a papillary-looking tooth between each dissepiment. On the calicular surface the costæ are small and slightly dentate. Columella well developed, formed of lax trabeculæ. Endotheca greatly developed, close, vesicular, and separating the interseptal loculi into cells; it closes the shallow calicular fossa, leaving a few foramina. Exotheca greatly developed; dissepiments stout, inclined forwards and downwards, arched; on each dissepiment is the tooth of the fourth cycle. No epitheca. Increase by extracalicular gemmation. Diameter of the calices $\frac{2}{5}$ inch, of the corallites a little more. Exothecal cells three in $\frac{1}{10}$ inch.

This fine Astræan is not to be identified with any known species; its endothecal development is extraordinary, and connects it with the Astræans from Antigua possessing much endotheca. It is worthy of notice that the European Miocene Astræans are generally characterized by having much vesicular endotheca.

From the Nivajè shale of San Domingo; varieties in Antigua and Persia.

16. Astræa cylindrica, spec. nov. Pl. XV. fig. 8.

Corallum flat; surface irregular, nearly plane in large specimens; marked by prominent truncated cones (ends of corallites), with very projecting and somewhat irregular costæ. Corallites wide apart, short, from $1\frac{1}{3}$ to $2\frac{1}{2}$ inches long, cylindrical, more or less parallel, becoming sensibly smaller close to the calice, projecting considerably (from $\frac{1}{3}$ to $\frac{1}{2}$ inch) above the common cœnenchyma; often twisted inferiorly, and swollen out in certain parts. Walls very well developed, stouter below than above. Costæ forming a marked structure; very slightly developed at the immediate calicular margin, they are soon considerably and often irregularly produced in some corallites, while in others they form thin, well-developed, subequal, more or less dentate projections, the small, dentate fourth and fifth orders being here and there seen as rudimentary costæ between the larger. The tallest corallites have subequal and regular costæ, and the smaller corallites usually have them irregular and produced, whilst those whose calices reach but a little above the cœnenchyma have their costæ produced on its surface. The small and rudimentary costæ correspond to septa. Calices as truncated cones with small blunt apertures, rather wide apart, from $\frac{1}{3}$ to $\frac{1}{2}$ inch high, circular at the margin, which is rather inverted; it is also much less in diameter than the corallite with its costæ. Fossa shallow in some, and about as deep as broad in others. Columella lax, parietal, and well developed. Septa small, unequal, and much smaller than their costæ, barely exsert, rounded at the margin, and there a little larger than elsewhere; delicate and linear within; in six systems of usually three cycles, rarely four, occasionally the fourth cycle in half a system; the primary septa are generally the largest, the higher orders are very small, and the fourth and fifth orders often incline to the tertiary septa. The laminæ are delicate, not cribriform, but perforated now and then, and join the columella by numerous close, slightly ascending, oblique dissepiments; they are slightly dentate, and unequally granulated laterally. Endotheca but little developed. Exotheca close, abundant, and shelving outwards; it is very distinct on some of the produced costæ. Epitheca none. Exothecal dissepiments four or five in $\frac{1}{10}$ inch. Diameter of the calices from $\frac{1}{5}$ to $\frac{3}{10}$ inch. In large specimens, here and there, the costæ are produced to $\frac{1}{10}$ inch.

From the tufaceous limestone of San Domingo. Coll. Geol. Soc.

The smaller specimens of this species consist of a few corallites, and the larger of tabular masses. The budding is always extra-calicular. The truncated extremities of the cylindrical short corallites, the small, dentate, rudimentary costæ, and the production of the larger costæ distinguish this species. There are some points of resemblance to *Astræa cavernosa* (recent, Antilles), *Astræa Forskœlana* (recent and subfossil, Egypt and West Indies), and to *Astræa Defrancii* (Miocene).

17. Siderastræa crenulata, Blainville, var. Antillarum.

An incrusting Coral, very short, with a slightly convex and gibbous surface. It resembles *Siderastræa crenulata* in all particulars, except in having a less deep calicular fossa, and the crenulations of the septa most marked near the papillary columella. The septa of the fourth and fifth orders turn towards and join that between them at various distances from the columella, and often the fourth orders appear longer than they really are. Diameter of the calices $\frac{1}{6}$ inch; depth of fossa $\frac{1}{20}$ inch.

Its nearest living species is *Siderastræa siderea* of the Antilles, and it is distant from the other American forms.

From the Nivajè shale of San Domingo (Coll. Geol. Soc.). It occurs also in the Miocene of Europe.

18. Cyphastræa costata, spec. nov.

This species is found also at Barbuda and Jamaica (see Barbuda, page 443).

From the Nivajè shale. Coll. Geol. Soc.

19 *a*. Stylophora affinis, spec. nov. Pl. XVI. fig. 4.

Corallum branched, large; branches nearly cylindrical, leaving the stem at an acute angle, slightly flattened on one side. The largest stem is $\frac{4}{5}$ inch in diameter. Blunt, aborted, branch-like swellings exist on some of the larger stems. Corallites radiating from the centre of the stem and branches, separated by about their own width of dense cœnenchyma, which is seen, in the larger specimens, to be very slightly cellular. Walls not distinguishable from the cœnenchyma in the substance of the mass, but slightly raised into a very shallow crateriform edge on the surface. Calices circular, a very little raised as crateriform elevations, very numerous, disposed irregularly, but very nearly equidistant in some places and less so in others; margins sharp. Diameter $\frac{1}{30}$ inch, rarely larger. The calicular margin, when well preserved, looks like a little ring placed on the intercalicular space, and the small styliform columella renders the appearance very distinct. Intercalicular spaces marked by a continuous and ridged line, which, being in the part of the spaces at the base of the calicular elevations, and being continued round each calice, is, from its general straightness, formed into irregular polygons. The line is sensibly raised, convex, and now and then dentated. Between the line and the calicular margin there are distinct papillæ, one row at the very marginal edge, the other corresponding to it a little lower down the calicular wall; a third is sometimes seen; and in places where there is an unusual distance between the calices, and when the "line" is wanting, the papillæ are numerous, distinct, and a little smaller. The line and the papillæ form a very marked distinction. Between some calices there are faint elevations. Septa whole, not exsert, but little visible in perfect calices, but very distinct when the coral is worn. Upper margin perfect, and concave upwards, the septa appearing festooned to the columella; they are delicate, very little thicker at the wall than elsewhere, and join the columella high up near its point. The papillæ at the calicular edge extend a little on the wall, and may be considered as rudimentary septa and costæ; if so, there is a second cycle, and also a third in half of each system. The persistence of six septa, nearly all of the same size, is very remarkable. Columella styliform, large and dense in the corallite, and forming a rounded-off cylinder with a sharpish rounded tip, which is very distinct halfway down the calice. Calicular fossa shallow, about half as deep as broad. Endothecal dissepiments stout, transverse, numerous. The walls and columella do not fill up the lower parts of the corallites. Increase by extracalicular gemmation.

From the Nivajè shale Coll. Geol. Soc.

19 *b*. Var. minor.

A portion of a branched *Stylophora* in a mass of shell- and coral-breccia from the Nivajè shale differs from the typical form of *S. affinis* by having its calices much wider apart, and consequently by having more cœnenchyma. It is a small form; the calices are about the same size as those of the larger variety, where, however, they are closer together.

This new species and its variety are closely allied to *Stylophora costulata*, Edwards & Haime, from Gaas (Miocene), and less so to *Stylophora raristella* (Dax and Turin). In some very large specimens there are irregular gibbosities, like truncated shoots, from the main stem; and the Jamaican specimens often present this form of corallum in small branches. The imperfect septal development and defective costal arrangement distinguish the new species from *S. costulata*, but still the alliance is very close. Apart from the form of the coral, there is much resemblance to *Stylophora palmata* (recent, Red Sea). The fossil forms are from La Palarea, Scinde, Biarritz, Dax, Turin, Vienna, Belforte, and Gaas.

20. Agaricia agaricites, Lamarck.

Three fragments of one specimen are of this species, which now exists in the American seas. The Coral is known under various generic synonyms, such as *Pavonia*, *Madrepora*, &c. It is remarkable that dissepiments clearly exist in the interseptal loculi of these specimens, as well as synapticulæ.

From the Nivajè shale. Coll. Geol. Soc.

21. Agaricia undata, Lamarck, var.

A fragment imbedded in Nivajè shale, with pieces of one of the *Turbinolides* and of a *Stylophora*. It is more closely identical with *A. undata* than with any other form; the slanting calices and the inferior surface unequally costated are very characteristic of that species. At the same time the specimen has more septa and closer "collines" than the typical *A. undata*, and it presents many resemblances to forms of the genus *Mycedia*. Both *Agaricia* and *Mycedia* are found in the existing American seas.

From the Nivajè shale. Coll. Geol. Soc.

22. Alveopora fenestrata, Dana.

This fossil is from the Heneken Collection, and coincides with the description of *A. fenestrata* by Edwards and Haime (see descriptions of fossil *Alveoporæ* from Antigua and Jamaica, pp. 426 & 442).

From the Nivajè shale. Coll. Geol. Soc.

23. Porites Collegniana, Michelin.

Occurs in the Nivajè shale in a Coral-breccia. Coll. Geol. Soc. It is also found in the Vienna Basin (Reuss).

III. Jamaica.

1. Placocyathus Barretti, spec. nov. Pl. XVI. figs. 1 *a*–1 *c*.

Corallum simple, elongated, greatly compressed, the small axis of the calice being to the large as 100 to 366; conical and pedunculated, the lower part of the base being curved in the direction of the great axis; pedicel very slender. Epitheca well developed, pellicular, and permitting the costæ to be seen; it is in more or less transverse wavy ridges, and it ceases two or three lines below the horizontal calicular margin. Wall very thick and dense. Costæ: the larger are all nearly equal; the smaller correspond with the rudimentary septa, and are continued down between the larger, gradually merging into a row of rounded granules as the epitheca covers them: the larger are to be traced more or less to the pedicel; they project but little at the calicular margin, and are rounded; where the epitheca commences they become flatter, and are sparsely granular, the granules being really dentations in one series; shortly, however, the granular appearance is lost, and a ridged form is seen, some of the lateral costæ evidently uniting with others a little above the pedicel; they are close, but not crowded; many are parallel, and never crested nor sharply spined. Calice with its margins a little sinuous, very long, narrow, and a little curved, the long axis on the same plane as the short. Fossa deep and narrow. Septa very numerous, barely exsert, rounded at the wall, and a little thicker there than elsewhere; often a little curved, extending well inwards. Except the rudimentary septa, which correspond to the short costæ, the septa are subequal, and the principal are not easily recognized; generally one is large, and the next smaller; they are rounded above, and are nearly perpendicular at their inner margin; free margin not incised; lamellæ granular. The granules, which are conical and large, form linear series, which are directed from below inwards and upwards. Septa in six systems of at least six cycles. There are forty-three septa to an inch. Columella essential, lamellar, attached to the septa by trabeculæ passing at right angles from it; its surface is very long, and it probably was sharp; above the free surface there is a deep, linear, calicular fossa. Pali as delicate rounded lobes, barely to be recognized, attached to the usual laminæ; the granules of the pali form series parallel to their circular outline. Endotheca none. Height $1\frac{1}{2}$ inch; length of calice $3\frac{1}{3}$ inches; breadth 9 lines; depth of fossa 4 lines, of interseptal loculi much more.

This interesting simple Coral was discovered in Jamaica by the late Mr. Barrett, with whose memory I associate it.

Jamaica; varieties in San Domingo. Brit. Mus.

2. Placotrochus alveolus, spec. nov. Pl. XVI. figs. *2 a, 2 b.*

Corallum simple, very long, low, and narrow; trough-shaped, rounded at the extremities, by one of which it was attached; transverse outline triangular. Wall very thick, stout at the calicular margin, covered close up to this by a dense epitheca, which shows traces of the costæ tolerably distinctly above, where they are represented by a series of granules, and less so below, where they are simple elevations on the wall; all the granules are microscopic. Sides of the wall more or less wavy. Between the semicircular margin of the calicular end and the base there is a circular hole with irregular and rounded lips—the "erosion." This lateral wound is evidence of a former appendicular attachment. Calice very long, gutter-shaped, on an even plane; margin very narrow, slightly elevated at the extremity, and compressed a little here and there. Septa very numerous, sixty to one inch; primary, secondary, and tertiary nearly equal; very delicate, rounded above, finely granulated, and barely exsert at the wall; the small septa which extend well inwards are numerous, and a large septum is succeeded by one of these, then a middle-sized one follows. Inner margins very delicate, rounded, and separated from those opposite by the space which leads down to the columella. Costæ indistinct, parallel. Columella essential, lamelliform, free, sharp, very long and continuous, joining the septa (out of sight) by trabeculæ. Length (fractured specimen) 2 inches 4 lines; breadth 6 lines; height ½ inch.

A Coral of unique shape. It is very different from the other species of the genus, but its columella and its deficiency of pali and endotheca prove it to be a form of *Placotrochus*.

3. Thysanus excentricus, gen. et spec. nov. Pl. XVI. figs. 3 *a*–3 *c*.

Five specimens of a simple Coral (Nos. 1–5), in the British Museum, very unusual in shape, and all specifically related, have the following characters. The description is taken from No. 1, a young individual.

Corallum simple, resembling in shape a half-folded ovate leaf, the lobes of whose base are joined, the petiolar junction being still evident. There are three angles to the corallum:—1. An inferior and anterior angle which projects forwards and obliquely downwards (the petiole of a leaf would be attached here). 2. A superior and anterior angle, which is immediately above the first, and is connected to it by a linear and concave furrow; it is situated at the anterior rounded overlapping margin of the calice, and this margin forms the base of a triangle, of which the inferior angle is the apex. A lateral view shows a curve between the calicular end and the pointed inferior angle. 3. A posterior angle is produced by a curved line passing backwards and downwards from the first angle, which joins the posterior calicular end, and forms a gutter-like extremity. The line from the first to the third angle is the base in the ordinary sense; this base is linear, and is marked by a rounded shallow keel. There is an erosion or spot in some specimens, where the corals were once attached, immediately above the first angle. There is a general curve of the receding lines to the left, and the corallum is gently twisted in that direction. The width of the corallum in front and above is greater than at any other part, and it becomes narrower towards the third angle. The width of the calice is very small in comparison with its length.

Corallum narrow and long, low, and generally triangular, presenting the appearance as if the anterior end were the original turbinate coral, which has since grown posteriorly only. Wall well developed, imperforate, marked anteriorly by a curved linear furrow and traces of an erosion—the mark of an appendicular process. Epitheca exists, very rudimentary, but is visible around the first angle and close to the erosion. Calice long, narrow, slightly curved, wider in front, where it is more rounded than behind, being there sharply oval. Lateral plane higher than the antero-posterior. Fossa tolerably deep. Furrow between the free ends of the septa very distinct. Margins slightly everted, thin, and a little irregular. Costæ very numerous, very regular, faintly yet decidedly prominent, sharply dentate, the dentations being delicate and numerous. Costal curves very elegant. The keel between the first and third angles is really a costa, and all the costæ have a relation to it, passing off from it at acute angles, very much as the veins of some leaves pass off from the midrib. One large costa is usually followed by a very much smaller one. Septa numerous, corresponding to the costæ, hardly exsert, but the larger are more so than the smaller. Laminæ rounded above and within, not incised, regularly granular, in series; a little thicker at the wall, but some are enlarged internally. Size of the septa very irregular; anteriorly two large septa join at the wall, and posteriorly all the septa have an eccentric relation to the centre of the curve formed by the anterior calicular margin; they do not pass from the wall at right angles. Apparently there are many systems of four cycles each, and there are 132 great and small septa. Columella situated very deep in the coral, parietal and rudimentary. Endotheca and exotheca none.

Dimensions.—Height of corallum between the first and second angles $\frac{1}{3}$ inch; length of base between the first and third angles $\frac{5}{6}$ inch; length of calice a little more than $\frac{5}{6}$ inch; breadth of calice $\frac{3}{10}$ inch.

No. 2. An older individual, stouter, and more marked by an erosion. Calicular fossa deep.

No. 3. A large specimen, more fully developed, but deficient in its calicular margin. It is taller, but still keeps the peculiar form of the species. Costæ less sharply but well toothed. Mark of erosion very visible. Septa larger, and the inner paliform enlargement very evident on many. Septa 140. Columella more developed.

The specimens 4 & 5 are fragmentary.

These corals resemble a produced *Ceratotrochus*, if such a variation in form could occur. The lateral or rather the anterior erosion is seen in *Thysanus corbicula* from San Domingo. The absence of endotheca proves that they are not young buds of such a genus as *Rhipidogyra*, and includes them amongst the *Turbinolides*. The eccentric distribution of costæ and septa is faintly seen in a fossil from the chalk-marl of Lemburg—*Turbinolia galeriformis*, Kner (a *Ceratotrochus*). The more or less transverse ends of the larger septa are very peculiar, as is also the existence of a small amount of epitheca.

The *Thysani* have, in common, an eccentric arrangement of the septa and costæ, a lateral erosion, a badly developed epitheca, and a parietal columella.

4. Astrocœnia decaphylla, Edwards & Haime, var.

In the form of a short stunted branch. From the Tertiaries of Jamaica; Lower Cretaceous of Europe. Brit. Mus.

5. Siderastræa grandis, spec. nov. Pl. XVI. figs. 5 *a*, 5 *b*.

Corallum many inches high; no calicular surfaces are left. Corallites very tall, slender, crowded, and polygonal. Septa crowded, in six systems of four cycles; the fourth and fifth orders curve to the larger, and the third to the second also; there are three rows of large granules on the laminæ near the wall, also traces of endotheca; the free edge of the secondary septa is beautifully dentate; transverse, granular, synapticular processes well developed. Columella tolerably developed. The height of the corallum and the slender corallites distinguish the species. Corallites not more than 2½ lines broad, and generally less.

Coll. Brit. Mus.

6. Cyphastræa costata, spec. nov.

A specimen specifically the same as the forms found fossil at Barbuda and San Domingo. It presents a great development of the endotheca; its fossilization is more complete than that of the others.

7. Montlivaltia ponderosa, Edwards & Haime. Pl. XVI. figs. 6 *a*, 6 *b*.

A large, simple, heavy Coral. It is short, plano-convex, and subelliptical. Below the calice it is conico-convex; laterally it is slightly constricted. It has been free, and there are the remains of a small tubercle-like pedicel, quite in the centre of the base, towards which faint costæ radiate. Epitheca well developed, thin in some parts, thicker in others, and here and there not reaching as far as the top of the wall; it is very generally perforated by circular foramina. Costæ seen more or less distinctly through the epitheca, but never very well; they are marked by distinct but weak striæ, the epitheca being thickened and ridged between them, and they are sharply spined, the points often coming through the epitheca. Calice longer than broad, subelliptical; ends rounded; sides less so, and in their middle either straight or incurved. Margin not entirely on the same plane; that of the long axis is a little lower than that of the transverse. Wall well developed at the margin. Calicular fossa very shallow, especially if the central elliptical depression be not considered. The fractured specimen (No. 2) proves the mass which forms the floor of the central depression to be a flat and dense columella, formed by tortuous ascending trabeculæ. It is quite possible to consider the flat or slightly concave surface of the depression the floor of the coral, but this is not really the case. The columella is essential and spongy. Septa very numerous, crowded here and there; primary, secondary, and tertiary nearly alike; in six systems of six cycles, but the higher orders are not developed in all the systems. The primary septa project upwards from the wall for 2 lines, and the higher orders do not project much. The lateral (external) projection is but slight, and the costæ project but little from the wall. Septal margin rounded near the wall, then spined or acutely serrate; it inclines gradually, and the inner end is usually but little lower than the outer. Septa thin, often a little curved; their inner end is perpendicular in the largest; their base appears to rest on the columella, and the upper corner is very angular and free. Laminæ marked by distinct rows of granules, which are less developed internally and inferiorly. The septa are thicker at the wall than elsewhere. Endotheca not to be distinguished except in fractured specimens, but it is well developed. Exotheca represented here and there by a few dissepiments. Height of corallite $1\frac{1}{3}$ inch, length $3\frac{1}{3}$ inches, breadth $2\frac{1}{2}$ inches; length of columella 1 inch 1 line, breadth 4 lines, height $\frac{1}{5}$ inch; height of septal edge above the columella $3\frac{1}{2}$ lines.

A younger specimen has the corallum very short, and more convex than the other, also shield-shaped below, and the central projecting boss, like a pedicel. Epitheca tolerably developed. Calice less elliptical; sides more curved, and the plane of the short axis higher than in the larger specimen. Fossa a little deeper. Septa more acutely and slenderly spined, as well as the costæ; some spines of the septa are very straight and sharp, all are slender; in six systems of five cycles. Columella as in the large specimen, very distinctly separated from the wall. Exotheca barely a trace. Length of corallum 1 inch 8 lines, breadth 1 inch 5 lines, height 8 lines without the boss.

The close affinities of the genera *Caryophyllia* (*Lithophyllia*)*, *Circophyllia*, and *Montlivaltia* account for the synonyms of this great simple Coral. If the central fossa had its foundation on the base of the coral-wall, and if the septa had met internally, as they usually do in Astræans without columellæ, there would have been no difficulty in classifying the species amongst the *Montlivaltiæ*; but it is by no means improbable that a genus will have to be determined which will admit these simple corals with a columella and an epitheca, especially as new forms are presenting themselves daily for examination. I have noticed a young *C. ponderosa* amongst some Miocene fossils from Travancore, and, therefore, it occurs in the Tertiaries of Postrero, San Domingo, and of Jamaica, and also in the Miocene of Guadaloupe and Travancore.

Coll. Geol. Soc. and Brit. Mus.

8. Astræina Dendroidea, gen. et spec.?

A dendroid Astræan, multiplying by fissiparity, and forming a bush-like mass, but taller than broad; it is much altered by fossilization, all the details, except the general shape and the walls, having been destroyed.

9. Alveopora Dædalæa, var. regularis. Pl. XIV. figs. 4 *a*, 4 *b*.

From hard white limestone, in the form of casts, as at Antigua.

10. Porites.

Several specimens of casts of a massive *Porites* from the limestone; the details, except the reticulations, are destroyed.

* The term *Caryophyllia* has been applied by Edwards and Haime (Hist. Nat. des Corall.) to the forms previously comprehended under the well-known generic term *Cyathina*, and the former Caryophyllians are termed *Lithophyllia*. I retain, however, the older and generally received nomenclature.

IV. Montserrat.

1. Astræa Antillarum, spec. nov.

A specimen in the form of a rolled flint, found with silicified Wood, has the corallum large, tall, probably resembling in shape that of the San-Domingan *A. exothecata*. Corallites close, unequal in size, but quite distinct; the transverse section shows them to be circular in outline. Septa in six systems of three cycles. The primary and secondary septa are nearly equal, and reach to the columella; the tertiary are small and straight; all are slender, wide apart, and very distinct. Costæ tolerably developed, subequal. Walls moderately developed, by no means strong. Columella small, and occupying a small space. Endotheca greatly developed, vesicular, and forming cells between the septa. Exotheca well developed; large cells broad, others squarer, with shelving dissepiments. Diameter of the corallites $\frac{3}{10}$ inch.

The interspaces are filled with opalescent or porcellanous silica; sclerenchyma often destroyed.

Coll. Geol. Soc.

V. Barbuda.

1. Cyphastræa costata, spec. nov.

Corallum large, compound, with a large base; very hard. Corallites long, slender, numerous, close, but distinct, except at certain points; converging from the wide base towards a subplane, slightly gibbous, and irregular surface. Walls very dense, generally increasing in density and thickness as they become more remote from the calices; in some places the walls encroach upon the exothecal space, and the corallites are joined by their walls, a dense structure being formed. Wherever the walls become thicker, it is at the expense of the intercorallite space, and not of the interseptal loculi. Walls thin at the calicular margin. Costæ well developed, and forming with the exotheca a very marked structure; at the calicular margin they project a little upwards, are a little dentate, and slightly prominent along the outer slope of the truncated calicular elevation. They correspond to the septa in number, the primary and secondary costæ being but little larger than the tertiary. They are not crowded, but have a deep fossa between them, are not continuous with those of other calices, but are frequently irregularly projected, and often touch. In longitudinal sections they are crossed by dissepiments regularly during their whole course; their edge is not simply linear, but each costa presents a series of wedges placed one over the other, the thin end of one wedge resting on the thick end of that below it, the dissepiment intervening. The dissepiments project beyond the costal edge, and render it irregular; they are absorbed now and then by the development of the walls. Calices circular, forming low truncated cones; they are well separated from each other, and frequently, where four meet, a considerable space exists. Calicular edge sharp. Fossa very shallow. Columella largely developed, consisting of nearly horizontal trabeculæ from the lace-like septa, and of its special tissue. Tissue spongy, filling up much of the lower part of the calice, and projecting a little at the bottom of the shallow fossa. Septa delicate, a little thicker at the calicular margin than elsewhere, barely projecting; they slant rapidly downwards and inwards, being slightly dentate. Laminæ perfect and granular at the wall, but perforate and cellular elsewhere. In six systems of three cycles. The primary septa are a little projecting at the margin, arched inwards, then become concave, and finally reach the columella; the secondary either do not reach the columella, or do so by the trabeculæ, and are a little smaller than the primary; tertiary often barely developed. Endotheca greatly developed, extending even to the calicular floor; seen, in longitudinal sections, as faint lines on the septal laminæ, curved and often oblique, and as cross-bars between the septa at very short intervals; near the calice the dissepiments become oblique, and form complete floors between two septa, or simply join the septal laminæ by cross-bars. Exotheca greatly developed, that between the calices formed by wide dissepiments, and marked out into checkered spaces by the costæ; in the spaces a little papillary eminence is now and then seen; lower down and in longitudinal views the dissepiments are stout, project more than the costæ, and form cells generally higher than broad, but occasionally very broad and less high; they are nearly on the same plane throughout the corallum. There are six dissepiments to $\frac{1}{10}$ inch. The young buds have not the tertiary septa. Diameter of the calices from $\frac{1}{20}$ to $\frac{1}{10}$ inch.

The perforate laminæ of the septa, the exothecal development, and the density and compactness of the walls determine the genus. Only one recent West Indian form has been described, differing widely, however, from any other species. The *Cyphastræa oblata* from St. Thomas's has few costæ and almost confluent walls. The other species inhabit the reefs of New Holland, the Fejees, the Sandwich Islands, and the Red Sea. There are two Corals doubtfully referred to *Cyphastræa* by Milne-Edwards; they are both from the Lower Chalk, and were originally noticed by Reuss.

From the hard superficial limestone. Coll. Geol. Soc.

VI. Barbadoes.

1. Astræa Barbadensis, spec. nov. Pl. XV. figs. 6 *a*, 6 *b*.

Corallum tall, subplane, with tall and slender corallites, which are crowded, but distinct. Calices circular, but slightly prominent and very shallow. Costæ well developed, not much produced, except the primary, which now and then join those of neighbouring corallites; they are slightly spinous and inclined at the surface, and a little wavy in their longitudinal course, but are distinct and strong at their base. Primary and secondary costæ equal, the primary being now and then most produced; the tertiary do not vary much in size from the others, but are less produced. Septa stout, projecting upwards considerably from the calicular margin, especially the primary;

superior margin irregularly dentate. Each septum corresponds with a costa, is large at the wall, tolerably thick internally, and not delicate in any part of its course. Laminæ not granular, well developed, not perforated, joining the columella by delicate processes which pass upwards and inwards. In six systems of three cycles. The primary and secondary septa are nearly equal, and reach the columella; the tertiary reach but a little way inwards, and end in a sharp edge. Columella parietal, slightly developed. Exotheca tolerably well developed between the costæ; cells nearly square and very small. Endotheca very scanty. Wall cylindrical, well developed. Diameter of the calices $\frac{1}{10}$ inch.

The fossilization of this specimen is peculiar; the loculi are not filled with any mineral, and the sclerenchyma is silicified and very crisp in its texture.

This species is closely allied to the recent *Astræa annularis* (Pacific?), but differs in not being convex and subgibbous in shape, in not having a strong paliform tooth on the septa, and in not presenting delicate walls and horizontal processes from the laminæ to the columella. It is more remote from a common West Indian form (*Astræa stellulata*) than it is from *A. annularis*.

There is no recent Coral which corresponds to this tall, subplane, simply laminar Astræan.

From the Marl; the specimen was obtained from a well 40 feet deep. Coll. Geol. Soc,

A cast has also been obtained from the Marl-formation of Antigua.

2. Oculina, sp.

A worn specimen; species not to be determined. Coll. Geol. Soc.

3. Madrepora, sp.

A rolled specimen. Coll. Geol. Soc.

These last two specimens are too fragmentary for specific determination, and their original position with regard to the raised reef is uncertain.

D. *General Observations on the Genera and Species.*

I. Antigua.

The absence of simple Corals from the collection from Antigua is somewhat remarkable, especially when their prevalence in San Domingo and Jamaica is considered. Equally remarkable is the presence of no less than nine species of *Astræa*, some of them second to none in size and development. The large blocks of these *Astrææ*, the existence of *Mæandrinæ*, *Alveoporæ*, and a species of *Stephanocœnia*, together with a large *Rhodaræa*, indicate a reef with "Pacific" rather than West Indian peculiarities.

The predominance of the genus *Astræa* is remarkable, and there is no instance of so many forms being found elsewhere in so small an area. The majority of the specimens from Antigua are great masses of Coral covered with casts of the calices, and are for the most part Astræans. By far the greater number belong to the species I have named *Astræa crassolamellata,* from the great thickness of the outer part of the principal septa. The six varieties and the typical form of this species form a most interesting group; and although no specimens have as yet been discovered except in Antigua, still there are some remarkable specific alliances. I have preferred terming the several forms described, varieties, for they all have the closest structural resemblance to each other and to the typical form. There is generally some variation in the appearance of the individuals of compound corals; this is not simply the result of immaturity or of arrested development, but is to be referred to the causes which determine individual differences in secondary and tertiary characters. Some masses of the species *Astræa crassolamellata* consist of aggregations of corallites which have those individual peculiarities and deviations from the type which are to be seen in a few corallites in the typical specimens; and in the variety *pulchella,* which is very polymorphic, the corallites of a large corallum vary sufficiently in different parts of it to constitute other varieties were the specimen broken up and its original entirety not understood.

The restriction of *Astræa crassolamellata* to the Marl-formation is interesting. The species does not appear to have any close West Indian affinities, either fossil or recent, and it must be referred to that part of the Miocene Coral-fauna which, having a much earlier origin, died out in Tertiary times.

The fossil Corals of the West Indies appear to have relation to two distinct Coral-faunas, one of which existed during the Oolitic period, and has also left its traces in the Lower Cretaceous strata, and another whose first appearance is uncertain, but which attained its greatest development during the Miocene period, and is now represented in the Pacific Ocean and its associated seas.

The European fossil Corals related by structural resemblances to *Astræa crassolamellata* are *Astræa Lifolensis,* Middle Oolite, and *Astræa Guettardi,* Miocene. A specimen of the first from the Vosges, in the British Museum, has great resemblance to those of the new species; and the description of *Astræa nobilis,* now merged into *Astræa Guettardi* by Milne-Edwards and J. Haime, suggests the existence of several important points of structural affinity between that species and *Astræa crassolamellata.*

The species *Astræa endothecata,* of which there are varieties in Antigua, is a San-Domingan type; and *Astræa Antillarum,* from Montserrat, is closely allied to it.

Astræa cellulosa and its variety with curved septa are very remarkable forms; they are in many respects miniatures of the great *Astræa endothecata,* and are found in the older strata. Their discovery in a formation where fossil Wood, and Testacea not purely marine, are noticed is interesting; for the presence of fresh or brackish water is very antagonistic to coral-growth, and especially as the great *Astræa* which they resemble was found in the Marl, which contains no evidence of such conditions.

Astræa megalaxona increases by fissiparous growth, as well as by extracalicular gemmation; in this it resembles the recent *Astræa Pleïades*; moreover it would appear that one of the varieties of *Astræa crassolamellata* does so likewise.

Astræa radiata, var. *intermedia*, connects the fossil *Astræa endothecata* with the recent *Astræa radiata* of the Caribbean Sea; and *Astræa costata* has a close affinity with the recent *Astræa cavernosa* of the West Indies.

Astræa Barbadensis, which is common to the Marl-formation of Barbadoes and Antigua, has a close affinity with *Astræa annularis* of the Pacific, but differs from all the known recent West Indian forms.

Astræa Antiguensis is a well-marked species and a very fine form; it has many structural affinities with *Astræa endothecata*, and to a slight extent with *Astræa cavernosa*.

There are two species of *Isastræa*, one of *Astrocœnia*, and one of *Stephanocœnia*, at Antigua.

The range of the genus *Isastræa* has been difficult to determine, on account of the state of preservation of some Corals of the genus *Prionastræa*, which would appear to be of Miocene age. The *Isastrææ* of the Antiguan beds have a very remote affinity to the Miocene corals formerly called *Prionastræa irregularis*, *P. diversiformis*, and *P. aranea*, but a very close resemblance to the true *Isastrææ* of Tisbury. They are without columellæ, and can only be classified under the genus *Isastræa*; one species equals *Isastræa tenuistriata* (Inferior Oolite) in the number of its septa, but is a dwarf, its corallites never measuring more than $\frac{3}{10}$ inch across: the other has great resemblances, both in its structure and mode of fossilization, to the *Isastræa oblonga* (Portland); it is smaller, however, and the septal number is never so complete.

Isastræa angulosa, Edwards & Haime (Mæstricht), is also closely allied to the *Isastræa turbinata* from Antigua.

The *Astrocœnia* so common in Antigua is found in irregular masses, which present most curious varieties of silicification. The form is hardly separable from *Astrocœnia ornata* (Turin, Miocene), even as a variety, but the typical form is found in small masses. This variety is only remotely allied to the species of *Astrocœnia* from Jamaica, which is the *A. decaphylla*, a European Cretaceous form.

The *Stephanocœnia tenuis* of the oldest beds has not been found in the Marl; it has only a generic affinity with the species from the Miocene of San Domingo, and its alliances with all the known forms are remote; it approaches *Stephanocœnia formosissima* and *Stephanocœnia intersepta* more closely than it does the Eocene species. The genus ranges from the Jurassic strata to the recent Coral-formations, species having been determined from the Oolite at St. Mihiel, from the Lower Cretaceous strata at Gosau, and from the Eocene; but not hitherto from the Miocene, though *S. intersepta*, which is barely separable from the Gosau *Astræa* (*Stephanocœnia*) *formosissima*, Sowerby, is said by Lamarck to exist in the American and South Seas.

The *Solenastræa Turonensis* of the Faluns appears to be represented in Antigua: there is some doubt about the accurate determination of the Antiguan form, on account of its state of preservation; but, as far as the structures can be seen, the fossils are specifically the same.

Species of the genera *Astroria* and *Cœloria* are found in the Chert, and are remarkable for the beauty of their silicification, the original hard tissues being turned into homogeneous black flint, whilst the interspaces are filled with opalescent silica. These are the first fossils of the genera which have been noticed; and the species are remote from *Cœloria labyrinthiformis*, which is said by Dana to exist round the Bermudas and in the Red Sea.

It is very doubtful whether the species of *Cœloria* and *Astroria* (see note attached to the description of the species, p. 424) said to be of West Indian origin are really so. *Astroria Sinensis* is commonly offered for sale as a West Indian specimen, with other corals decidedly belonging to the East Indian fauna. The Red Sea *Astroria astrææformis*, and *Astroria stricta* from the Straits of Malacca, have very close structural alliances with the new species from the Chert of Antigua, one of which (*Astroria polygonalis*) is a well-marked and most important species.

The Antiguan species prove how gradual is the passage from a perfect *Astræa* to a sinuous *Cœloria*, through the fissiparous *Astrææ* already mentioned and the various *Astroriæ*.

It will be found difficult to maintain the present genera intact when the anatomy of these forms is better understood; for in one specimen there are such variations of thickness of wall, depth of fossa, and length of series, as seriously interfere with its satisfactory classification; and it is most probable that in most specimens, when they were entire, similar variations existed.

The *Alveoporæ* are reef-corals, and although there are species common to the limestones of Antigua, Jamaica, and San Domingo, still the genus is no longer West Indian, but Pacific. These are the first instances of fossil *Alveoporæ*.

The large *Rhodaræa* is allied to *R. Raulini* of the Dax Miocene, though but slightly; all the recent species are found in the Chinese and Australian Seas, not in the Caribbean.

There are none of the species of those genera which are so strongly represented in the present West Indian Seas amongst any of the collections of Antiguan fossil Corals in the British Museum, the Museum of the Geological Society, or the Museum of Practical Geology. For example, the following well-known recent West Indian genera are quite unrepresented:—

Eusmilia.	Colpophyllia.	Prionastræa.	Oculina.
Ctenophyllia.	Manicina.	Siderastræa.	Porites.
Dendrogyra.	Diploria.	Parastræa.	Madrepora.
Lobophyllia.	Cladocora.	Phyllangia.	Millepora.
Symphyllia.	Cyphastræa.		

There is a *Mœandrina* in the Chert which has very short series, and is very sinuous, but its details are too deficient to enable me to determine its specific affinities.

II. San Domingo.

The genera are very numerous, and include many simple corals. *Astræa, Stephanocœnia, Alveopora,* and *Mœandrina* are represented here as well as in Antigua.

The great *Astræa endothecata,* whose varieties at Antigua have been noticed, flourished formerly in the coral-reefs of San Domingo; it is characterized by the extraordinary development of its endotheca, and is only second in size to the great *Astræa crassolamellata* of the Marl of Antigua. Considering that several forms of *Astrææ* at Montserrat and Antigua are more or less structurally related to the great Astræan of San Domingo, it is necessary to examine the Astræans of the European Miocene seas for their alliances, especially as the Testacea of the Nivajè and Esperanza shales have a mid-tertiary facies.

It is, then, provisionally that I collect the Astræans with an unusual development of endotheca into a subgenus, as follows:—

Astræa Ellisiana. Dax, Turin, &c.	Miocene.
—— Reussiana. Vienna.	
—— Raulini. Leognan.	
—— Defrancii. Bordeaux and Turin.	
—— vesiculosa. Dax.	
—— cellulosa, et var.	Antigua.
—— endothecata, var.	
—— Antiguensis.	
—— Antillarum.	Montserrat.
—— endothecata.	San Domingo, Miocene. Miocene? of Persia*.
—— Forskælana. Red Sea and West Indian Seas, recent; subfossil in Egypt.	

The species are placed according to their affinities.

The range of species closely allied to *Astræa exothecata* is from the Miocene of Europe and of the East and West Indies to recent times, the only existing form being common to the Red Sea and the Caribbean.

Astræa cylindrica is a very interesting form, as it has not been found elsewhere than in the Nivajè shale; it resembles somewhat the recent *Astræa cavernosa* of the Antilles, and *Astræa costata* of the Marl of Antigua; it differs from *A. Forskælana* in the development of the endotheca and the rather cribriform septa.

Stephanocœnia is found in a ramose form; its presence in San Domingo is interesting on account of a species having been found in the Chert of Antigua, the geologic age of which is uncertain.

Alveopora fenestrata is found fossil; it is now common as a reef-coral in the South Seas; but although *Alveopora Dœdalœa* and its varieties also occur fossil in Antigua and in Jamaica, still there are no species of the genus in the present Caribbean Sea.

Barysmilia, which has a species at Le Mans (Greensand), at Gosau, and also at Uchaux†, is a well-marked genus; the species in the yellow shale at Esperanza, San Domingo, is clearly intermediate between the other forms.

* See a specimen in the British Museum. † Edwards and Haime, *op. cit*

In the yellow shale there is a ramose Coral which, provisionally, is classed with *Phyllocœnia.* With one exception, its structural characteristics agree with a very remarkable Coral which has been referred to many genera, having been called by Goldfuss *Madrepora limbata,* by Bronn *Oculina limbata,* by M'Coy *Gemmastræa limbata,* and by Milne-Edwards *Stylina limbata.* Our species has no columella visible; and although it is notorious that the little sharp columellæ of *Stylinæ* constantly fall out, still I have considered it advisable to disregard this and to classify the form with *Phyllocœnia,* and to state the probability that other specimens will determine the presence or absence of a columella. Another species so closely resembles *Phyllocœnia sculpta* (Michelin, Zooph. pl. 71. figs. 1 & 3), that it can only be considered a variety with a tile-shaped corallum. *Phyllocœnia sculpta* is from the Hippurite-limestone of Martigues. There are no existing forms known, and it is worthy of notice that the San Domingan species are but very distantly allied to the Eocene and Miocene species of the genus.

Brachycyathus, known amongst European Corals from the Neocomian, has a species at San Domingo, very remote, however, from *B. Orbignyanus.*

Stylophora, a genus closely allied to *Astrocœnia* and to the *Oculinidæ,* is represented by one species in the Blue Shale of San Domingo; it is more closely allied to the Miocene species from Dax, Gaas, and Turin than it is to any recent one. The recent *Stylophora mirabilis* of the West Indies is a doubtful species, but many live around the Fejees, East Indies, Seychelles, Zanzibar, and the Cape of Good Hope, and in the Red Sea.

Siderastræa crenulata, a well-known species from the Gironde Miocene, has a variety in the Blue Shale of San-Domingo. There is a very close resemblance between all the *Siderastrææ,* but the recent West Indian species are clearly more allied to the Miocene forms than the latter are to the Eocene species.

Flabellum is represented by two species in the Blue Shale, and in the Limestone there are many examples of impressions which probably denote a third. *F. dubium* of the Shale resembles in some points *Flabellum Galapagense,* Edwards & Haime, from the Miocene of the Galapagos. There are no recent species in the West Indies, but they abound to the west of America.

Placotrochus, a genus inhabiting the coral-sea of the Philippines and China, has a fossil species both in San-Domingo and Jamaica.

Trochocyathus cornucopia, Edwards & Haime, a species common to Tortona and the Vienna Miocene, is represented in the San-Domingan Tertiary beds; it is so characteristic a form that it stamps their age satisfactorily.

The San-Domingan *Thysanus corbicula* is allied to the Jamaican *Thysani*; but these beautiful corals do not appear to have any very close recent allies, although they have affinities with *Flabellum, Rhizotrochus,* and *Ceratotrochus.*

Dichocœnia tuberosa, a common fossil of the Blue Shale, belongs to a genus doubtfully represented in the French Grès Vert, but well known in the present Caribbean Sea and in the Indian Ocean and Red Sea. Singularly enough, the fossil San-Domingan species is more closely allied to *D. porcata* and *D. uva* of the Indian and Red Seas than it is to *D. Stokesii, D. Cassiopea,* and *D. pulcherrima* of the sea around Cuba and St. Thomas.

Agaricia agaricites and *A. undata* are common both in a coral-breccia in the San-Domingan shales as well as in the West Indian seas. The genus dates from the Cretaceous period, occurring in rocks of that age in France; it has a very wide distribution in the present day, and is found subfossil by the side of the Red Sea.

Cyphastrœa costata, found in the Barbuda limestone, occurs also in San Domingo; a slight variation exists in the wavy course of the exotheca, but this forms no specific distinction. The genus is distinguished from *Astrœa* by the imperfect condition and cribriform appearance of the septa, and the condition of the septa in *A. Forskœlana* shows the close relation of that species to the *Cyphastrœœ.* The correlation of growth between certain parts of the sclerenchyma of compound Astræans is as yet little understood; but thick septa and large columellæ are usually found associated with thin walls and slender costæ, whilst thin septa, thick walls, and large costæ are common; it is, therefore, quite possible that the thick walls, great costæ, and well-developed endotheca and exotheca may have a significance with regard to the cribriform septa. There are recent species in the Caribbean and East Indian seas.

III. Jamaica.

There is a general relation between the fossil Corals of Jamaica and of San Domingo, and several species are common to both islands. *Cyphastrœa costata,* common to Barbuda and San Domingo, is found also in the Tertiaries of Jamaica; and *Alveopora Dœdalœa,* fossil in San Domingo and Antigua, but recent in the Pacific, is a common form in the hard, white Tertiary limestone.

Porites is represented in Jamaica by a fossil species related to the recent forms in the Caribbean Sea.

The great *Montlivaltia ponderosa* of the Guadaloupe Miocene is found in Jamaica and also in San Domingo; moreover *Placocyathus Barretti* is a prominent Jamaican form.

A very remarkable *Placotrochus* with a lateral erosion is peculiar to this island, and a species of *Thysanus* also. As in considering the species from Antigua and San Domingo, Corals were noticed allied to forms in Secondary European strata, so in Jamaica *Astrocœnia decaphylla* (the *Astrœa decaphylla* of Michelin, from Gosau and Corbières) is found in an admirable state of preservation.

The new species of *Siderastrœa* in the British Museum is a tall and massive form, well worthy of the name "*grandis.*" Doubtless, as more specimens are obtained, the Corals will determine the age of the Tertiaries lying upon the Chalk in this island.

IV. Barbadoes.

The Corals from this island were obtained partly from a well sunk 40 feet in the Coral-marl, and some were picked from the shore.

Astræa Barbadensis is a very distinct species; it is found fossil also in the Marl-formation of Antigua, and it is more closely allied to the recent *Astræa annularis* of the Pacific than to any recent West Indian species. The *Oculina* and *Madrepora* are too fragmentary to be determined specifically; they would appear to have come from a dense Coral-breccia.

V. Guadaloupe, &c.

Paterocyathus is a new genus.

Cyathina is represented by a species like the *C. arcuata* of Europe; there are no recent *Cyathinæ* in the West Indies.

A species of *Solenastræa* and a *Mæandrina* are also found in the island; and the genus *Trochosmilia* is said to be represented there, associated with the Palæozoic *Favosites*.

Montserrat has the *Astræa Antillarum*, closely allied to *Astræa endothecata*, amongst the beds which contain its silicified Woods; and from Barbuda there has been, as yet, only one fossil Coral obtained —a *Cyphastræa*, which was discovered in a mass of Shells and Corals under the superficial soil.

It is most unfortunate that the state of fossilization of the Trinidad Upper Parian Corals should have rendered their determination doubtful. Mr. Etheridge, using Dana's nomenclature, distinguishes some fossil Astræans with recent alliances; a *Turbinolia*, an essentially Eocene genus, and the *Astræa Pleïades*, which most probably is *Astræa megalaxona*.

E. *Conclusion.*

It has been noticed that the *Testacea* sent from Antigua with the Corals have been stated to belong to the present age. This is correct; but there are a few Shells and casts of Shells of an older date. A *Helix*, common as a fossil, is not now, according to Dr. Nugent, an inhabitant of the island; and the extinct *Melaniæ* are found in great abundance with silicified Woods.

Both in Jamaica and in San Domingo there are late Tertiary Shells and Corals, but it is impossible to bring these facts in antagonism with those which give a more remote age to the strata whence the specimens described were obtained.

So with regard to Antigua, Barbuda, and Barbadoes, it is not correct to give the whole Islands a Pliocene or Postpliocene age because recent and subfossil Shells are found in them.

As yet, the *Testacea* have not assisted in determining the geologic age of the three coral-formations of Antigua; but Mr. C. Moore has given a Miocene age to the *Mollusca* from the San-Domingan shales, whence the Corals here described were derived. The Alabama Eocene Shells and Corals are distinct from those of the raised Coral-beds of the West Indian Islands; and it is worthy of remembrance that, although there are genera and species of Corals in Antigua, San Domingo, and Jamaica belonging to the great European Miocene Coral-age, still there are a few European Miocene genera of Corals which are not as yet known to belong to the West Indian Miocene.

The range, in strata, of the genera of Corals is often so great, and the species of remote formations are so frequently closely allied, that the *Zoantharia* form better guides for estimating the external physical circumstances of the regions in which they existed, than for determining the age of strata. There are few subjects better understood than the relation between the presence of certain genera and species of Coral and certain definite, external, physical conditions. Depth of sea, purity of sea-water, its intense aëration, force of wave, absence of fresh water, the climate and nature of the coast-line, with all their possible varieties, appear to determine, according to their mutual reactions, the presence and persistence of species and genera. Indeed, very slight variations from the general rule of the external circumstances in a Coral-sea would appear to prevent the development of certain genera. It is a reasonable induction that, if a species be found in strata of any age and distant in space, the two sets of strata were formed under the same external physical circumstances.

The question of contemporaneity may be fairly considered when the strata are close together in which identical forms, or those closely allied, are found. Thus, *Stephanocœnia formosissima*, of Gosau and Uchaux, is so closely allied to *S. intersepta* of the present South Seas, that there is hardly a specific difference. When the latter is broken from recent Coral-limestone, all that can be said is that the modern and the ancient Corals existed under the same circumstances of climate and aqueous distribution.

But when *Stephanocœnia dendroidea* is found fossil at San Domingo, and a closely allied species at Antigua, and when the short distance between the formations, and the existence of the equivalents of the Caribbean and of the older and newer Parian formations throughout the West Indian Islands are considered, the sameness of external circumstances may be received as a concurrent testimony of identical age.

There is nothing anomalous, as would at first appear to be the case, in finding species already classified amongst European Cretaceous Corals, in West Indian Miocene strata; nor in finding species of Jurassic Corals closely allied to forms in these Mid-tertiaries.

The European Miocene contains both Jurassic and Lower Cretaceous genera, and in some instances the specific relations of the Corals are very close. Thus, *Astræa Lifolensis* is hardly worthy of a specific distinction from *Astræa Guettardi*, and the *Phyllocœniæ* of the formation at Corbières greatly resemble those of Dax and Castel Gomberto.

The Isastræans from Antigua, whatever may be the geologic age of the Chert, are very closely allied to those of the Oolites, and it is unnecessary to repeat the close resemblance of some and the identity of other San-Domingan Miocene Corals to European Cretaceous forms.

It is somewhat singular that the majority of the genera common to the earlier Secondary formations and to the Miocene are extinct; and that, on examining the Corals common generically to the Jurassic and the Miocene (the two great Coral-ages), many of these genera will be distinguished in the Lower Cretaceous horizon.

The determination of the geologic age of the Trap, the Inclined Conglomerate, the Chert, and the Marl of Antigua can only be subject to doubt at present; but that these three last strata should be of the same age as the coral-reefs in the surrounding sea is impossible, inasmuch as the silicified Corals have a greater resemblance to European fossil forms and to Pacific and East Indian recent forms than to those of the present Caribbean Sea.

From the consideration of the affinities of the fossil Corals of Antigua, San Domingo, and Jamaica, all of them possessing forms in common—species and genera of European Miocene age, and many now existing in the Pacific and East Indian seas, together with a few varieties of species peculiar to the present West Indian Ocean,—the doubtful age of the beds of the first Island may be approximated to that of those in the others.

The paucity of recent species in these Miocene Coral-beds is very remarkable. In Antigua there is not one West Indian recent species; and in San Domingo the *Agaricia agaricites* is the only decided recent form, for the *Agaricia undata* being in the form of a variety, and the general absence of the characteristic West Indian genera, give a foreign look to the Miocene Coral-fauna of that Island.

There are species common to the European and West Indian Miocene, and several genera appear in the latter for the first time as Miocene.

The relation of the Lower Cretaceous system underlying the Tertiaries in San Domingo, Jamaica, and Trinidad must be remembered in reflecting on the apparently misplaced Cretaceous Corals in those Islands and in Antigua.

There was a vast alteration in the physical geography of the West Indian seas caused by the gradual upheaval of the former Coral-reefs and banks, now recognized as the Newer Parian of Trinidad, the Shales of San Domingo, the Inclined Beds of Jamaica, and the compound formation of Antigua, previously to which these probably contemporaneous formations attained far less than their present magnitude. The area of elevation was a vast region, and the remains of the flora of the period prove the corresponding depression to have been great. It appears that this slow and yet immense physical change terminated the Miocene age in the Caribbean region; or, rather, altered the external conditions which were necessary for the persistence of the species, and produced such new combinations of those external conditions as were antagonistic to the perpetuation of the old Coral-fauna, but favourable to the development of those varieties of its species which were the progenitors of the present peculiar Caribbean types.

If the breaking down of the Arctic barrier-land ended the

Miocene period of Europe by the production of a great change of climate and the consequent introduction, by emigration, of forms with more or less arctic affinities into the European fauna and flora—if this be held to be a reasonable explanation of the cause of the difference between the Miocene and Pliocene formations in Europe, corresponding data exist to connect the end of the Miocene Coral-fauna of the West Indies with the physical revolution which closed the Pacific from the Caribbean.

The peculiar Coral-fauna of the Caribbean Sea is strongly represented in all the superficial deposits of the Islands, and there are no forms, so far as is yet known, amongst these which have other than West Indian affinities. Some genera are found which prove that the causes producing the more or less arctic condition of the European Pliocene, affected very slightly the climate of the Caribbean Sea also. But in all the calcareous formations which are coralliferous and are considerably elevated above the level of the Caribbean Sea, there is a very limited series of Corals with generic relation to those now existing and characteristic of the West Indian Coral-fauna, but a predominance of forms resembling those of the present Coral-seas of the Pacific, South Sea, and the Indian Ocean*.

The most strongly marked West Indian species are not represented, even in the raised beds, by allied species; and it can readily be believed that a great change in the distribution of land and sea preceded the extinction of the Corals with Pacific affinities.

In the Coral-seas of the South Sea, Pacific and Indian Oceans, and Red Sea, the external circumstances which are so well known to influence Coral-life are very different from those which operate in the restricted West Indian regions.

In the first there is an extraordinary freedom from the effects of great rivers, such as pour mud and fresh water for leagues into the pent-up Caribbean Sea: in the great Ocean there are opportunities for migration of species, but in the case of the Caribbean there are impediments on all sides: in the Coral-islands of the Pacific the soundings are soon found to be great; but in the northern part of the Caribbean, the great banks, which in their shallow sea somewhat resemble the shoals to the north of the Malay Archipelago, are rarely affected by the furious surf and force of wave, which appear to determine the persistence of several species; on the contrary, peculiar genera are seen to flourish around Cuba and the Bahamas.

The presence of species of *Alveopora*, *Stylophora*, *Flabellum*, *Placotrochus*, *Rhodaræa*, *Astroria*, *Cœloria*, &c., in the raised Coral-formations must refer to a different condition of the physical circumstances of the West Indian seas from that now existing, and to those peculiarities of climate, of sea-depth, purity and force of sea, and of coast-line, which are noticed in the ocean between Eastern Africa and America. It is worthy of notice that, at the present time, the Australian, Pacific, and Indian Ocean Corals differ as a rule in species and often in genera, that the nearest coral-reef is hundreds

* Mr. J. Carrick Moore asserts that the San-Domingan Shells have a Pacific facies; see Quart. Journ. Geol. Soc. vol. vi. 1850, p. 43, and vol. ix. 1853, p. 131.

of miles to the west of the Isthmus of Panama, and that the Corals of the Atlantic are few and far between; yet the existing Coral-provinces are all represented in the Miocene beds now under consideration.

The genus *Flabellum* has no species in the Caribbean Sea, but there are some in the San-Domingan Miocene; they abound in the Australian, South, and China Seas as recent forms, and a fossil species has been discovered in the Galapagos Islands; it was named by Milne-Edwards *F. Galapagense*, and determined by him to be derived from a Miocene bed. This fossil has a resemblance to a new form from the San-Domingan shale; moreover the great *Montlivaltia* of the Jamaican Miocene is found at Travancore. This carries the subject of a former connexion between the Central American Sea and the Pacific Ocean, during the life of the Miocene Corals, a step further; and the consideration of the extent of the Newer Parian series, of the relation of the Tertiary formations of the Isthmus to the central mountain-chain, and of the elevation and magnitude of the Miocene strata in the Antilles, strengthens the hypothesis that the Corals of the San-Domingan and Antiguan beds were washed by the same sea which nourished the progenitors of the present Pacific forms.

Nothing can be more satisfactory than the determination of the alliances between the San-Domingan and Antiguan fossil Corals and those characteristic of the Faluns and of the Viennese, Bordeaux, Dax, Saucats, and Turin Miocene.

The affinity between the Corals of the European Miocene and the Pacific recent forms is as decided as that noticed now for the first time between them and those of the Antilles Miocene.

Doubtless further researches will discover more species common to the European and American Miocene than have yet been described, and perhaps some genera also; but, from the study of the forms now under consideration, it is evident that a greater facility for Coral-migration between the two sides of the Atlantic existed formerly than is now the case.

The researches of Prof. E. Forbes and Mr. Godwin-Austen have led to the belief that, during the Mid-tertiary period, Europe was very much in the condition of the present Pacific Archipelago; Mr. Darwin concurs in this view, and it is reasonable to affirm the prolongation of the maze of islands across the Atlantic. Prof. Heer accounts for the specific identity of European and San Domingan Miocene Plants by a great continent intervening; but such masses of land are antagonistic to coral-growth, by the production of rivers of great size; moreover, there are positive proofs of old Coral-reefs between San-Domingo and the Atlantic. A series of islands, formed very much like the Antilles, with Coral-reefs around them, extending from the Mid-pacific across to Europe, would remove Heer's difficulty, and account for the relation between the Miocene Corals of the Old and New World and those of the Galapagos and East Indian raised beds, as well as the relation between the former and the recent species of the great seas to the west of America.

On the Fossil Corals *of the* West Indian Islands. Part I. Appendix. By P. Martin Duncan, M.B., F.G.S.

ERRATA, AND NOTES ON PLATES XIII.–XVI.

Page 415, line 37, dele *a*, 4 *b*.
,, 434, line 1, *add* 7 *c*.
,, 442, line 30, for *C. ponderosa* read *M. ponderosa*.

Plate XIII.

In Figs. 1 *a*, 2 *a*, and 5, the septa and the original hard parts are white, whilst, from a difference in their silicification, the corresponding parts are black in figs. 3, 4, and 6.

In the natural cast, fig. 1 *b*, the black portions were once occupied by sclerenchyma; the interstices now alone remain, being filled with a white siliceous mineral.

Fig. 8. The costæ, which are often worn, are generally rather more visible than those on the side nearest the number.

10. The dark lines are the sclerenchymatous parts more or less thinned during mineralization, the interstices being white from infiltration.

11. The costæ are best seen at the lower margin; the dark spots are spaces on either side of their extremities. In this specimen the sclerenchyma is white, and the interspaces black.

12 *a*. The septa and wall are white in this figure, and black in fig. 12 *b*. The natural appearance of the sclerenchyma has been nearly obliterated by the process of silicification.

Plate XIV.

Fig. 9. The appearance of the costæ can be determined by reference to Plate XV. figs. 7 *a* and 7 *c*.

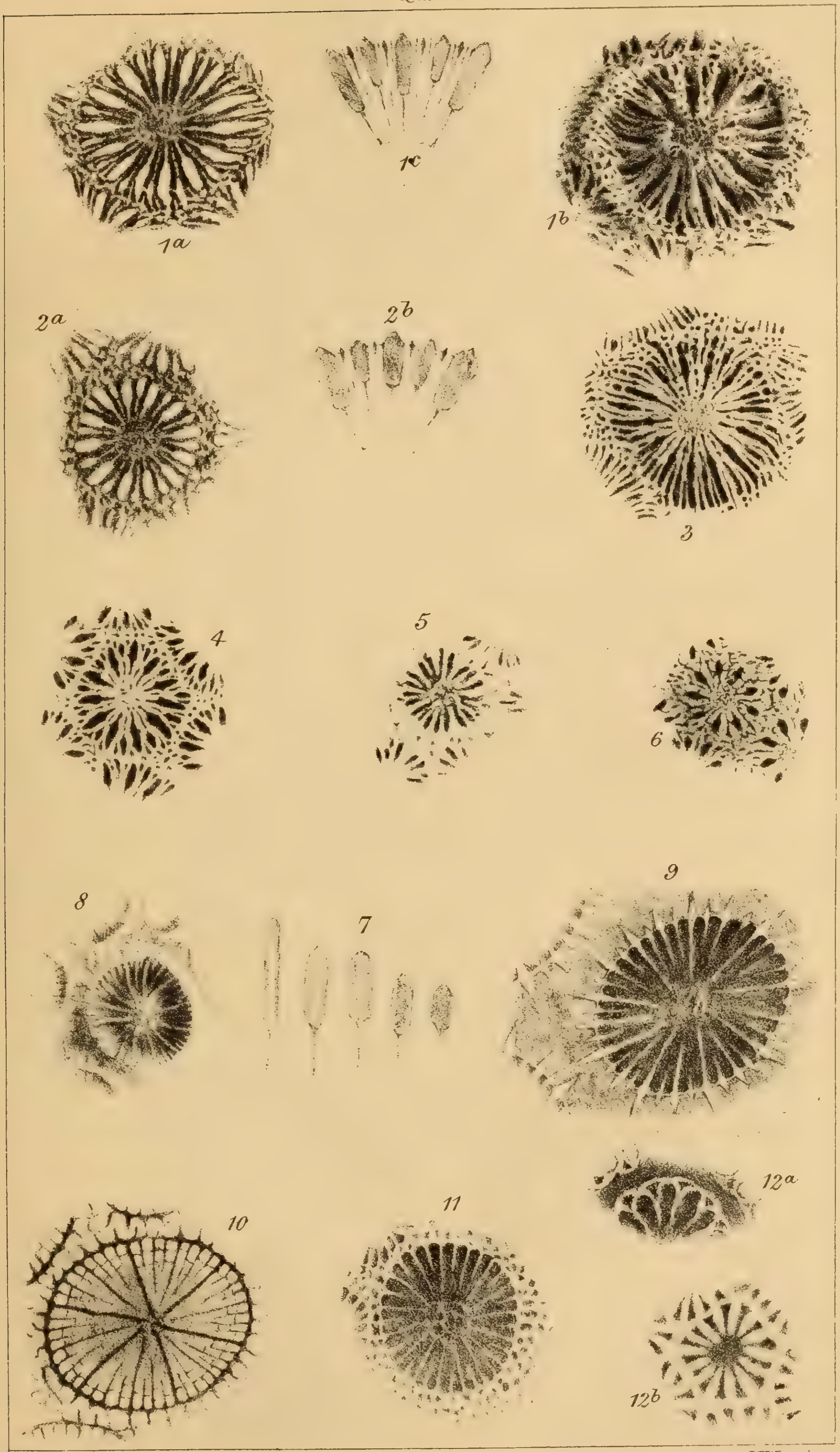
Plate XV.

Fig. 2 *b*. The columella should appear as a thin white line extending across the long axis of the central black space.

6 *c*. The dentations of the septa have been omitted accidentally.

7 *c*. This figure represents the larger costæ, the dentate smaller costæ, and the exothecal dissepiments of *Astræa endothecata*.

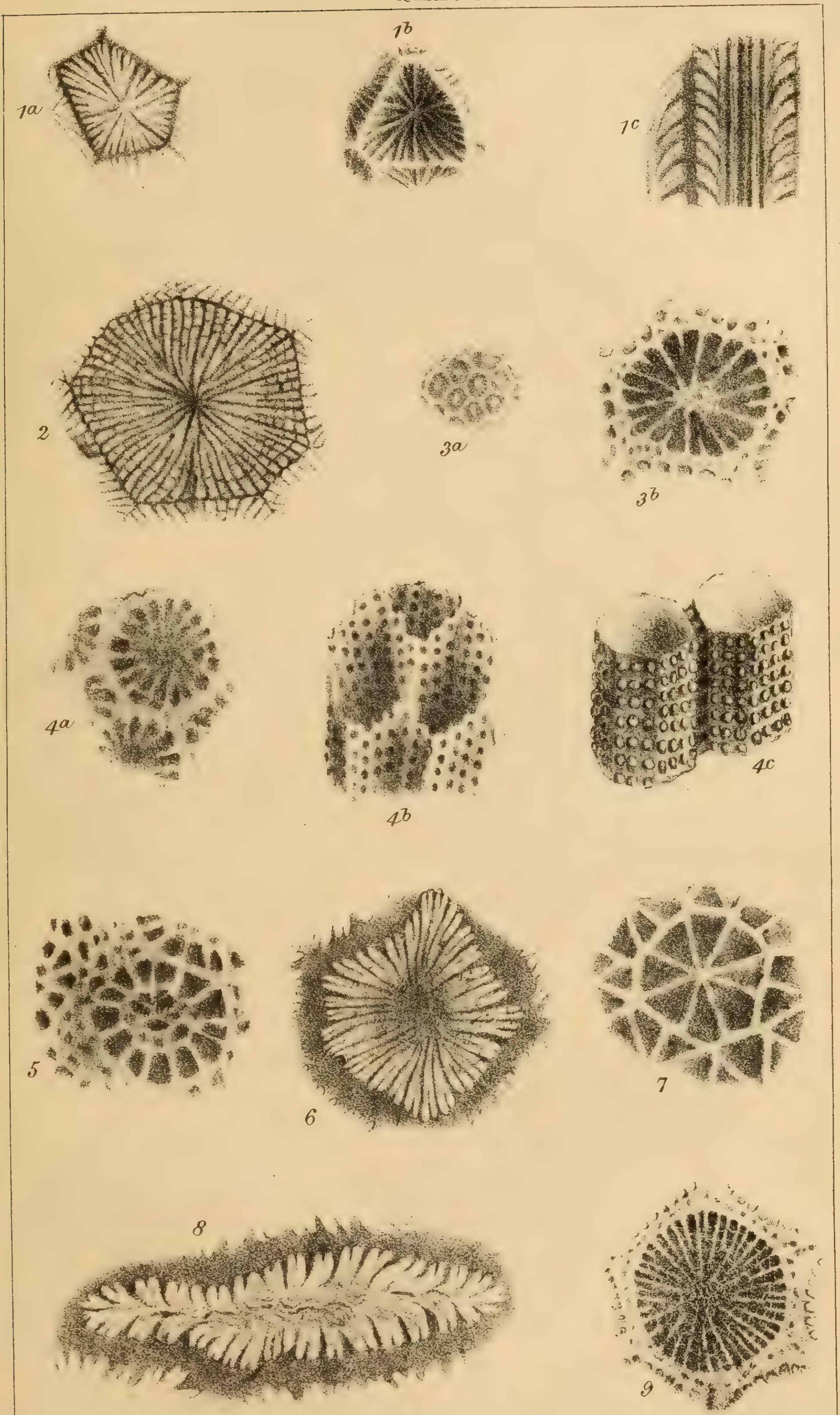
The artist has given the general appearance of the specimens, and, in most instances, the minute characters also, with great exactness; but in the others the condition of the Corals and their variable colour will account for slight discrepancies.—[P. M. D.]



Geo. West lith. ad nat.

W. West imp.

WEST INDIAN FOSSIL CORALS.



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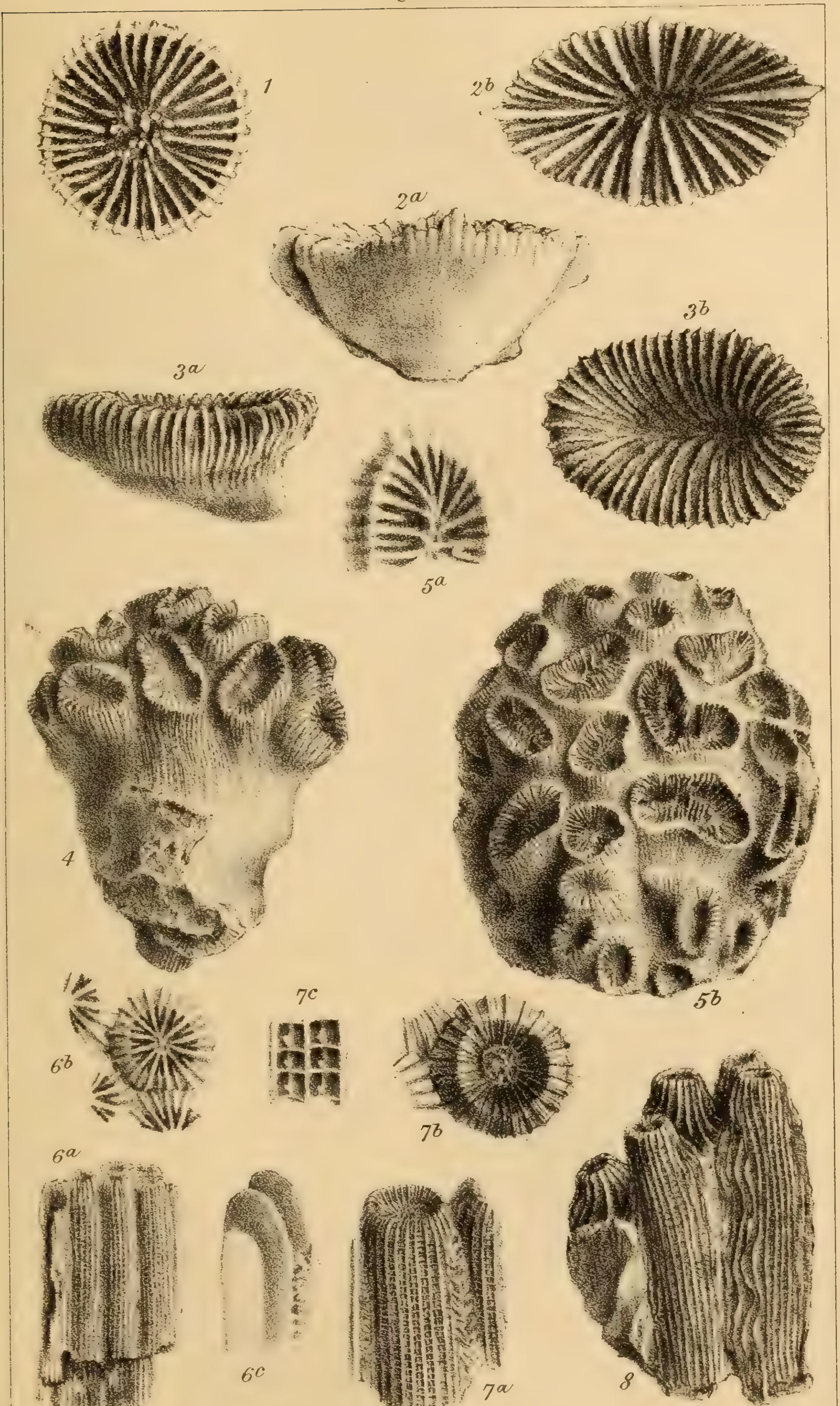

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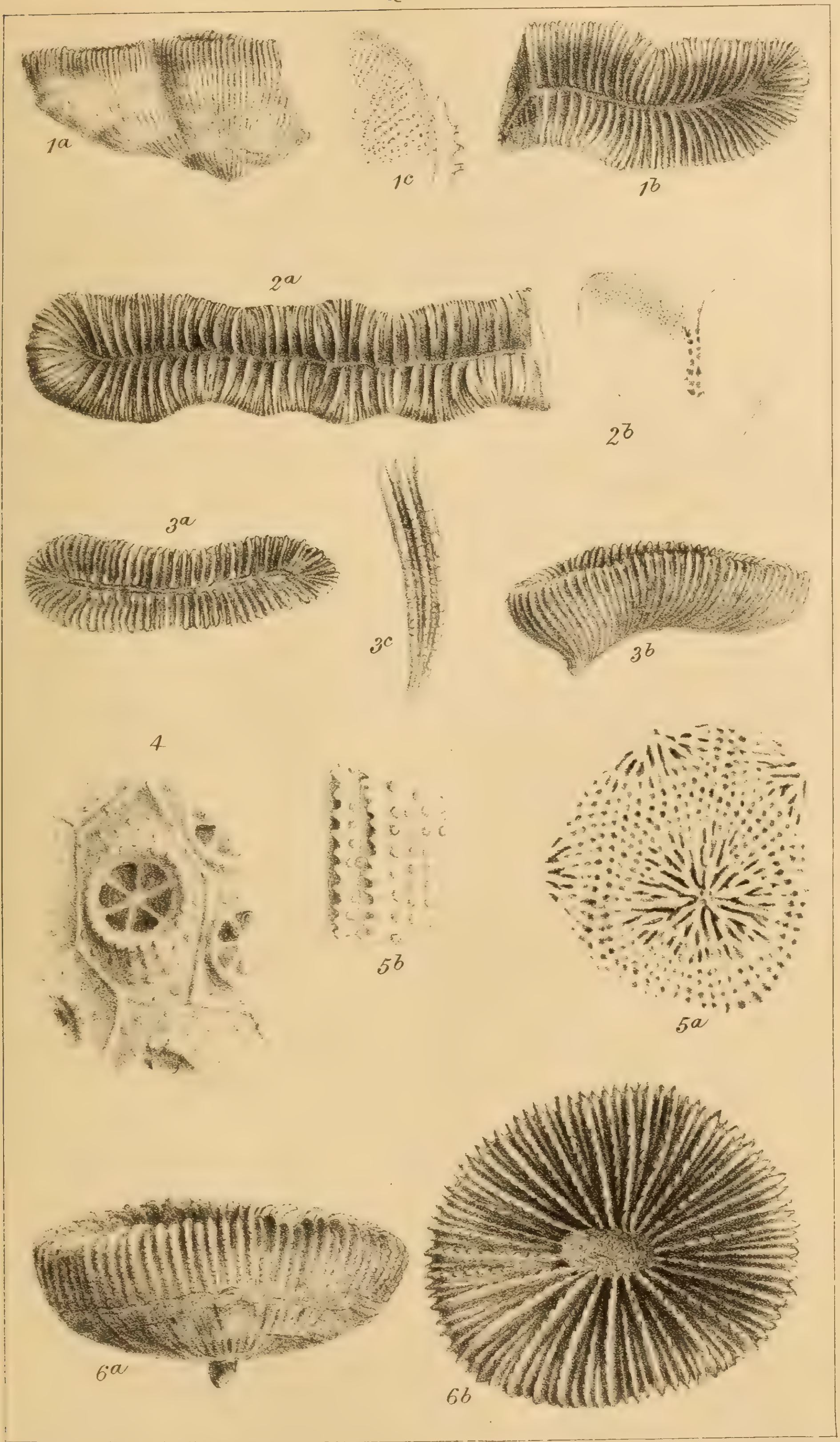

Geo. West. lith. ad nat.

W. West imp.

WEST INDIAN FOSSIL CORALS.

EXPLANATION OF PLATES XIII.–XVI.,

Illustrative of the Fossil Corals of the West Indies.

Plate XIII.

Fig. 1. *Astræa* (*Heliastræa*, Edwards & Haime) *crassolamellata*: *a*, transverse section of a corallite; *b*, natural cast of a calice; *c*, diagram of the septal arrangement.

2. —— ——, var. *nobilis*: *a*, transverse section of a corallite; *b*, diagram of the septa.

3. —— ——, var. *magnifica*; transverse section of a corallite.

4. —— ——, var. *magnetica*; transverse section of a corallite.

5. —— ——, var. *Nugenti*; transverse section of a corallite.

6. —— ——, var. *minor*; transverse section of a corallite.

7. The primary septa of the various forms.

8. *Astræa* (*Heliastræa*, Edwards & Haime) *Antiguensis*; the calice, magnified ½ a diameter.

9. —— (——) *costata*; transverse section of a corallite, magnified 3 diameters.

10. —— (——) *cellulosa*; transverse section of a corallite, magnified 6 diameters.

11. —— (——) *tenuis*; transverse section of a corallite, magnified 3 diameters.

12. —— (——) *megalaxona*: *a*, transverse section of part of a corallite, magnified 4 diameters; *b*, transverse section of a cast of a corallite, magnified 3 diameters.

Plate XIV.

Fig. 1. *Isastræa turbinata*: *a*, transverse section of a corallite; *b*, calice; *c*, longitudinal section of a corallite; all magnified 2 diameters.

2. —— *conferta*; transverse section of a corallite, magnified 4 diameters.

3. *Stephanocœnia tenuis*: *a*, part of corallum; *b*, transverse section of corallite; both magnified 5 diameters.

4. *Alveopora Dædalæa*, var. *regularis*: *a*, transverse section of corallites; *b*, longitudinal view; *c*, same view of a cast; all magnified 6 diameters.

5. —— *microscopica*; transverse section, magnified 15 diameters.

6. *Astroria polygonalis*; transverse section of a cast, magnified 2 diameters.

7. *Astrocœnia ornata*; transverse section of part of a corallum, to illustrate the thinning of the larger septa and the absorption of the smaller during silicification, magnified 10 diameters.

8. *Cœloria dens-elephantis*; transverse section of the cast of a corallite, magnified 2 diameters.

9. *Astræa* (*Heliastræa*, Edwards & Haime) *endothecata*, var. 1; transverse section of a corallite, magnified 2½ diameters.

Plate XV.

Fig. 1. *Brachycyathus Henekeni*; calice, magnified 4 diameters.

2. *Placotrochus Lonsdalei*: *a*, lateral view of a corallite; *b*, calice; both magnified 4 diameters.

3. *Thysanus corbicula*: *a*, lateral view of a corallite; *b*, calice; both magnified 2½ diameters.

4. *Barysmilia intermedia*; corallum.

5. *Dichocœnia tuberosa*; *b*, corallum, of the natural size; *a*, calice, magnified 3 diameters.

6. *Astræa* (*Heliastræa*, Edwards & Haime) *Barbadensis*: *a*, lateral view of corallum, magnified ½ a diameter; *b*, calice, magnified 3 diameters; *c*, two septal laminæ, magnified 4 diameters.

7. —— (——) *endothecata*: *a*, lateral view of a corallite; *b*, calice.

8. —— (——) *cylindrica*: lateral view of part of the corallum.

PLATE XVI.

Fig. 1. *Placocyathus Barretti* (part of a corallite): *a*, lateral view; *b*, calice (both diminished ⅘ths); *c*, the columella and one of the pali, magnified 2 diameters.

2. *Placotrochus alveolus*: *a*, part of a calice, of the natural size; *b*, cross-section, magnified 2 diameters.

3. *Thysanus excentricus*: *a*, calice; *b*, lateral view of a corallite (both of the natural size); *c*, costa, magnified 2 diameters.

4. *Stylophora affinis*; calice, magnified 10 diameters.

5. *Siderastræa* (*Astræa*, Edwards & Haime) *grandis*: *a*, longitudinal view of the septa; *b*, transverse section of corallites; both magnified 4½ diameters.

6. *Montlivaltia ponderosa*: *a*, a young corallum, of the natural size; *b*, calice, of the natural size.

MAY 20, 1863.

Sir Charles Tilston Bright, C.E., 12 Upper Hyde Park Gardens; James Dees, Esq., C.E., Whitehaven; E. C. Hartsincke Day, Esq., Charmouth; W. Dickinson, Esq., M.A., Croydon; Robert Francis Hodgson, Esq., 126 Marine Parade, Brighton; the Rev. Charles Kingsley, M.A., F.L.S., Rector of Eversley, Hants, and Professor of Modern History in the University of Cambridge; Edward Coulson Musson, Esq., B.A., Martyr Worthy, near Winchester; Thomas Glazebrook Rylands, Esq., F.L.S., Heath House, Warrington; and John Scott, Esq., 3 Chester Place, Hyde Park, were elected Fellows.

The following communications were read:—

1. FURTHER OBSERVATIONS *on the* DEVONIAN PLANTS *of* MAINE, GASPÉ, *and* NEW YORK. By J. W. DAWSON, LL.D., F.R.S., F.G.S., Principal of M'Gill University, Montreal.

[PLATES XVII.–XIX.]

CONTENTS.

I. Introduction.
II. Perry, Maine.
III. Gaspé, Canada.
IV. New York.
V. Conclusion.

§ I. *Introduction.*

SINCE the preparation of my paper "On the Devonian Flora of North-eastern America," published last year*, I have been enabled to explore more thoroughly than heretofore the plant-bearing beds at Perry, in Maine; and Mr. R. Bell, of the Geological Survey of Canada, has collected some interesting specimens from the Gaspé sandstones, which have been kindly placed in my hands by Sir W. E. Logan for determination. Some important facts have also been ascertained respecting the distribution of the Devonian rocks of the State of New York, which give to several of the Plants from that region a somewhat older geological position than that assigned to

* Quart. Journ. Geol. Soc. vol. xviii. p. 296.

them in my former paper. These supplementary facts I now propose shortly to state.

§ II. *Perry, Maine.*

With respect to the geological relations of the rocks at this place, I have little to add to the descriptions of Professor Hitchcock, referred to in my former paper. The beds at Pigeon Hill and its vicinity, referred by him to the Upper Silurian, consist of hard, grey and reddish shale and sandstone, overlain by trappean or trap-ash beds, and traversed by trap-dykes. They are somewhat, but very unequally, hardened and altered, and are inclined at high angles, with prevailing dips to the north-east. They contain abundance of *Lingulæ*, and of small Lamellibranchiate Shells which have been referred to the genus *Modiolopsis*. Mr. Billings regards the *Lingula* as an undescribed species, and it appears to differ from that found at St. John. I think it quite possible, however, that these beds at Perry may be the equivalents of the St. John slates; and from their relation to other beds at Pembroke which contain fossils of Lower Helderberg age, and identical in many species with my "Arisaig group" in Nova Scotia, I cannot doubt that they are of Upper Silurian date, unless indeed they may be Lower Devonian.

Upon these beds repose, in an unconformable manner, the Devonian red conglomerates. In their lower part they contain thick beds of coarse breccia, containing angular fragments of the harder members of the underlying series, sometimes 3 feet in length. These beds are well seen at the mouth of the Little River of Perry, near Point Pleasant. Above these are red conglomerates, with rounded pebbles of quartzite, syenite, and other hard rocks. The pebbles are of moderate size; and there are interstratified beds of bright red sandstone, with green spots and stains, and occasional thin grey layers. The thickness of these beds exposed on the south side of Little River is about 1300 feet. They are probably the equivalents of the upper part of the St. John series and the Upper Red Sandstones of Gaspé; and it is worthy of note, as suggesting a caution to explorers of those regions, that these rocks strikingly resemble in their mineral character the Lower Carboniferous red sandstones and conglomerates of some parts of Nova Scotia and New Brunswick, and also the probably Mesozoic "New Red Sandstones" of these provinces.

The fossil Plants occur most abundantly in a layer of grey sandstone, about 2 feet thick, and apparently of small horizontal extent, in the upper part of the red conglomerate. This little bed is filled with fragments of Plants, and probably occupies a spot where a stream running from neighbouring land emptied itself into the sea. It is rather a portion of the red sandstone bleached by the deoxidizing and solvent action of the vegetable matter, than a distinct bed; and the same remark applies to the numerous grey spots and thin layers in other parts of the series. A very pretty illustration of this occurs in a bright-red, fine-grained sandstone farther up the Little River, in which Mr. Jethro Brown, of Perry, has found fronds of *Cyclopteris Jacksoni*, and branches of *Psilophyton*, which have im-printed themselves in light-greenish stains on the red stone. The Plants have been drifted, and are for the most part in fragments, the smaller and more delicate of which occur in the upper part of the bed, and those of larger size in its lower part. Above and below the Plant-bearing bed are red sandstones, passing into the usual red conglomerate. Though there are abundant exposures of the red sandstone and conglomerate on the coast of Perry, I could not learn that fossils have been found in any other locality than those above-mentioned, so that their occurrence must be considered rare. In the underlying Upper Silurian Series I could find no Plants, except some obscure fragments of slender stems.

With the assistance of Mr. Brown, I was enabled to obtain a number of specimens from the original Plant-bearing bed, the actual exposure of which we indeed worked out. The more important of these I shall now notice in detail.

1. Coniferous wood (Dadoxylon et Aporoxylon).

Among the most abundant fossils at Perry are fragments of stems and roots, and strips of bark, belonging to two or more species of coniferous trees. They are pyritized, so that their structures can be made out only as opaque objects, or after treatment with nitric acid. In the specimens formerly collected, I was able to observe only a porous woody tissue (*Aporoxylon*). Some of my present specimens, however, show three or four rows of discs on the cell-walls, and are not distinguishable from *Dadoxylon Ouangondianum* of St. John, though they are not in a sufficiently good state of preservation to admit of satisfactory comparison. Some of the flattened stems show marks of lateral branches or cones at rare intervals (Pl. XVIII. fig. 20); others are long, slender, and tortuous, and were probably roots (Pl. XVII. fig. 5).

Among the specimens collected by Mr. Brown is one with a porous tissue, in the form of a flattened stem or branch, 2 inches in diameter, and with a pith half an inch in diameter (not of the Sternbergia-type). The structure of the wood closely resembles that of *Aporoxylon primigenium*, Unger.

2. Stigmaria pusilla, spec. nov. Pl. XVII. fig. 3.

Allied to S. exigua, *but with larger and more distant scars, not in depressed areoles.*

A few fragments of the bark of this species were found scattered over the surface of a slab at Perry. It is of the same slender type as *Stigmaria exigua*, of the Chemung group of New York, but is sufficiently different to warrant the belief that it was the root of a distinct species of *Sigillaria*.

3. Cyperites.

Two kinds of leaves, resembling those of *Sigillaria*, occur at Perry. They are a line or less in breadth and 3 inches or more in length, and have respectively two and four well-marked ribs. Though no trunks of *Sigillaria* have been found, I regard these leaves and the *Stigmaria* above described as evidence of the existence of two species of that genus.

4. Anarthrocanna Perryana, spec. nov. Pl. XVIII. fig. 21.

Stem cylindrical, swelling slightly at the nodes; ribs flattened, about fourteen in the circumference of a stem three-fourths of an inch in diameter; ribs at the nodes apparently continuous with the decurrent verticillate (?) *petioles or branchlets.*

This curious stem at first sight resembles a *Calamites*; but it has no distinct articulation, and the ribs appear to separate from the stem and to pass into the decurrent and probably verticillate branchlets or petioles, which are given off at an acute angle, and bear traces of slender leaves, which are, however, too imperfect for description. The plant corresponds sufficiently, I think, with the characters of Gœppert's genus *Anarthrocanna* to be included in it. It was probably allied to *Calamites* or *Asterophyllites*; and possibly the species next mentioned may be the fruit of this Plant, though I have not seen them in connexion.

5. Carpolithes spicatus, spec. nov. Pl. XVII. fig. 15.

Carpels or spore-cases: oval, about a line in length, apparently with a thick outer coat; densely placed on a thick rachis.

This is evidently a spike of fructification, and may be allied to *Trigonocarpum racemosum*, described in my former paper. It more nearly resembles the fructification of *Annularia* and *Sphenophyllum* than any other fossil fruits known to me. Its parts are too indistinct to admit of minute description, and the two-ranked appearance of the seeds or fruits is probably deceptive, as there are indications that the specimen is a cylindrical spike flattened.

6. Lycopodites Richardsoni, spec. nov. Pl. XVII. figs. 1 & 2.

Stem slender, tortuous, dichotomous; barren branches with short erect or recurved leaves, apparently in two ranks; fertile branches lateral, one-sided, in the form of sessile strobiles. These strobiles are the Lepidostrobus Richardsoni *of my former papers.*

Under the name quoted in the above description, I described in a former paper* a very singular specimen collected at Perry by Mr. Richardson, and which, though at first sight it resembled a pinnate leaf, I believed to be a cone of the nature of *Lepidostrobus*. More perfect specimens confirm this view, and show that these cones were sessile on one side of a slender and probably creeping stem, terminating in dichotomous branches having short, stout, slightly recurved leaves, apparently in two rows. The generic name of *Lepidostrobus* being no longer applicable, I propose to place the Plant in *Lycopodites*, a genus no doubt at present somewhat unsettled, but in which this Plant, at least, fairly deserves a place.

7. Psilophyton.

Fragments referable to this genus are very abundant at Perry,

* Canadian Naturalist, vol. vi. p. 174.

but all in a very imperfect state. I believe that I can recognize representatives of the three species which I have named respectively *P. princeps*, *P. elegans*, and *P. glabrum*, but cannot be quite certain of this. Here, as elsewhere, I should have been ready to refer these Plants to the convenient category of Fucoids, but for my knowledge of their forms and structures obtained in Gaspé.

8. LEPTOPHLŒUM RHOMBICUM, Dawson. Pl. XVIII. fig. 19.

Additional specimens of this Plant have enabled me to ascertain that its branches bifurcated regularly, in the manner of *Lepidodendron*, and tapered somewhat rapidly; that its leaves were long, parallel-sided, and one-nerved; and that it produced strobile-like bodies with narrow-pointed, closely appressed scales borne on the sides of the branches. I have attempted to give a restoration of the Plant, from several specimens in my possession, in Pl. XVIII. fig. 19. The other characters of the genus, and the points in which it differs from *Lepidodendron* and *Ulodendron*, are stated in my former paper.

9. LYCOPODITES COMOSUS, spec. nov. Pl. XVII. fig. 14.

Stem short, not observed to branch, densely covered with long filiform leaves.

This little Plant, of which several specimens, all equally diminutive, were found, somewhat resembles *Selaginites Erdmanni* of Germar, but is smaller and differently proportioned.

10. CORDAÏTES (PYCHNOPHYLLUM) FLEXUOSUS, spec. nov. Pl. XVII. fig. 9.

Leaves lanceolate, acuminate, broad at the base; nerves numerous, parallel, somewhat sinuous and uneven.

A number of more or less perfect specimens of this leaf were found. It has the general appearance of the leaves of *Cordaïtes*; but less distinct venation, and apparently less rigidity than the other species. I place it in this genus merely provisionally, as its true affinities are, of course, quite uncertain.

11. CYCLOPTERIS JACKSONI, Dawson. Pl. XIX. fig. 26.

This is by far the most abundant species at Perry, and a large number of specimens were obtained. One of these shows that the full-grown frond was a foot in length, with a strong woody rugose petiole a quarter of an inch thick at the base. Some of these petioles in a pyritized state show traces of scalariform vessels. Old stipes deprived of their leaves very closely resemble the *Rhachiopteris pinnata* of the Marcellus shale of New York, though not quite so large, and perhaps more rugose. Among the numerous scattered pinnæ of this species there are some of much smaller size than the others, which may possibly indicate a distinct species; but, for the present, I am rather disposed to regard them as merely a variety. (See Pl. XIX. fig. 26, *c*.)

I also found a few detached pinnules, which I believe to belong to *Cyclopteris Halliana*, of the Chemung group of New York. I have attempted to represent the characteristic forms of the ordinary varieties of *C. Jacksoni* and of *C. Halliana* in Pl. XIX. figs. 26 & 28. I may add here that the stipe of *Cyclopteris Jacksoni* has a few leaves between the pinnules of the upper part, but is less leafy than that of *C. Halliana*.

12. Cyclopteris Rogersi, spec. nov. Pl. XVII. figs. 17, 18; and Pl. XIX. fig. 27.

Habit of growth resembling that of Cyclopteris Jacksoni, *but the pinnules are more elongated and almost cuneate in form, also less densely placed, and with veins more nearly parallel. Stipe stout, woody, furrowed longitudinally, and marked with strong transverse bars or punctures.*

This Fern is less abundant than *C. Jacksoni,* from which the points above mentioned appear sufficient to distinguish it. Its stipe is marked in the manner of *Rhachiopteris punctata* of the Chemung group of New York, and of *C. Roemeriana*, Gœppert, from the Upper Devonian of Europe; of the latter species the present may be regarded as the American representative. I have endeavoured, from the small fragments collected, to give characteristic representations of the appearance of the species. It was probably about the same size as *C. Jacksoni*, but with its stipe not leafy, and its pinnæ and pinnules less densely placed.

It would seem that the remarkable group of pinnate *Cyclopterides*, to which this species belongs, was characteristic of the Upper Devonian throughout North America and Europe. I dedicate the present member of it to Prof. W. B. Rogers, who has done much to direct attention to the deposits of Perry, and has kindly permitted me to use the specimens in his collection.

13. Cyclopteris Brownii, Dawson. Pl. XVII. fig. 6.

This fine species, described in my former paper from a mere fragment of a frond, I am now able to figure in its full dimensions, from a fine specimen in the collection of Prof. Rogers of Boston; several others, nearly as perfect, were found by Mr. Brown and myself last summer. It has a large simple frond, flabellate in form and divided toward the edges, which are sometimes slightly reflected, as if they had borne marginal fructification. It belongs to the group of simple-leaved *Cyclopterides,* like *C. orbicularis*, Brongn., of the Coal-measures, or *C. digitata* and *C. Huttoni* of the Oolite. It very closely resembles a beautiful leaf from the Ponent (Upper Devonian) of Pennsylvania, figured, but not named, by Prof. H. D. Rogers in his Report on the Geology of that State (vol. ii. pt. 2. pl. 22). This resemblance did not appear from my imperfect specimen of last year; but I can scarcely now doubt that Prof. Rogers's Plant is the same, or very closely allied. The leaf from Pennsylvania was compared by Prof. Balfour, to whom it was submitted by Prof. Rogers, with that of *Salisburyia adiantifolia*, to which it unquestionably bears a strong resemblance; and it may admit of doubt whether it is really a Fern or a coniferous leaf. In the absence of fructification it may be impossible to decide this question; but the form and texture of the leaf appear to me more those of a Fern, possibly allied to *Adiantum* or *Lindsæa.*

14. Sphenopteris recurva, spec. nov. Pl. XVII. figs. 7 & 8.

Leaflets small, cuneate, terminating the divisions of a dichotomous winged petiole.

This Plant is represented by small and obscure fragments on the Perry sandstone. Its venation is not preserved; and it may be a small *Cyclopteris* with terminal pinnules, like my *C. Acadica,* from the Lower Coal-formation of Nova Scotia.

15. Trichomanites filicula, spec. nov. Pl. XVII. figs. 12 & 13.

Pinnules slender, attached to long petioles, and bifurcating into slender points.

This species approaches *T. Beinertii* and *T. adnascens,* and there are indications that, like the latter, it may have been parasitic on petioles or branches of other Plants. Numerous specimens occur at Perry, but all are small and somewhat obscure.

16. Filices incertæ sedis. Pl. XVII. figs. 10 & 16.

Among the Plants collected by Mr. Brown are two somewhat obscure examples of the frond or pinnule represented in Pl. XVII. fig. 10. It is of a linear form, with crenations or teeth on the margins. The midrib is delicate; the nerves, which are rather indistinct, appear to be netted near the midrib in the manner of *Glossopteris,* Brongn.; but they are distinct toward the margin, where there are, in the sinuses of the teeth, dark spots, which are probably remains of fructification. These evidences of marginal fructification remove the Plant entirely from *Glossopteris*; and I am not aware of any other genus of fossil Ferns in which it could be placed. It may have been allied to such recent genera as *Lonchitis* or *Hypolepis.* The specimens are, however, so imperfect and obscure, that I content myself in the meantime with representing what I can make out of their form and venation, trusting that they may at some future time be named from more perfect examples.

The frond or pinnule shown in Pl. XVII. fig. 16 represents another uncertain species. It is cuneiform in shape and broad at the base in all the specimens that I have seen. It has not been found attached to a stem or petiole. Its venation is less coarse than that of *Cyclopteris Brownii,* and much coarser than that of *C. Rogersi* or *C. Jacksoni.* It approaches also more nearly to parallelism, and seems less forked. This leaf would go into the genus *Noeggerathia* of some authors, and may be a distinct species; but I am by no means certain that it is not a young state or marginal division of *Cyclopteris Brownii,* and hence refrain, for the present, from naming it.

17. Carpolithes lunatus, spec. nov. Pl. XVII. fig. 11.

Base rounded regularly, apex broadly truncate and mucronate; nucleus surrounded by a narrow margin.

This species is described from a single specimen, which, however, appears sufficiently well characterized.

18. Carpolithes ? siliqua, spec. nov. Pl. XVII. fig. 4.

Elongate, smooth, flattened, sides slightly sinuate; two inches or less in length; a quarter of an inch or less in breadth.

These objects are too thick and carbonaceous to have been fronds or leaves, and too regular in form to be fragments of stems. They may, however, have been swollen extremities of roots.

§ III. *Gaspé, Canada.*

The Plants collected at Gaspé by Mr. Bell, last summer, consist principally of *Psilophyton princeps* in all states of preservation, still further illustrating the predominance of that species in the Gaspé sandstones, many parts of which were then, for the first time, explored by Mr. Bell. In addition to the facts previously known respecting this Plant, the specimens now obtained illustrate the internal structure of its creeping rhizomes, previously found only flattened or as casts. Mr. Bell has also added to the Gaspé flora *Leptophlœum rhombicum,* previously found only at Perry, and *Didymophyllum reniforme,* a Plant of the Middle Devonian of New York, thus connecting by new links the contemporary floras of these distant localities. His collection also contains two new and curious species of fossil wood, and several fragments possibly indicating new species, but at present of ambiguous character. The more important of these discoveries I indicate under the following heads.

1. Psilophyton princeps, Dawson (rhizomata). Pl. XVIII. fig. 22.

Sir W. S. Logan had obtained from the marine limestones at the base of the Gaspé sandstones, constituting the lowest members of the Devonian Series, if they are not Upper Silurian, a few flattened stems, which in my paper on the Devonian Plants of Gaspé* I referred with doubt to *Psilophyton.* Mr. Bell has collected many additional specimens, some of them perfectly flattened, and which, but for obscure remains of the surface-markings, might readily be mistaken for *Algæ*; others retain more or less perfectly their cylindrical form. The latter are all rhizomata, usually about half an inch in diameter, and retain the structures of the outer bark and internal axis in a calcified state, the cell-walls being changed into coaly matter. The outer bark is seen under the microscope to consist of cellular tissue, dense toward the surface, and more lax within, as seen in a transverse section; while in the longitudinal section the outer portion is found to consist of cells elongated in the manner of bast-tissue, and the inner of ordinary parenchymatous cells. The thick inner bark, which was probably of lax cellular tissue, has disappeared. The slender cylindrical axis consists of woody fibres externally, and of scalariform vessels within; it has a vacant space of very small size in the centre, which may represent a pith, but is perhaps merely a result of decay and shrinking, which have caused the vascular bundle to separate from the woody sheath, and the fibres of the latter to separate in such a manner as to present very

* Quart. Journ. Geol. Soc. vol. xv.

different aspects in different parts of the axis of the same rhizome. This structure, it may be observed, corresponds perfectly with that of the aërial stem of the same Plant, illustrated in my paper on the Devonian Plants of Gaspé, the differences being merely those which might have been anticipated from the greater size of the rhizome, and its probably subaquatic or subterranean character. I have endeavoured, in Pl. XVIII. figs. 22*a* to 22*g*, to represent the structures above described, which, with what was previously known, almost complete our knowledge of this interesting Plant.

It is further interesting to observe that *Psilophyton princeps* has now been found to extend from the very bottom of the Devonian series to its upper members, and throughout every part of Eastern America in which land-plants have been found in these beds. That it has not been recognized in Europe I attribute to its want of decided external characters, when in an imperfect state of preservation, having caused it to be mistaken for Algæ, roots, &c. Similar views might have prevailed here, but for the vast profusion of these Plants found *in situ* in Gaspé, and the admirable preservation both of their external markings and internal structure.

2. Nematoxylon crassum, gen. et spec. nov. Pl. XIX. fig. 24.

Fragments of wood with a smooth thin bark, and a tissue wholly composed of elongated cylindrical cells with irregular pores or markings. No pith, medullary rays, nor rings of growth.

The specimens to which the above description refers are fragments, the largest of which may have been 2 inches long, an inch wide, and half an inch thick. They present under a magnifying-glass a fibrous appearance (as if made up of thin threads or wires), from which I have taken the name of the genus. They are calcified, and when sliced show their structures very perfectly. Under the microscope they at first sight remind the observer of the structure of *Prototaxites*; but the cells are of one-third greater diameter than in *P. Logani*, and are destitute of its peculiar markings, and there are no rings of growth or medullary rays. The wood-cells are of great length, somewhat tortuous, loosely aggregated, and much thickened by ligneous deposit, which appears to be traversed by many narrow tortuous lines or pores. The whole stem seems to be perfectly homogeneous, and the only other structure observed was a faint and doubtful trace of the existence of parenchymatous cells in some of the spaces between the fibres. The figures show a longitudinal and cross section, magnified, and a few detached cells or woody fibres still more highly magnified.

With respect to the affinities of this tissue, I can give no opinion. It may have been that of a Plant whose stem, destitute of true vessels and composed of woody fibres imbedded singly in cellular tissue, bore the same relation to that of an Endogen which *Prototaxites* bears to an ordinary Exogen. On the other hand, it has a sufficiently strong resemblance to the fibrous outer bark of some *Sigillariæ* to render it possible that it may have belonged to a Plant of this character, of which the axis and inner bark have perished.

3. Nematoxylon tenue, spec. nov. Pl. XVIII. fig. 23.

Slender stems with thick coaly bark, and woody fibres of much smaller diameter than in the last species, and marked with minute dots.

The stems of this species are small, not exceeding half an inch in diameter, but are distinctly surrounded by a thick, shining, coaly bark. The wood is calcified, and appears to be perfectly homogeneous, and composed of the tissue represented in Pl. XVIII. figs. 23 *a* to 23 *c*, the last two of which are drawn to the same scale as fig. 24 *b*, to show the different dimensions of the cells. It may be doubted if this species has any real affinity with the last, but they correspond in their negative characters, and both appear to indicate the existence of certain woody Plants of singularly simple and homogeneous structure. Many of the small carbonized fragments scattered over the surfaces of the Gaspé sandstones belong to the present species, and were noticed in my former paper on the Plants of Gaspé as aporous tissues of uncertain nature.

4. Incertæ sedis.

Among Mr. Bell's specimens are many fragments of quite uncertain character. One of these is a stem thickly studded with minute irregularly placed points or tubercles, and having a finely striated surface (Pl. XIX. fig. 25). It resembles the "branching root" figured by Mr. Salter from the Devonian of Stromness. Another is a stem with interrupted ridges, in the manner of *Rhachiopteris striata* from the Devonian of New York, fig. 31. It may be the stipe of a Fern. Another (fig. 29) is a very slender stem marked with minute raised scales or rudimentary leaves, and possibly a *Lycopodites* of the type of *L. Milleri*, Salter. To these I have added, from my own collection, a little Stigmarioid Plant, fig. 31, which, if really a *Stigmaria*, is the most diminutive of the genus; but it may admit of doubt whether it is not an imperfectly preserved Lepidodendroid Plant.

5. Algæ. Pl. XIX. figs. 32 & 33.

In Mr. Bell's collection are numerous specimens, apparently of Sea-weeds, resembling the Cauda-galli Fucoid of the Devonian rocks of New York. They appear to include two distinct forms. One of these (fig. 32) consists of cylindrical and dichotomous filaments, and may be referred to the provisional genus *Chondrites*. It appears to be the first or fibrous form of *Fucoides Cauda-galli* mentioned by Vanuxem (Report, p. 128, fig. 30). The other (fig. 33) is a continuous frond, and shows indications of having been thickened or folded at the convex margin. It might be placed in the genus *Zonarites*, and is probably identical with Vanuxem's second or continuous form, for which he proposes the name *Fucoides velum*. Both occasionally appear as if looped or attached at both extremities, as was the case in Vanuxem's specimens. The first-mentioned species, or variety, is found in beds believed to be Upper Silurian, and which contain obscure remains of Land-plants, at Aune à la Barbe in the

Baie de Chaleurs. The second is also from rocks at Gaspé*, supposed to be Upper Silurian, but below those containing Land-plants.

§ IV. *New York.*

In my paper of last year several species were referred to the Cattskill group, being so labelled in the collection of the Geological Survey of New York. Prof. Hall has, however, communicated to me, and published in the 'Canadian Naturalist,' observations recently made by Mr. Way and others, and confirmed by his own examinations, of sections and fossils, which show that the rocks from which these Plants were obtained really belong to the underlying Portage and Chemung groups. This brings the distribution of the Devonian Plants of New York more nearly into harmony with that observed at Gaspé and elsewhere, and leaves the Cattskill group, as now restricted, destitute of that evidence of connexion with the underlying beds which these Plants seemed to afford.

I desire to change the name *Pecopteris* (*Alethopteris*) *decurrens*, of my last paper, into *P. discrepans*†,—a species from the Coal of Pennsylvania having been described by Lesquereux under the former name.

§ V. *Conclusion.*

The present paper raises the number of species obtained from the Devonian rocks of Eastern America to about eighty-two, but does not in any respect invalidate the general conclusions stated in my former paper. Of the whole number of species, only two can with certainty be referred to the Lower Devonian, and these also occur higher in the series. Twenty-one are found in the Middle Devonian, and of these nine or ten ascend to the Upper Devonian, which has afforded about sixty-eight species; and of these probably ten are known in the Carboniferous System. It must be observed, however, that the precise age of the beds at Perry and St. John is uncertain, and that they are referred to the Upper Devonian principally on the evidence of their fossil Plants,—the stratigraphical evidence being sufficient merely to prove their Precarboniferous date.

EXPLANATION OF PLATES XVII.–XIX.

Plate XVII.

Figs. 1 & 2. Portions of pinnæ of *Lycopodites Richardsoni*; (2 *a*) leaves enlarged.
3. *Stigmaria pusilla.*
4. *Carpolithes? siliqua.*

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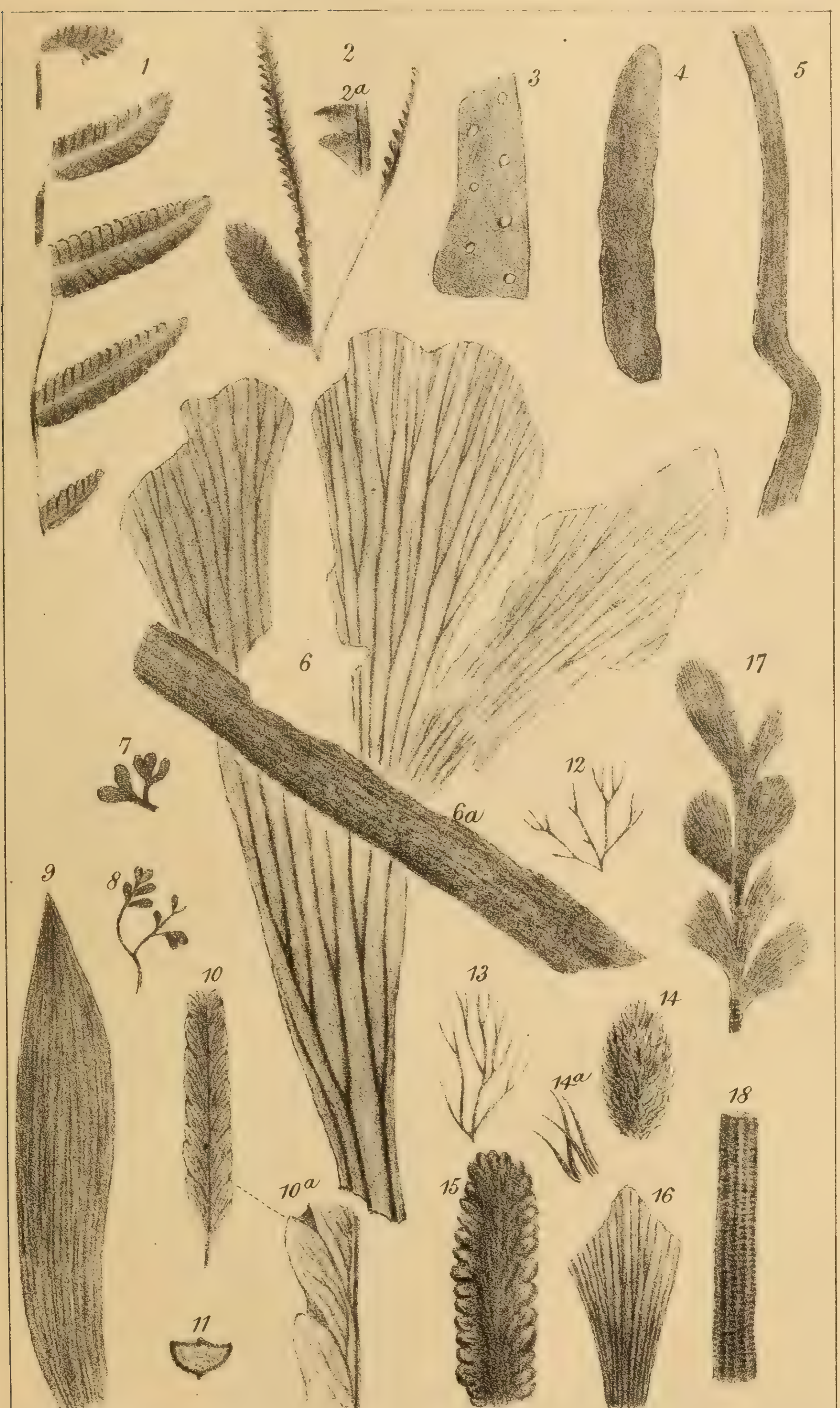
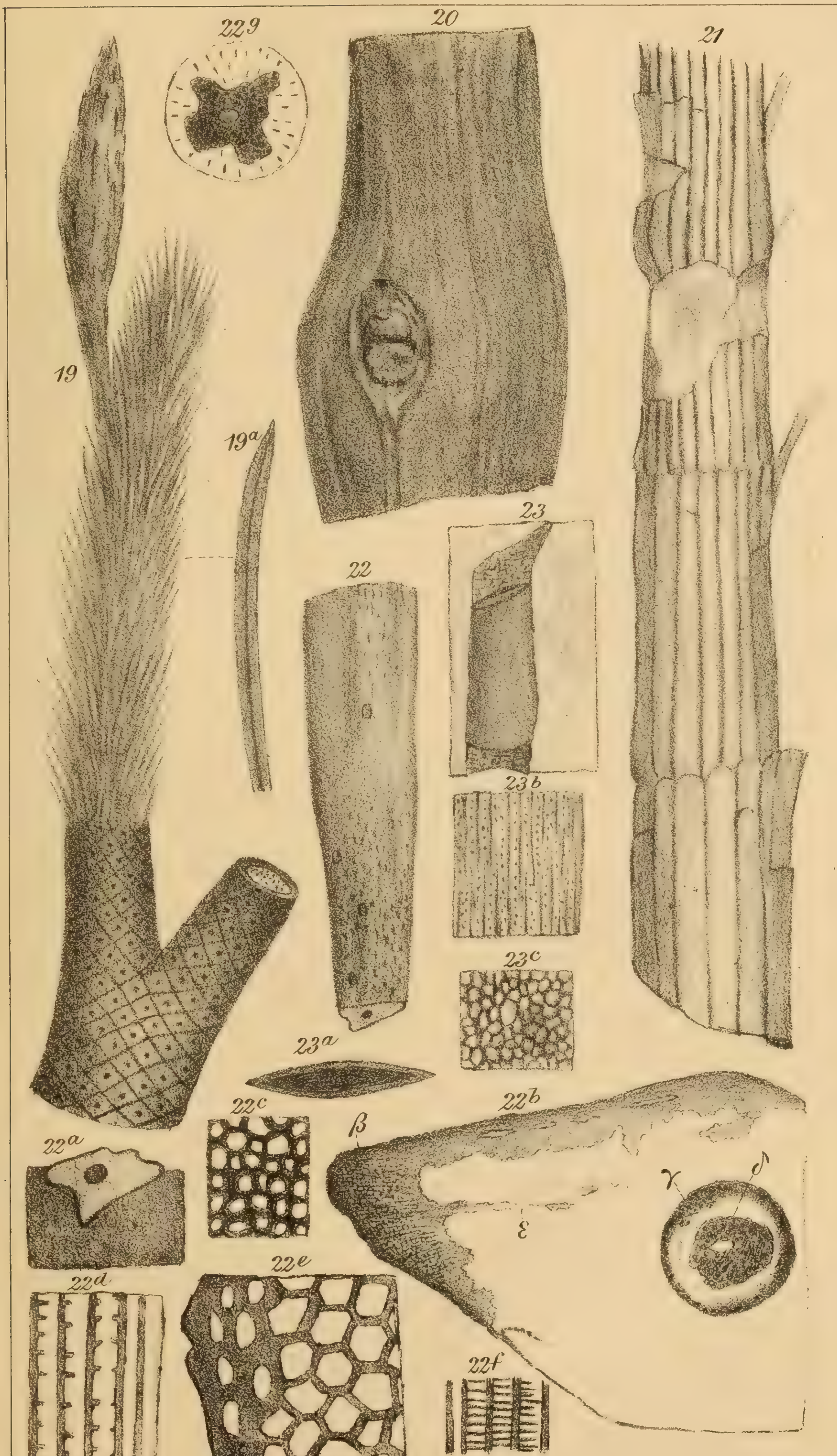
* Prof. Hall informs me that he has ascertained the ordinary *Fucoides Cauda-galli* of New York to be fragments of spiral forms, which he proposes to describe, under a new generic name, in a forthcoming Report of the Regents of the University of New York. It is possible that the Gaspé fucoids above noticed may also have been spiral in their growth.

† This correction has already been made in the list of errata occurring in vol. xviii. of the Society's Journal, and published, together with the title-page and index of that volume, with No. 73 of the Journal.—Edit.



J.W.D. del. G. West lith. W. West imp.

DEVONIAN PLANTS, N.E. AMERICA.



J.W.D. del. G. West lith.

W. West imp.

DEVONIAN PLANTS, N.E. AMERICA.

J.W.D. del. G. West lith. W. West imp.

DEVONIAN PLANTS, N.E. AMERICA.

Figs. 5. Fragment of root of Conifer.
6. Portion of pinna of *Cyclopteris Brownii*; (6 *a*) stipe of *C. Jacksoni.*
7 & 8. *Sphenopteris recurva.*
9. *Cordaïtes flexuosus.*
10. Pinna of a Fern, not named; (10 *a*) portion magnified.
11. *Carpolithes lunatus.*
12 & 13. *Trichomanites filicula.*
14. *Lycopodites comosus*; (14 *a*) portion magnified.
15. *Carpolithes spicatus.*
16. Fern, not named.
17. Pinna of *Cyclopteris Rogersi.*
18. Stipe of *Cyclopteris Rogersi.*

PLATE XVIII.

Fig. 19. *Leptophlœum rhombicum*, restored; (19 *a*) leaf.
20. Fragment of bark of Conifer.
21. *Anarthrocanna Perryana.*
22. Rhizoma of *Psilophyton princeps*; (22 *a*) cross section of the same, showing the axis and bark; (22 *b*) portion of cross section magnified, showing remains of the bark β, of inner bark ϵ, of the woody sheath of the axis γ, of the scalariform centre of the axis δ; (22 *c*) cross section of the tissue of the axis, magnified 100 diameters; (22 *d*) longitudinal section of the tissue of the axis; (22 *e*) cross section of the outer bark; (22 *f*) longitudinal section of the axis of the aërial stem for comparison with *e*; (22 *g*) cross section of the axis of another specimen, magnified as in *c*.
23. Portion of the stem of *Nematoxylon tenue*; (23 *a*) cross section slightly enlarged; (23 *b*) longitudinal section; (23 *c*) transverse section, magnified 200 diameters.

PLATE XIX.

Fig. 24. Longitudinal section of the stem of *Nematoxylon crassum*, magnified 100 diameters; (24 *a*) cross section; (24 *b*) transverse section of a few cells, magnified 200 diameters.
25. Stem with tubercles; (25 *a*) magnified.
26. Pinna of *Cyclopteris Jacksoni*; (26 *a*) separate pinnule; (26 *b*) diagram of venation; (26 *c*) small variety.
27. Pinna of *Cyclopteris Rogersi*; (27 *a*) separate pinnule; (27 *b*) diagram of venation.
28. Pinna of *Cyclopteris Halliana*; (28 *a*) separate pinnule; (28 *b*) diagram of venation.
29. *Lycopodites.*
30. Stem with ridges.
31. Stigmaria?; (31 *a*) areole magnified.
32. *Fucoides* (*Chondrites*) *Cauda-galli* (reduced).
33. *Fucoides* (*Zonarites*) *velum* (reduced).

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2. *Notice of a* NEW SPECIES *of* DENDRERPETON, *and of the* DERMAL COVERINGS *of certain* CARBONIFEROUS REPTILES. By J. W. DAWSON, LL.D., F.R.S., F.G.S., Principal of M'Gill University, Montreal.

THE following notes relate to new facts ascertained in the course of a re-examination of the remains of Reptiles from the Coal-formation of Nova Scotia, made in the preparation of a *résumé* of the characters of these creatures, which is in course of publication. I desire now to communicate these facts to the Geological Society, as they are connected with, and supplementary to, the descriptions published at various times in its Journal.

§ I. *Dendrerpeton Oweni*, spec. nov.

Among the Reptilian remains found in erect trees at the South Joggins, there have occurred several portions of skeletons, which, from their sculptured cranial bones, plicated teeth, and the forms of their scales and limb-bones, I have referred to the genus *Dendrerpeton*, but to individuals of much smaller size than the full-grown specimens of *Dendrerpeton Acadianum*. It did not occur to me to suppose that they were specifically distinct from the larger individuals until I observed that bones of this kind contained in the collections sent by me to the Geological Society, or represented in the figures drawn for me by Mr. Smith, were referred by Professor Owen, in his published notes on these specimens and drawings *, to the genus *Hylonomus*, or at least mentioned as probably of that genus. As the admission of these into *Hylonomus* implied a very different range of characters from those which I had attributed to that genus, and, indeed, left little distinction between it and *Dendrerpeton*, I have been induced carefully to re-examine all the specimens in my collection, with the view of determining whether they, in any respect, occupied an intermediate place between the genera in question. The result has been to convince me that there is no generic affinity between these specimens and *Hylonomus*, but to establish a probability that there was a second species of *Dendrerpeton* in the Coal-measures of Nova Scotia, differing from *D. Acadianum* in the following particulars:—(1) *its much smaller size*; (2) *its longer and hooked teeth*; (3) *the greater corrugation of the dentine of the intermaxillary teeth*; (4) *the proportions of the skull*, which seems to have been shorter and broader, with the orbits larger and more oblique. On the other hand, it differs from all the species of *Hylonomus* in the following respects:—(1) the corrugated character of the teeth, which are always simple in *Hylonomus*; (2) the presence of an inner row of large teeth, which do not occur in *Hylonomus*; (3) the sculptured surface of the cranial bones, always smooth or faintly puncto-striate in *Hylonomus*; (4) the form of the vertebræ and scales, and the short and stout limbs. In all these respects it resembles *Dendrerpeton Acadianum*, and in some of them is more remote from *Hylonomus* than that species.

On the grounds thus stated, I refer this creature, without doubt, to the genus *Dendrerpeton*, and regard it as probably a distinct species. I may add, in confirmation of the distinctness of *Dendrerpeton Oweni*, that I have recently found a specimen showing the jaw and teeth of a small individual of *D. Acadianum*, corresponding in their forms with those of the latter species, though the size is that of the former.

I refer to the present species the bones figured in Prof. Owen's paper in the Quarterly Journal of the Geological Society, vol. xviii. Plate X. figs. 3 & 4, and Plate IX. fig. 4. The maxillary bone in Plate IX. fig. 15 belongs to *D. Acadianum*, having the form of teeth and the bony sculpture of that species.

* Quart. Journ. Geol. Soc. vol. xviii. p. 242, 1862.

§ II. *Remains of Skin and Horny Scales.*

In some of my earliest explorations of the reptile-bearing stumps of the Joggins, I observed on some of the surfaces patches of a shining black substance, which, on minute examination, proved to be the remains of cuticle, with horny scales and other appendages. The fragments were preserved; but I found it impossible to determine with certainty to which of the species, whose bones occur with them, they belonged, or even to ascertain the precise relations of the several fragments to each other. I therefore merely mentioned them in general terms, and stated my belief that they must have belonged to the species of *Hylonomus* *. More recently other specimens have been obtained, and I have undertaken the detailed examination of the whole. I shall now endeavour to describe the principal fragments, and afterwards to consider the probability of their having belonged to certain of the Reptiles entombed with them.

1. One of my specimens is a flattened portion of cuticle, $2\frac{1}{4}$ inches in length, and $1\frac{1}{4}$ inch in average breadth. The greater part of the surface, though wrinkled, is smooth and shining to the naked eye; but under the microscope it shows minute pits or pores, and in places indistinct imbricated scales. A limited portion of the upper and, I suppose, anterior part is covered with imbricated scales, visible to the naked eye, and which are thin and quite free at the lower edges, though apparently attached to the skin by the whole breadth of the base. Most of them show a small spot, or pore, near the anterior edge, and smaller points, or subordinate scales, on their surfaces. In contact with the upper part of this specimen there are many fragments of the skull of *Dendrerpeton Oweni*.

2. In another portion of cuticle, similarly marked, the form of the posterior part of the animal appears to be preserved, and also a mark representing the point of attachment of the hind leg, near to which, and also along the dorsal ridge, the skin is covered with much smaller scales. The lower or abdominal side shows only a slightly pitted or porous surface. A notch in the lower or abdominal surface may perhaps represent the anus; and, immediately in advance of this, the removal of a part of the outer surface showed an interior membrane marked with rows of small pits or depressions. This was found in close proximity to a mass of bones of *Dendrerpeton Oweni* mixed with some of *Hylonomus Lyelli*, and is represented in pl. 1, fig. 5, of my work already referred to.

3. A third portion of cuticle, procured from a different trunk, presents precisely the features of that above described, but is flattened, and has on its surface a number of vertebræ and detached bones of *Hylonomus Wymani*. These, however, lie on its outer surface, and the dimensions of this species would seem to be too small to suit so large a surface of skin.

4. Another well-preserved fragment, less than 2 inches in length, presents a very different aspect from those just described.

* Quart. Journ. Geol. Soc. vol. xvi. p. 277.

Its general surface is covered with small imbricated scales, not essentially different from those already mentioned, but these are associated with other appendages. On either side of what seems to have been the middle line of the back, covered with small scales, there is a series of flat horny processes, which probably formed a double spinous crest. Outside these there are two elongated tufts of densely grouped, slender, bristle-like processes; exteriorly to which, there is, on each side, a row of flat, horny, transversely wrinkled plates. Near them was a short row of conical, truncated, horny tubercles. Sections of all these appendages show that they were horny and attached to the skin. This specimen will be figured, with enlarged views of its appendages, and a section of one of the thicker scales, in the work already mentioned.

5. Another fragment may have belonged to a different species from either of the preceding. It is about an inch in length, and rather less in breadth, and is covered with very small imbricated scales. It is crossed by six or seven obscure ridges, which, both at the lower margin and along a middle line, project in points covered with larger scales; and a row of large scales with round pores connects these points along the lower edge. If, as seems likely, this fragment represents the side of the trunk or tail, it would perhaps indicate a division of the subcutaneous muscles by a mesial line, as in Fishes and Newts. A separate fragment has a larger lobe or point, of the same structure as those above described.

6. A few separate fragments show appendages which may have been connected with some of the larger portions of integument above described. Two of these detached fragments show pointed and probably membranous appendages, marked on each side with rows of scales not overlapping, and each with a pore in its centre. The manner in which they are folded and bent shows that they must have been soft, except at the tips, which were probably horny. They are arranged in series, as if originally attached to the sides of the body of an animal of a somewhat elongated form. Another and very small fragment shows a sort of scale, perhaps abdominal, marked with transverse slightly furrowed ridges. Another and much larger portion of cuticle has a beautiful covering of imbricated scales, fringed at the lower margin with larger scales.

The whole of these specimens are chemically in the condition of highly bituminous coal, affording an example of the production of that substance from animal membrane and horny matter. They present the appearance of jet, and burn with much flame and a bituminous and ammoniacal odour. It is remarkable that in no case do the portions of cuticle contain the skeleton of the animal to which they belonged. This may be accounted for by supposing that the skins were ruptured in decay, and allowed the bones to fall out; or possibly they may in some cases have been cast while the animals were alive. Their preservation implies that the mass in which they were imbedded was wet and impervious to air, as must have ordinarily been the case in these deep pits in damp soil.

Six species of Reptiles or Batrachians have left their bones in the repositories containing these remains of cuticle. Of these, *Dendrerpeton Acadianum* was an animal too large to permit us to suppose that the integuments in question belonged to it. *Hylonomus aciedentatus* and *Hylerpeton Dawsoni* are each represented by a single specimen only, and these do not occur on the same surfaces with the remains of cuticle. Three species remain; and each of these is represented by several individuals, whose remains occur near to the fragments of cuticle, and whose size renders it possible that they may have been its owners. Of these species *Dendrerpeton Oweni* seems to have the best claim to the specimens described above as Nos. 1 and 2, and probably also to No. 3. The specimens described as Nos. 4 and 5 would then probably belong to *Hylonomus Wymani* and *H. Lyelli*, the larger portion noticed as No. 4 to the trunk of the latter, and that noticed as No. 5 to the trunk of the former. The pointed appendages, referred to as No. 6, are not attached to any of the larger fragments; but their size and associations render it likely that they belonged to *Hylonomus Lyelli*, and possibly to *H. aciedentatus*.

I have ventured, in the work above mentioned, to give rough restorations of the dermal coverings of these animals, according to what I regard as the most probable arrangement of the parts; but such attempts must be regarded as merely provisional, and to be corrected by future discoveries. I may add that I have no means of determining the arrangement of the *bony* scales which these Reptiles, or some of them, also possessed. These bony scales present, under the microscope, a structure peculiarly similar to that of the bones of *Dendrerpeton* and *Hylonomus*. They do not appear to be attached to any of the portions of cuticle, and it is most probable that they were placed on the head, neck, or abdomen, or perhaps generally over the lower surface of the body.

I have already expressed my belief that the species of *Hylonomus* may have Lacertian affinities; and I think their dermal coverings lend some countenance to this view. We may, however, suppose them to have been either true Reptiles having certain Batrachian tendencies, or Batrachians presenting some structural points now limited to true Reptiles; or, lastly, we may suppose that the specimens entombed in the erect *Sigillariæ* may be the young of species of Reptiles too large and vigorous, when adult, to be entrapped in such pitfalls.

I would, however, observe that, in the case of *Hylonomus*, the smooth cranial bones, the simple teeth, the long curved ribs, the well-developed limbs, and the cutaneous appendages must absolutely prevent this genus from entering either the Order *Ganocephala* or the Order *Labyrinthodontia*, as defined by Owen. If they should prove to be really Batrachian, a new Order must be constituted for their reception, and its definition will present many points of coincidence with those of the characters of the humbler tribes of Lizards.

I propose, in the memoir already referred to, to figure and describe all the characteristic bones of these creatures in my possession, with the view of enabling naturalists to form more definite opinions on these points.

3. *On the* Upper Old Red Sandstone *and* Upper Devonian Rocks.

By J. W. Salter, Esq., F.G.S., A.L.S.

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3. North Devonshire.
4. Somersetshire, Gloucestershire, and Shropshire.
5. South Ireland.
6. Foreign Equivalents.
7. General Conclusions.
8. Appendix.

§ 1. *Introduction.*

I was engaged for three summer months in 1854, and again for a short time last year, in examining carefully the lower beds of the Mountain Limestone and the uppermost beds of the Old Red Sandstone, with a view to establish, if possible, the correlation between the Upper Old Red and the corresponding portion of the Devonian series —a relation which has been called in question by good observers.

The memoir of Sedgwick and Murchison* was, indeed, a full statement of the identification of the Old Red Sandstone, as a mass, with the Devonian; a comparison first suggested by Lonsdale from a consideration of the fossil evidence, and ably supported by Godwin-Austen from his Rhenish explorations, though afterwards called in question by him. The identification is repeated in the later edition of 'Siluria.' Yet, over the North-European districts, there is a singular deficiency of proof of the superposition of the Devonian to the Upper Silurian rocks, and more especially of the gradual passage, at any one point, of the Old Red Sandstone into rocks of the Devonian type.

It has been argued, and with reason, by Sharpe† that in Belgium Old Red Sandstone of the ordinary type *underlies* the whole of the Devonian rocks with marine fossils. The opposite case occurs in the red conglomerates of the Catskill group in America, which themselves *overlie* the Devonian. But it has been much overlooked that, in the latter country, the whole Devonian mass, distinguished by its fossils, is clearly superposed on Upper Silurian rocks; while it has been by no means certain what part of our great Old Red Sandstone group is represented by the red conglomerates either of America or of Belgium. Nor has it been decisively shown that the Old Red Sandstone passes conformably into the strata above or below it; all that could be said with certainty was this—that the Devonian rocks contain fossils of a newer type than the Silurian and overlie them, and that the Old Red Sandstone holds some intermediate place between the Silurian and the Carboniferous rocks.

In this state of the question, the positive identification of any one part of the Old Red series with any one portion of the Devonian became of paramount consequence; since, if we could know the true succession of the Old Red beds as accurately as that of the Devonian rocks has been already traced, we might be able to prove or disprove the correlation of the two series. I have tried to do this, and have, I hope, succeeded.

* "On the Devonian Rocks of the Rhenish Provinces," Trans. Geol. Soc. 2nd ser. vol. v. pp. 633 &c.

† Quart. Journ. Geol. Soc. vol. ix. p. 18.

In the measured sections given by Sir H. De la Beche in the 'Memoirs of the Geological Survey'*, those of East and West Pembrokeshire show a clear succession from the Upper Old Red Sandstone to the Carboniferous Shales. The most complete of these sections are those from Caldy Island and Skrinkle Haven, Tenby, where the whole mass of the Mountain Limestone is underlain by shales and limestones, and these again by the upper beds of the Old Red Sandstone, in unbroken succession. About 150 feet of the latter formation is given in detail. Twenty miles to the west another section, different in detail, but in the main similar, is exhibited in the wild coast-line of West Angle Bay, Pembrokeshire†. The discrepancies, and agreements too, between the different parts of these sections are very striking. I examined them all, and then, crossing the Bristol Channel, took up the corresponding sections on the Barnstaple river and the coast at Croyde Bay. A single fossil in the collections made by Prof. Phillips in West Pembrokeshire gave me the hope of identifying the lowest beds of the limestone-shale with the uppermost Devonian beds, nor was I at all disappointed.

The detailed examinations are written, and wait for publication in the Memoirs of the Geological Survey. I will here confine myself to general statements, somewhat different from those made, on my evidence, in the Anniversary Address of the President of the Geological Society in 1855. In that year I visited the South of Ireland, and, in company with Mr. Jukes, saw ample confirmation of the succession observed in the North Devon and Pembroke sections. The results obtained are correctly stated in 'Siluria,' 2nd ed., pp. 299, 300. In Mr. Hamilton's Address I had, however, ventured prematurely to identify the Lower Limestone-shales of Pembrokeshire with the Pilton group (uppermost Devonian) of North Devon; and this in the teeth of palæontological evidence which was fully stated, and which ought to have weighed more heavily with me. So exactly similar, however, are the two sections physically, and so exactly does the fauna of one represent the fauna of the other, that I allowed myself to believe that two sets of species, closely allied but actually different, had lived at one and the same time on either side of a barrier so narrow as the width of the Bristol Channel!

This idea, which was backed by the strong conviction and published opinion of Sir H. De la Beche, was in accordance too with the doctrine of marine provinces lately advocated by Prof. Edward Forbes, and there is no wonder that I embraced it.

In the meantime I was enabled to see, in 1857, the Cornish section, and was satisfied that the Upper Devonian group in Britain was divisible into two series‡. And I had in Ireland seen the uppermost of these in its true place—beneath the Limestone-shale—and forming, or resting immediately on, the uppermost portion of

* Vol. i. pp. 61, 108, 111, &c.

† These sections are unrivalled for extent and completeness. The vertical beds exposed to the coast-waves are worn by them in a manner to clear them of all detritus, and exhibit the whole series in a remarkably distinct manner.

‡ 'Siluria,' 2nd ed. p. 300.

the Old Red Sandstone. These two formations, when Von Dechen's Map of the Rhenish Provinces was published, were found to be parallel to the two highest divisions of the Devonian system on the Continent.

I may now proceed to a few details.

§ 2. *South Pembrokeshire.*

The best section, sheltered from the south-west winds, and accessible in part at all tides, is on the eastern side of Caldy Island. The Upper Old Red marls and sandstones, forming the southern horn of Drinkim Bay, end upwards in yellow conglomerates, and are covered by 400 feet of shale and limestone in a most variable series. At the very base are beds of shale with ordinary Carboniferous fossils, such as occur among the alternating shales and calcareous beds beneath the mass (nearly 2000 feet) of the Carboniferous Limestone, and in the base of that rock itself.

The Old Red Sandstone, therefore, at this locality is abruptly distinct from the overlying beds, in colour, substance, and more especially in its destitution of fossils.

On the eastern side of the island, where the shales are best seen, I found the upper portion of the Old Red for some distance much softer than the beds below, almost destitute of cornstone, and chiefly consisting of sands and marls of bright colours, mixed with beds of pale conglomerate, which last is persistent through the island, forming reefs on either side, and stretching away far into South Pembrokeshire. This band of pale conglomerates is a good horizon; by taking advantage of it I was able to compare, bed by bed, the variable series of sandstones and marls below; and on the west side of the island, about 50 feet down in the Old Red series, to my great astonishment, a bed of *Serpulæ* occurred, in masses, like the *S. filograna*. I believe the species to be new, and call it *Serpula advena* (see figure, p. 496).

Crossing by boat to Skrinkle Bay, of which De la Beche and Ramsay have given detailed sections, the same beds are visible, even to minute details. It is needless therefore to describe the separate sections. Nearly every bed of calcareous shale, nodular or flat-bedded limestone, cherty sandstone, and oolitic limestone (which is very common) can be traced in the three sections. There is a special group of oolite-beds and grit near the base, a band of oolitic limestone two-thirds up, and between the two a remarkable series of thin cherty sandstone-bands, permeated thickly by the *burrows of worms*. All of these subgroups are recognizable on the east and west of Caldy Island, at Skrinkle Bay, and, as will be seen afterwards, to the extreme point of Pembrokeshire.

These sections are all accessible by paths down the cliff, or better still by boat from Tenby.

At Skrinkle the upper 133 feet of Old Red Sandstone rests on some white sandstones, which are conspicuous at Caldy. The upper 37 feet of Old Red is, however, lost by an oblique fault, and this should be borne in mind in comparing the sections.

The shale-series is remarkable for the quantity of broken and rolled Fish-remains. *Psammodus* or *Helodus*, *Cladodus*, and, more rarely, *Orodus* seem to be the chief cartilaginous Fish, with scales of *Palæoniscus* in plenty. Black rounded masses, which I cannot but regard as coprolitic, but in which my friend Mr. R. Smith can find no phosphates, contain bones of Fish, with Shells of *Orthoceras*, *Nucula*, *Cytheropsis*, &c. Sometimes rounded masses of this kind seem to have no organisms included in them. All are blackened. Again, rounded masses of the ordinary colour of the shale occur, enclosing *Cytheropsis* in myriads. Perhaps the whole may be water-worn, as Sir Henry De la Beche suggested* in the case of the very similar Bristol bone-beds. I do not know how to explain the blackening of the included Shells on that view of the case.

The number and size of the Worm-burrows, often 3 inches broad and many feet in length, form, perhaps, one of the most striking features in the Lower Limestone-shales. They are present, of small size but in great numbers, in the group of cherty rocks before mentioned, and which can be traced, about 70 or 80 feet from the base, throughout the whole of South Pembrokeshire. The action of the Worms bringing clayey matter into sandy beds, and *vice versâ*, gives great toughness to the rocks, and they resist the sea-action well.

Twenty miles to the westward the small bay of West Angle opens at the mouth of Milford Haven, and here a sharp faulted synclinal, in the middle of the bay, permits the whole section to be twice seen in the promontories and reefs on either side of the bay. The section has changed considerably from what is exhibited on the eastern coast, and nearly 150 feet† more shales are added to the upper part. In these shales a very perfect cleavage is established, fully justifying the term "Carboniferous slate" applied to this formation in Ireland by Sir R. Griffith‡.

Sundry other changes are observable when this section is compared with that on the opposite sea-border. The Fish-beds are indeed present, the bands of oolite and grit agree remarkably in the lower part of the section, but the thick bands of limestone are replaced by nodular beds, which indicate a deficiency in the supply of lime. Again, there is a difference of importance near the base, inasmuch as the nodular limestone-bands there contain a vast quantity of a peculiar Bivalve, for which, as I cannot find a name, I have proposed the term *Curtonotus* (see Appendix, p. 494). It occurs in red limestone and grit, to the exclusion of all other fossils, in the bottom bands on the south side of the bay.

The yellow conglomerates have disappeared, but yellow and brown sandstone has taken their place; and there is a further remarkable change in the upper part of the Old Red Sandstone, to which I will direct particular attention.

* Mem. Geol. Surv. vol. i. p. 124.

† The upper part of the Skrinkle section measures 135 feet, that of Angle 322 feet. The conditions under which the beds were deposited were greatly different.

‡ It is, however, the Lower Limestone-shale of Dr. Smith, as seen at Bristol and the Mendips.

I may observe, that the section north and south of the bay is an unequal one, so far as the Upper Old Red is concerned, though marvellously exact in the overlying beds. On the northern horn of the bay the stacks and cliffs show a great many bands of conglomerate; on the south side scarcely any, the distance being barely a mile. Northward, the Old Red Sandstone is red sandstone and marl nearly to the top, intermixed only with a few subcalcareous bands and grey sandstone; but on the south side each of these intercalations becomes magnified, so to speak. The limestones are thicker and more frequent, and are crowded with fossils; the grey shales thicken out to the exclusion of the red marls; grey sandstone is abundant; and the result is that, out of 120 feet, there is not above 25 feet of red shale in the upper portion of the Old Red Sandstone at this point. Then follow red, green, and grey beds, in the usual fashion, all the way to Freshwater *.

By this remarkable change in the mineral character we are prepared for a considerable change in the conditions of life. The solitary *Serpula* in the cliffs of Caldy had already indicated the neighbourhood of marine life. I found scattered specimens of the same *Serpula* here, about 70 feet below the top; but with it were a number of other forms, familiar to me only in North Devon, namely, *Avicula Damnoniensis*, in abundance; *Cucullæa trapezium*?; *Rhynchonella laticosta*; *Bellerophon*, three species, one identical with the *B. bisulcatus* of North Devon; with numerous undescribed forms of *Pleurotomaria*, *Nucula*, *Sanguinolites*, *Modiola*, *Axinus*, and *Discina*. In beds of shale associated with these are numerous linear Plants (observed first by Sir H. De la Beche), but not determinable; they extend their range into the underlying Old Red †.

§ 3. *North Devonshire.*

This change in the mineral character, accompanied by the introduction of a marine fauna, conducts us somewhat less abruptly than would otherwise be the case to the calcareous and slaty sediments on the opposite coast of Devonshire. The red tint is, indeed, not wholly lost in North Devon, but is confined to narrow belts of the Devonian rocks.

I crossed from Combe Martin and Ilfracombe to Barnstaple, in more than one direction, and could find no red colour at all. A purple tint, however, stains the belt of slate-rocks (Morte Slates of Sedgwick and Murchison) which intervenes between the grey Middle Devonian slates of Ilfracombe and the Upper Devonian of Barnstaple and its neighbourhood. It is of these last that I must now say a little, the "Marwood beds" of the above authors being the uppermost strata of their Devonian system; and these, in their grey sand-

* It is worth while noting that the Old Red Sandstone at Freshwater, where it overlies the Silurian rocks, commences with a conglomerate of Silurian pebbles. We have, indeed, plenty of evidence that there is not in Pembrokeshire a continuous section from the Silurian to the Old Red Sandstone; and in all probability none but the upper division of the latter formation is present.

† Mem. Geol. Surv. vol. i. p. 107.

stones, calcareous layers, and argillaceous shales, are only (on a much larger scale) the limestone, shale, and sandstone we have left in South Pembrokeshire.

Neglecting then the purple Morte slates, which, being destitute of fossils, cannot yet be safely paralleled with any special division of the Old Red*, I may, however, say that they pass up by insensible gradations and loss of colour into the Marwood series.

In ascending order we have:—

1. Purple slates and sandstones of Morte Bay.

Marwood Beds. {
2. A band of pale, nearly white slate, with a few Bivalves.
3. A thick series of greenish-grey grits, with bands of *Cucullæa* and *Avicula Damnoniensis*, in abundance, and with much olive shale, in which a new *Lingula* occurs abundantly.
}

4. An alternating series of calcareous sandstone, grey shales with thin nodular bands of limestone, and grey cleaved slate full of fossils, and many hundred feet thick. *Avicula Damnoniensis* and *Rhynchonella laticosta*, with numerous *Lamellibranchiata*, occur in the lower part; and *Strophalosia caperata* with *Spirifer Barumensis* throughout.

The series No. 4 is the upper part of the "Pilton group" of Phillips; and its aspect in the grand coast-section of Baggy Point and Croyde Bay is exactly like that assumed by the Carboniferous Slates of Pembrokeshire, as they lie, in the section before noticed, upon the fossiliferous beds of the Upper Old Red.

So like are the two sections, and so exactly does the succession appear to correspond, that my faith in fossil-evidence gave way, in 1854, before this apparent identity. The grey sandstone and intervening Plant-beds of Baggy are so like those of West Angle (on a larger scale), and the overlying calcareous and shaly series so like

Fig. 1.—*Generalized Section in Pembrokeshire and North Ireland.*

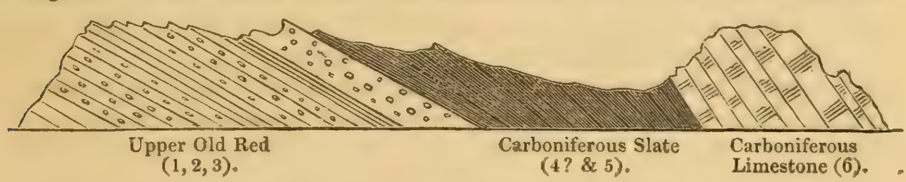
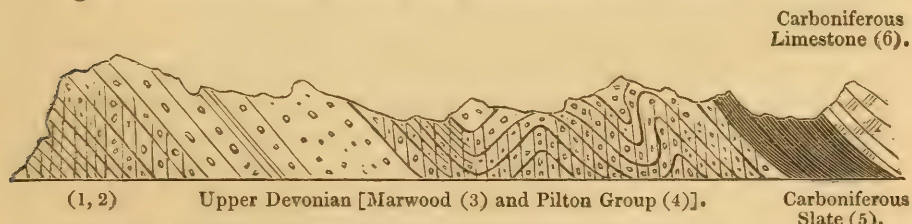


Fig. 2.—*Generalized Section in Devonshire and South Ireland.*



the bottom part of the Carboniferous Slate of Angle—having a very similar set of fossils and a few even identical,—that an older geologist

* Professor Jukes admits, as I do, these reddish-purple slates to be the equivalents of the Old Red of the South of Ireland, and in the same mineral condition.

than myself must be forgiven for having identified them. Sir H. De la Beche was decided in his opinion of their being equivalents*. This view, however, is, I think, erroneous. The Upper Pilton group (No. 4) in the main represents a series unknown in Pembrokeshire (compare figs. 1 & 2), or only represented by beds a few feet thick at the base of the true Carboniferous slate, while its lower portion and the whole of the Marwood group (No. 3) are certainly equivalent to the capping of the Old Red Sandstone. I hope I shall have the full concurrence of the Irish geologists in this last view; Mr. Jukes did all he could to persuade me, in South Ireland, of the intercalation of group 4. I could not, however, disbelieve the North Devon section, but I had misinterpreted it.

I will now give a few of the chief fossil types, and glance at the necessary conclusions. The band of pale slate at its base is an excellent landmark for following the broken outline of the Marwood beds, from Baggy Point, where they are best exhibited, to eight or ten miles east of Barnstaple. The whole country is cut up by north and south faults, and by oblique faults not laid down on any of our maps, but they do not confuse the sequence much.

Either at Baggy Point, Braunton, Marwood, or Sloly quarries (the last locality being best known), the Marwood beds contain the following species:—

In the calcareous sandstones (often a brown limestone), *Cucullæa trapezium* and its varieties, *C. Hardingii*, *Ctenodonta* (*Pullastra*) *antiqua*, *Avicula Damnoniensis*, *Edmondia*, *Sanguinolites*, *Axinus*, *Myacites*, *Modiola*, and *Orthonota* of large and small undescribed species. *Spirifer Verneuilii* and *S. laminosus*? occur very rarely. The latter is a Carboniferous species, as also is *Rhynchonella pleurodon*, which is also met with in this bed, together with species of *Natica*, *Platyschisma*, *Macrocheilus*, *Pleurotomaria*, and *Orthoceras* with lateral siphon, chiefly, if not all, of undescribed species. Two species of *Bellerophon* are very common, one of them being either *B. bisulcatus*, Rœmer, or closely allied to it.

In the greenish shales, or silty beds, are found *Bornia* (*Calamites*) *transitionis*, Gœppert, and *Lepidodendron* (*Knorria*) *dichotomum*, Haughton, and its roots. *Lingula Mola*†, sp. nov., is abundant, and *Orthonota*, or *Myacites*, rare. *Discina* also occurs, and Worm-burrows are exceedingly abundant.

Above these sandstone-beds and olive shales commences the calcareous and argillaceous Pilton group. It is chiefly grey slate and finely laminated calcareous sandstone; but thin actual limestone-bands, oolitic in parts, are frequent in it. Towards the bottom the shale-beds are rich in Bivalves, both Lamellibranchs and Brachiopods. Of the characteristic shells *Avicula Damnoniensis* is the most abundant species; *Strophalosia* (*Leptæna*) *caperata* occurs of *large* size, and is associated with *Spirifer disjunctus*, Sow., *S. Barumensis*, Sow., *Productus prælongus*, Sow. (*P. Christiani*), *Orthis in-*

* Mem. Geol. Surv. pp. 133, 140, &c.

† Named after the Rev. F. Mules, of Muddiford, Barnstaple. Specimens are in the Museum of Practical Geology.

terlineata, Sow., and *Phacops latifrons*, Bronn. But with them are present species of the new genus *Curtonotus*, of *Ctenodonta*, *Modiola*, *Chonetes* (small species), *Bellerophon*, and *Aviculopecten* (two or three species); also *Encrinites* of the genera *Actinocrinus*, *Poteriocrinus*, and *Rhodocrinus*, all abundant.

There are also black nodules, which contain phosphates disseminated in the shale along certain lines, and they are, I believe, droppings of Fish. They exactly resemble those in the very similar slate-series of Angle. There are crowds of Encrinites, not, so far as I can make out, of the same species, but exceedingly like those of the Angle Bay section.

There are *Orthoceras* and *Nucula*, a small spiral *Euomphalus*, smooth and black, and a minute *Loxonema*,—all of which closely represent analogous forms in the West Angle series. And there are the occasional pebble-beds (layers of flat shale-pebbles mixed with black nodules of various sizes), and the shells above mentioned, with *Curtonotus*, long meandering sand-lines, drifted patches with Shells in them, Annelide-burrows, &c., all as at Angle.

Some of the species at Baggy Point are identical with those at Angle. I do not know how to distinguish the *Rhynchonella* from *R. pleurodon*. I find it exceedingly difficult sometimes to decide if the *Spirifer* be *S. disjunctus* or one of the varieties of *S. attenuatus*, &c. But these doubtful cases (and there are not many of them) are overruled by the fact that the characteristic Shells are all of the Devonian type. The catalogue given (p. 480) scarcely contains a Carboniferous form; on the contrary, the peculiar species are abundant throughout.

As this is both the most complete and most accessible section, I will here say of it that the dip continues southwards, though with several minor faults and flexures, to Croyde Bay (where there is good accommodation for the geologist), and here the highest beds of the series are still full of *Phacops latifrons*; while the *Chonetes* and other shells, such as *Athyris concentrica*, are common. *Spirifer laminosus*, a Carboniferous fossil, occurs here among them, but rarely.

The section on the south side of Croyde Bay is only a repetition of that on the north, and the cliffs along the coast to Saunton show only the same fossil forms.

Exactly similar sections are obtainable along the Ilfracombe road from Braunton, along the course of the Knowlwater to Marwood, and again from Barnstaple. On this last section a few notes may suffice. I had the advantage here of the great local knowledge of the Rev. F. Mules, who has produced a MS. map of the range of the several subdivisions of the rocks of North Devon. It gives the general course of these formations with accuracy, from Morte Bay to Exmoor, beyond which the Marwood beds have not yet been traced. I did not myself go quite so far east.

The road-section from Muddiford to Barnstaple shows a perfect sequence from the purple slates, through the white band, to a well-developed Marwood group. The great quarries at Sloly are those best known as containing the *Lepidodendra*, *Calamites*, and other Plant-fragments first described by Professor Sedgwick. I have the measurements of all the beds, and I find that *Lingula* occurs in great quantities in the olive shales, while the calcareous sandstones are full of *Cucullæa*, *Bellerophon*, *Orthoceras*, &c. The whole must have been accumulated in a very shallow sea.

Thence southward, undulating beds of slate with many sandstone-bands contain all the fossils of the Pilton group. Top Orchard quarry, near Pilton, is a favourite locality. In beds below this, and very near the base of the group, I found a single specimen of *Curtonotus*, which is somewhat important, inasmuch as this genus, both in Pembrokeshire and in South Ireland, belongs only to the beds which underlie the true Carboniferous slate. *Spirifer disjunctus*, *Productus Christiani*, i. e. *prælongus*, *Avicula subradiata*, and *Athyris concentrica* are still the common fossils.

But nearer Barnstaple these Pilton beds begin to trough small patches of a barren softer slate, which is only seen well developed south of Pilton, and occupying the lower ground east and west of Barnstaple. Another anticlinal roll throws in a trough of it about Ashford and Heanton Punchardon, and it is fossiliferous on Ashford Strand. South of the river it may be seen along the course of the railway, skirting the marshy ground, and there is a good section of it at the railway-station.

It is extremely difficult to say precisely where the Pilton group ends and this group of shales begins; but the absence of sandstone-bands and the presence of only Carboniferous species show sufficiently the reality of the change. *Strophalosia caperata*, var. *membranacea*, is occasionally present, but not the ordinary variety. It is associated with *Spirifer laminosus*, *S. cuspidatus*, *Streptorhynchus crenistria*, *Chonetes Hardrensis*, *Athyris Roissyi*, *Bellerophon decussatus*, *Productus costatus*, *P. Martini*, *Orthis Michelini*, *Venus parallela*, Phillips, *Spirifer ovalis* (small), *S. bisulcatus*, *Phillipsia seminifera*, and many others. But these are enough to show that we have passed from the sandy Pilton group to the true Carboniferous Slate. The Encrinites are exceedingly common; but those stems I have been able to compare with Pilton species are not identical, while all the peculiar Pilton species are quite absent. Yet the general aspect of the *Encrinites*, *Fenestella*, striated *Spiriferi*, *Chonetes*, &c., is so much that of the Pilton group just underlying, that it was only by great good fortune I made out the troughs of this newer formation, lying among the contorted beds of the Pilton group.

South of Barnstaple we are indeed fairly in the Carboniferous series. Along the course of the Fremington Pill I found, in 1854, shaly beds overlying these, still with Mountain-limestone fossils. The *Productus Cora*, or rather *P. Scotica**, as it ought to be called, is a fossil not yet detected even so low as the Limestone-shale. But how far upward the Mountain-limestone extends until it is capped by the Millstone-grit of Coddon Hill it would be out of my province to discuss here. It is more to the purpose to mention briefly the

* Sowerby's type-specimens of *P. Scotica* are identical with the shell D'Orbigny afterwards called *P. Cora*, and M'Coy *P. corrugata*.

result of a short visit to the southern side of the culm-trough, in the autumn of 1857. The Torquay section was briefly examined, and its correspondence with that of the Spirifer-sandstone group of the Rhine, as given in 'Siluria,' easily perceived.

The fossils of the ordinary Plymouth limestones, of all colours, are so well known that no time need be spent in proving them to be the equivalents of the Eifel limestone, or of the Combe Martin limestones of North Devon. Unfortunately the special object on which I was sent did not permit me to examine the Newton Bushel section*; but on crossing the Devonian slates from Plymouth, by Tavistock, to Launceston, I found everywhere the same silvery slate which must be familiar to every geologist who has visited Ilfracombe. Nor was I then aware of the importance of identifying the red band of the Morte slates with the beds about Launceston and Petherwin, though I now believe them to be equivalents—a point of no little importance in the geology of Devon and Cornwall; for, in a tolerably careful survey of the Launceston beds, I fully convinced myself (and, on my return, Sir Roderick Murchison) that the Petherwin limestone-group did not represent the Barnstaple series, as had been formerly supposed, but that it was a lower band in the Devonian series†. The reason for this determination will appear by comparing the following list of fossils, all of which came from the Landlake and Petherwin quarries, with those above named from the "Marwood group."

List of the Petherwin and Landlake Fossils (Upper Devonian).

Petraia Celtica.
Amplexus tortuosus.
Cyathophyllum cæspitosum.
Fenestella laxa.
—— antiqua.
Sanguinolaria? sulcata.
Ctenodonta (Pullastra) elliptica.
Orthonota (Cypricardia) semisulcata.
Axinus (Cypricardia) deltoideus.
Aviculopecten granulosus.
—— transversus.
—— alternatus.
—— arachnoideus.
Pterinea ventricosa.
Avicula subradiata.
—— exarata.
Cardiola retrostriata (Cardium palmatum).
Strophalosia caperata, rare.
—— membranacea, more frequent.
—— subaculeata (Leptæna laxispina, L. fragaria, &c.), abundant.
Orthis interlineata.
—— resupinata.
Streptorhynchus crenistria.
Spirifer protensus.

* I have lately seen it, for a single day, in company with Mr. W. Vicary, of Exeter. It is clear enough that there is an Upper as well as a Middle Devonian series in this place, the lower limestones of Bradley Woods being quite different from the higher, close to the town, and containing different fossils. The Upper or Clymenia-limestones must have existed close by, as pebbles from them, containing the *Clymeniæ*, are abundant at Teignmouth (Shaldon).

† That this determination is not without its value will appear on comparing the statements made to the above effect in 'Siluria,' p. 300, with those in the Preface to the 2nd Fasciculus of Prof. Sedgwick's Cambridge work, 1852, or more lately in the excellent Synoptical Table by Professor King, of Galway, in which these authors place the Petherwin Slates with *Clymenia* (the true Upper Devonian of the Continent) *above* the Marwood or Coomhola group. In the Continental sections one or other of these is frequently absent, the true reason for which will be apparent as we proceed.

Spirifer Urii (S. unguiculus).
—— lineatus?
—— Verneuilii.
—— Barumensis?*
—— disjunctus, including S. giganteus.
—— grandævus.
—— bisulcatus.
Atrypa desquamata†.
Rhynchonella pleurodon.
—— subdentata.
—— rhomboidea.
—— pugnus?
Euomphalus serpens.
Natica nexicosta.
Pleurotomaria cancellata.
—— antitorquata.
—— aspera.
Loxonema sinuosa?
—— nexilis.
—— tumida.
Bellerophon (trilobatus?), probably *B. bisulcatus*, Rœm.
Orthoceras cinctum.
—— laterale.
—— striatulum.
—— striatum, *M'Coy*.
—— fusiforme.
Cyrtoceras rusticum.
Nautilus megasipho.
Goniatites insignis.
—— bisulcatus.
—— biferus.
Clymenia lævigata.
—— striata.
—— linearis.
—— fasciata.
—— sagittalis.
—— plurisepta.
—— valida.
Phacops (Calymene) granulatus.

This list, it may be observed, differs in almost every point from the Barnstaple list, and the Petherwin beds were probably deposited in deeper water. It is true that several of the characteristic fossils are the same in both series; but there is an entire absence in the Pilton or Barnstaple series of the *Clymeniæ* and *Goniatites*, so characteristic of Upper Devonian strata on the Continent, and also of the *Phacops granulatus*. I have taken the list as it stands in my note-books, adding to it the species quoted by Professor Phillips, for which we are chiefly indebted to the researches of Mr. Pattison. Mr. Lee, of Caerleon, contributed some good materials.

It will be seen, too, that this list fails in two or three important points to tally with that of the fossils from the Barnstaple series. Instead of the large *Phacops latifrons*, we have the small *P. granulatus*; *Spirifer Barumensis* is, I believe, quite absent; *Productus prælongus* is not found there; and *Strophalosia subaculeata* takes the place, as an abundant species, which *S. caperata* occupies at Barnstaple. Much of this change may be due to a different depth of water for the deposit; but it cannot be wholly so; and I should look for the equivalent of the Petherwin beds, which are exactly the "Clymenien-Kalk" of the Prussian geologists, in the red slates of Morte Bay.

It was in vain to search for the Pilton group along the borders of the Culm-measures, which, contrary to expectation, I found to be unconformable to the Devonian beds, at least near Launceston. And in its lowest beds, very black shales with much chert in them are the usual state of things in the Culm-measures.

The shales or slates in which the Devonian limestones of Petherwin occur are very much like, in a general sense, those of Ilfracombe—that is, pale grey slate, with no sandstone-beds, and bearing all the marks of deep-sea accumulation.

* I am not sure of this species.

† This I think doubtful, but it is important to notice it. It may be *Atrypa reticularis*.

Further north, in the midst of the undulating trough of Culm-measures, a locality called Yealm Bridge, north of Launceston, has long been known as a fossiliferous place. It is a sharp and faulted anticlinal of hard slate-rocks, about a mile or a mile and a half in diameter; and Mr. Pattison, who knows the spot well, told me I should find *Petraia* and *Phacops latifrons* there. This then would identify the rock with the Barnstaple series, of which we otherwise have no trace on the south edge of the Culm district. I found this statement strictly correct; and the list of fossils, imperfect as it must be (being the result of only two days' examination), is yet a sufficient index of the true geological position. The dip being northwards, and the Culm unconformable, it was only to be expected that we should find higher beds in an exposure to the northward; and I believe this small inlier (to adopt a new and proper phrase, invented by Mr. Drew) is one of the best proofs we could have that the Barnstaple or Pilton group overlies the Petherwin group.

§ 4. *Somersetshire, Gloucestershire, and Shropshire.*

Before passing over to the South of Ireland, it will be well to notice the general character of the parallel sections further to the north-east, namely, at Dean Forest, Bristol, and the Mendips; and to call attention to the newly described section of the Clee Hills, as given in Mr. Roberts's and Professor Morris's account in the Society's Journal*. This must necessarily be brief, and it may be at once stated that all these sections conform nearly to the northern type, or that of Tenby above described. In all, the thick limestones are succeeded, in the downward section, by arenaceous shales and thin limestone-beds, and these by sandy beds, grey, and finally yellow as they pass into the red marls and sandstones of the Upper Old Red.

In Dean Forest Mr. James gives†, below the alternating shale-series, the following beds:—

Carboniferous..	Arenaceous shales.
	Coarse yellow sandstone containing Shells.
Upper Old Red.	Red marl.
	Red marl with yellow sandstone.
	Coarse yellow sandstone and whitish shale, full of Plants.
	Green shale and sandstone.
	Red marl.
	Thick yellow sandstone, with whitish shale.
	Red marl.
	Greenish and grey sandstones and shale, very micaceous, &c.

And so on until the whitish and grey sandstones cease to appear among the red marls. We must, by comparison with the Tenby sections, draw the divisional line as above.

In the Lower Purlieu section, in the same district, the limestones,

* Vol. xviii. p. 94. † Geol. Surv., Vertical Section No. 12.

mixed with shale, come close down upon the yellow sandstones, as is the case at Clydach in Monmouthshire in even a more striking way*.

The well-known Clifton section also gives the same results, with the great advantage of being all visible along the Avon. Mr. D. H. Williams gives†, below the thick alternating series of shales and limestone, crowded from top to bottom, as I have myself seen, with the same Mountain-limestone species as those common at Tenby,

Grey shale and red marl (thin limestones).
Light quartzose sandstone and conglomerates.
Red and claret-coloured marls and sandstones.
Light grey and brown sandstones and shales.
Red marls and light-grey sandstones, &c. &c.

I must by no means omit to notice the careful section of the Farlow beds‡ by Messrs. Roberts and Morris. In this compact paper, the passage upward from

1. Red sandstone, with cornstone, to
2. Yellow sandstone and conglomerate, containing *Holoptychius giganteus, Pterichthys macrocephalus,* and a larger species, and then to
3. Grey oolitic limestones, bearing Fish, or Crinoids, or Brachiopods in the several bands, and these interstratified again with clays of various colour,

is completely in accordance with the Pembroke sections. The Brachiopods are mostly identical with those from Tenby. *Spirifer cuspidatus,* and the varieties which seem to connect this species with *S. distans,* Sow., together with *Athyris, Rhynchonella,* and other fossils, completely recall to mind the Tenby sections.

The Fish too, though far more numerous and better preserved, are in the main identical. *Orodus, Psammodus, Helodus,* and *Cladodus,* among them, are excellent types for the Lower Limestone-shales.

But the measured thickness of this section gives us no idea of the masses to be seen in Pembrokeshire; and we have only the general accordance—of red sandstones surmounted by yellow grits full of characteristic Upper Devonian types—to assure us that the Upper Old Red is here, as in the sections above described, gradually losing its colour before being overlain by the deeper-water sediments of the Carboniferous series.

In the Mendips a valuable section by Mr. D. H. Williams§ shows the same alternations of impure limestone and shale, at the base interstratified, as at Caldy Island, with red limestones and oolitic bands; and a thick series of brown calcareous sandstones which can be exactly paralleled with Nos. 77 to 80 of the Skrinkle Bay section‖.

Then a few alternations of red shale and cherty limestone at the base conduct us to hard light-grey sandstones, which here form the

* Mr. Rees's Section, Geol. Surv., Vertical Section No. 12.
† Geol. Surv., Vertical Sections Nos. 11 & 12.
‡ Quart. Journ. Geol. Soc. vol. xviii. p. 95.
§ Geol. Surv., Vertical Section No. 12. ‖ *Ibid.* No. 12.

uppermost part of the Old Red, as they do in the sections just quoted. This is perhaps the nearest approach to the North Devon type that any of the sections on the parallel of the Bristol Channel present.

These light-grey sandstones and the intervening grey and greenish shales should be well searched. They are sure to contain the characteristic *Knorria dichotoma*; for this (or analogous Plants) was found by Earl Ducie in the Tortworth grits. And it would be a great corroboration of this view if some beds of the *Avicula Damnoniensis* could be found among them, as in the West Pembroke section.

§ 5. *South Ireland.*

While we wait for a memoir on the Irish Upper Devonians, I cannot do better than give a short abstract of the paper by Mr. J. Beete Jukes and myself, published in the 'Journal of the Geological Society of Dublin,' 1855, vol. vii. p. 63.

First, we found it impossible to separate the so-called Yellow Sandstone of the South of Ireland from the Old Red, for the good and sufficient reason that it is, as in all the other sections, the upper part of that formation itself, losing its colour preparatory to the introduction of the Carboniferous series. [The Yellow Sandstone of the North of Ireland is a different thing; as in Scotland it is there the base of the Carboniferous Limestone, and contains Carboniferous fossils only.] Both in the Yellow Sandstone and the red and green beds below we found the *Knorria* and its roots (*Filicites dichotoma*, Haughton). In more productive beds in Kilkenny and near Cork Prof. E. Forbes had already found the *Anodon? Jukesii*, which is probably a *Modiola*. *Stigmaria* and *Lepidodendron* occurred here, but no decided traces of *Sigillaria*, nor do I believe there are any instances of this genus occurring below the lowest Carboniferous beds.

Next, the Carboniferous Slate, which overlies the Yellow Sandstone, is very thin towards the east—that is, in Kilkenny, Waterford, and Wexford (the fine section at the Hook, Wexford, is the best worth study); but towards the west it thickens out, and from Cork to Bantry is interstratified at its base with grits, which form, near Glengariff, a group 3000 feet thick, and which were termed by us, as they had been previously by Mr. Jukes and the Irish Survey, "*Coomhola Grits*."

If a line be drawn from Kenmare through Macroom and Cork, thence south of Youghal to the Bristol Channel, it will coincide with the boundary between the northern or Herefordshire type of the Old Red Sandstone and Carboniferous Shale, without the intervention of the Coomhola Grits, and the southern or Devonian type as seen at Bantry, Kinsale, and all through Devonshire. It will define also the northern limit of the "Coomhola Grits." And, lastly, it is the boundary-line between the coarse shallow-water deposits of the Old Red Sandstone, with pebble-beds and Plants, and the more open-sea Devonian deposits, of thicker mass, finer grain, and lighter colour, full of marine Shells and Corals. The boundary is not an arbitrary one, but appears to have been a line of coast, or of shallow water, during the period of the deposition of the limestone-shale, as well as the uppermost beds of the Devonian series.

These grits, we observed, differed little from the Devonian grits below them, except in being chiefly grey, and having intercalated beds of dark grey, instead of greenish, shales. The partings of black or dark-grey shale constitute the only mineral character we could find to separate the two series.

The fossils of the Carboniferous Slates and Coomhola Series are as follows:—

Carboniferous Slate.

Among a host of others occur *Fenestella plebeia, Actinocrinus, Platycrinus, Poteriocrinus,* and *Rhodocrinus,* which I think identical with the Carboniferous forms. With them, however, were in abundance *Spirifer cuspidatus,* a Carboniferous form, with *S. disjunctus*? (I believe this to be the wide form of *S. bisulcatus,* so common in all the Pembroke sections). In addition were *Orthis Michelini, Streptorhynchus crenistria, Athyris squamosa, Productus,* sp., *Rhynchonella pleurodon* (abundant), *Orthoceras, Nucula,* and, lastly, the *Modiola Macadami,* Portlock,—a shell abundant in Lower Carboniferous beds. Annelide-trails and -burrows were abundant in all the beds, as they are also in the underlying Coomhola Grits.

Coomhola Series.

In the western part of Cork, and notably at Dunworley Bay, Dirk Bay, Skibbereen, and Glengariff, we have Encrinites of the same genera as above, but several of them apparently of different species from those of the Carboniferous Limestone. *Rhynchonella pleurodon, Spirifer cuspidatus*? (doubtful), *S. disjunctus* (*S. Verneuilii,* Murch.); many undescribed bivalves of the genera *Modiola, Ctenodonta* (*Nucula*), *Cucullæa, Axinus, Avicula, Aviculopecten,* and a new genus for which I proposed the name *Curtonotus*; *Bellerophon,* with rounded, keeled, and trilobate dorsal edges, as in North Devon; *Cucullæa* of several species, and *C. trapezium*; *Lingula,* new large species; *Rhynchonella pleurodon* and *R. laticosta*?; and, lastly, the most common Shell and Plant, *Avicula Damnoniensis* and *Knorria dichotoma* in every shale-bed.

The conclusions we arrived at were:—

1. That in South Ireland the Yellow Sandstone was the upper part of the Old Red.

2. The Carboniferous Slate, whether well or thinly developed, contains in its upper part the ordinary Carboniferous types.

3. A local but considerable group intervenes, physically more connected with the Carboniferous, but distinct as to fossils. It has the same Plants as the Upper Devonian (that is, Upper Old Red), some few Shells of the Carboniferous Limestone, and numerous Bivalves peculiar to itself. This group is the equivalent of the Marwood sandstones*.

* In part only: as I have above shown (p. 480), it is the true equivalent of the Upper Pilton group.—J. W. S.

4. In our postscript we inclined to the view that No. 3 was a decidedly Carboniferous group; but this was owing to the mistaken notion that the Pilton or Upper Marwood group was the equivalent of the Carboniferous slate,—a statement made on my own authority, as above noticed. For all else in this memoir, except the supposed identification of the *Spirifer disjunctus* in the Carboniferous Slate, and of *S. cuspidatus* (which I now believe to include *S. Barumensis*) in the Coomhola Grit, I am willing to be equally responsible with Mr. Jukes.

§ 6. *Foreign Equivalents.*

On these I do not intend to say much, having never seen the French and Belgian Devonian rocks. But the broad and general view of them given in the second edition of 'Siluria,' together with Messrs. Sharpe and Godwin-Austen's papers in our own Journal, surely entitle us to attempt the parallel, which I hope personal observation will enable me one day to verify.

In the last edition of 'Siluria' the three or, rather, four subdivisions of the Old Red Sandstone are thus given in ascending order:—

1. Tilestones or "Passage beds."	This term has given rise to much confusion, and the beds would be much better called "Ledbury Shales;" I, therefore, propose this term for them.
2. Lower Devonian, "Coblentz Sandstone," Lower Cornstone group of the Old Red.	Characterized by *Cephalaspis*, *Pteraspis*, *Pterygotus*, &c., as well as by peculiar Shells.
3. Middle Devonian, Eifel and Plymouth Limestones, Caithness Flags.	*Coccosteus*, *Asterolepis*, *Dipterus*, *Calceola*, *Stringocephalus*.
4. Upper Devonian, Yellow and Red Sandstone, Cypridina-schist, Flinz and Kramenzel-Stein, Petherwin Group.	*Holoptychius*, *Glyptopomus*, *Cucullæa trapezium*, *Avicula Damnoniensis*, *Spirifer disjunctus*, *Athyris concentrica*, *Strophalosia subaculeata*, *Cardium palmatum*, *Clymeniæ*, *Phacops granulatus*.

Comparing with the above series the last revision of the Devonian Geology of the Rhenish Provinces, as given in the Map of Von Dechen and his associates, we find the following:—

1. Ardennes Schiefer, Coblentz-Schichten (or Spirifer Sandstone), Wissenbach Schiefer.	These are represented truly by our Linton and Fowey groups, in North Devon and Cornwall.
2. Lenne-Schiefer, Eifel-Kalk.	Plymouth and Combe-Martin Limestones.
3. Cypridinen-Schiefer, including the Goniatite-shales, Flinz, and Kramenzel-Stein with *Clymeniæ*.	Petherwin Group in every detail.

4. Verneuilii-Schiefer, Argillaceous Sandstone. } Marwood (and Pilton?) Group, with exactly the same fossils.

These Verneuilii-Schiefer (a bad name for a group already named by Sedgwick and Murchison) come up in long parallel folds near Aix-la-Chapelle and rest on the Eifel-Kalk, without the intervention (at this place) of the Cypridina-Schist, and are themselves covered by the Kohlenkalk or Mountain Limestone. This fact is valuable, as indicating what we have as yet failed to detect in North Devon—an unconformity between the Marwood group and the other members of the Devonian formation*.

In the Bas Boulonnais, Sir Roderick Murchison described, in 1840, some of the Devonian species, but failed to make out that the whole series was only the uppermost portion of that formation; nor was Mr. Godwin-Austen, in 1853†, completely set free from the notion of older Devonian rocks being present, as Delanoue and others had determined.

But Mr. Austen's paper gives all the necessary elements for correcting this view; the stratigraphy is clear, and the lists of fossils complete. Below the Mountain Limestone he found a band of shale (Le Hure, Ferques, &c.), which he passes over without much comment, but which must either be the Limestone-shale or the Pilton group, and his paper conducts us at once to

The Yellow Sandstone group = "*Grès à Unio*" of Rozet [Psammite de Ludlow, of the Boulogne Meeting‡], Landrethun to Ferques, 25 feet thick (Bois de Beaulieu, &c.), meeting the Coal-measures (Dufrénoy), Marwood Sandstone (Austen).

There can be no doubt of the age of this sandstone. *Cucullæa Hardingii, C. trapezium, Bellerophon subglobatus*, &c., tell the story at once, and leave us free to consider the strata below them.

If the Boulogne formation were anything like the same in development as our North Devon series, the thickness of 25 feet of sandstone would give us a mere capping for the great Marwood series; accordingly we find, in descending order,

Bright red shales and clays.
Dark grey shales .... } Château de Fiennes.

Ferques limestone.—Near Malaise, Bois de Beaulieu, and to the Château de Fiennes. Great abundance of *Spirifer disjunctus*.

A selected list of the fossils of this limestone gives us the true Pilton group. We have *Athyris concentrica, Rhynchonella pleurodon, Spirifer Bouchardi, S. disjunctus, Strophalosia caperata* (*S. scabriculus*, Sharpe), and *Phacops latifrons* (*P. Latreillii*). With these, however, are a few which are more characteristic of the Newton-Bushel limestones than the Barnstaple group, namely, *Atrypa reticularis*,

* Unconformity to the largest extent has long been known between the Upper and Lower Old Red in South-west Ireland. Sir R. Griffith described it; Sir R. I. Murchison, Mr. Jukes, the Members of the Geological Survey of Ireland, and myself saw it in 1856; and since then Mr. Geikie has described the same thing as occurring in Scotland. See Quart. Journ. Geol. Soc. vol. xvi. p. 312.

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

‡ Bulletin de la Société Géologique de France, vol. x. p. 404, 1840.

Terebratula hastata, *Spirifer heteroclytus*? (*S. subconicus*), *Strophomena Dutertrii*, and *Strophalosia subaculeata*; also *Favosites polymorpha*, *Cyathophyllum*, and other Corals. Red shale, again, and dolomitic limestone lead down to the Blacourt Limestone (=Limestone of La Cédule, &c.), which is worked in part for iron-ores. Still we have the same fossils, with some omissions and additions, and then a series of shales, which is followed by compact micaceous sandstone with Ferns*, Calamites (probably *Bornia transitionis*), &c., with some of the above fossils. There is nothing in the whole section to indicate that we have reached a lower horizon than that of the Marwood beds. Mr. Austen's comparison of them with the Ogwell, Plymouth, and Linton groups is the only flaw in an admirable paper.

In Mr. Sharpe's paper in the same volume of our Journal †, an attempt is made to compare the Belgian series with our British rocks. Generally speaking, it comes to the same results as those given in 'Siluria' above quoted.

But the lower part of M. Dumont's "Système Condrusien" evidently includes the Barnstaple (and Petherwin?) group, resting as this does upon the Eifel or Middle Devonian series.

For the present it will be sufficient to indicate that the "Système Condrusien" may be divided thus:—

Upper = Carboniferous Limestone.
Lower = Barnstaple or Pilton group.

The grey micaceous sandstones and flags of the lower division certainly point to the same horizon as the sandstones, shales, &c., of the Boulonnais, and M. Gosselet's important paper‡ only confirms this idea.

I take advantage of this opportunity (referring to the abstract by Mr. Pattison in the Journal for November 1861, vol. xvii. part 2. p. 27) to enumerate the chief divisions of the series as given by M. Gosselet. In descending order, his numbers are:—

		English equivalents (J. W. S.).
Nos. 1. 2. 3.	}	Coal and Carboniferous Limestone.
4. Psammites de Condros	=	Marwood beds; containing *Phacops latifrons*, *Athyris concentrica*, *Spirifer Verneuilii*, and *Strophalosia scabriculus* (probably *S. caperata*).
5. Slates of Famenne	=	Petherwin beds and Upper Newton Bushel limestone; containing *Rhynchonella cuboides*, *Spirifer Verneuilii*, *Cardium palmatum* §.
6. Givet limestone	=	Plymouth and Ogwell.
7. Calceola slate	=	Limestone-shale (Chircombe, &c.).

* These fossils should be examined carefully. In all probability the Fern is *Adiantites Hibernicus*. Moreover, the so-called *Graptolites* from Caffiers have been determined to be leaf-stems or -stalks. Here we have all the analogies of the Marwood group.

† Vol. ix. p. 18. ‡ Bull. Soc. Géol. de France, 2me sér. vol. xviii. p. 18.

§ The author specially remarks the absence of the *Clymenia*; but though this

Nos. 8, 9, 10, the remaining Devonian groups, are not necessary to our purpose. But it is worthy of remark that the fossils quoted by M. Gosselet as having been found by M. Hébert in the Burnot conglomerate are Marwood species (*Cucullæa Hardingii*, *Productus? Murchisonianus*, &c.), and must have been obtained from other and higher beds.

It would appear, from all that has been published regarding the Upper Devonian beds of Saxony, the Hartz, Nassau, and Westphalia, that the Marwood beds are absent in these districts,—the Carboniferous Limestone resting at once on the Clymenia-limestone, or Petherwin group.

In the Rhenish provinces, in Belgium, and in the north-west of France, on the contrary, the Marwood group is present. And this variety in the distribution adds strength to the inference already drawn on other grounds, that the Marwood group is unconformable to the other members of the Devonian. The Carboniferous Slate is, as we have seen, only here and there developed to its full extent; and as we know that the Mountain Limestone itself is universal over the greater part of Europe, and has besides a much wider extension, the reasonable inference would be that, after the filling-up of the sea-bed towards the close of the Devonian period, a continued subsidence took place, which allowed the older beds to be gradually covered up successively, first by the Marwood and Pilton group, then by the Carboniferous Slate or Lower Limestone-shale (the terms are convertible), and lastly by the thick masses of the Mountain Limestone itself, which we know in many cases overlaps the whole Devonian series and rests upon the Silurian slates.

I should scarcely have referred to the North-American area but for the purpose of directing attention to a very interesting point, confirmatory of all that has been said above regarding the age of the uppermost Devonian—the "Chemung group" of the New York series.

Of this group Professor Hall has given sufficient details in his 'Geology of the Fourth District' to enable us to see that its fossils, as a whole, agree well with the Petherwin or Upper Devonian group. It includes several fossils with which we are familiar. Amongst them, *Phacops nupera*, Hall (*P. bufo*, var.); *Aviculopecten*, a great many species; *Orthis interlineata*; *Spirifer disjunctus*, and many others, including *S. Urii* (*S. unguiculus*); *Atrypa reticularis*, and many varieties of this variable shell, as in our own Newton-Bushel limestones, e. g. *A. dumosa*, *A. hystrix*, *A. tenuilineata*, &c.; *Petraia*, *Ceriopora*, &c.; also *Avicula Damnoniensis* in plenty. This group of species might be easily referred to the Barnstaple group, but it is more agreeable with the whole of the facts to consider it the equivalent of the Petherwin or Clymenia-group, and the fossils are rather in favour of this view. Moreover, Professor Hall lays

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omission is of importance, and may render it possible for No. 5 to be a lower member of the Barnstaple or Pilton group, this is unlikely, as *Cardium palmatum* is a *characteristic* Petherwin species, and rarely, if ever, occurs in the Marwood beds.

stress on its union, as a formation, with the rest of the New York series—the Portage, Hamilton, and other groups, which represent the mass of the Devonian. It is covered (unconformably?) by the Catskill conglomerate, which there can be no doubt represents our own Upper Old Red, and therefore the Marwood series inclusively.

§ 7. *General Conclusions.*

If I have thus established clearly, by position, by intercalation of marine beds with the red sandstone, and by fossils, the identity of the uppermost Devonian or Marwood group with the Upper Old Red (I must omit for the present the Petherwin group, which is also probably, but not certainly, included in this upper division), it remains to be seen whether the same great clue—the fossil evidence—will suffice to give us the long-wished-for identification of the Middle and Lower Devonian with the Middle and Lower Old Red Sandstone. It is not difficult of proof.

I hold that the masterly suggestion of Sir R. I. Murchison, that the Caithness Flags, full of *Coccosteus*, *Pterichthys*, and a dozen other genera, belong to the *Middle*, and that the Cephalaspis-beds of Scotland belong to the *Lower* Division of the Old Red, is the greatest advance made of late years in the classification of the British Devonian rocks.

Without this clue we were in a sea of difficulties and contradictions. But, following it out, the whole of the Old Red Sandstone subdivisions fall into their proper places, and can be correlated accurately with the Continental equivalents*.

Thus, in Russia, the Eifel, and the Hartz, *Coccosteus*, the characteristic Fish of the Middle Old Red beds, is found associated with the fossils of the Eifel or Middle Devonian limestone. In Russia, Sir Roderick Murchison informs me, they have been found by his friends in the same slab. The identity of this part of the two formations is thus proved, and need not further be discussed.

But what of the Cephalaspis-beds or Lowest Old Red? And how are we to identify them with the Lowest Devonian, the Coblentzian or Rhenane series?

Professor Ferd. Rœmer† and Professor Huxley‡ have unexpectedly answered this question for us. The former obtained a fossil which he supposed to be a naked Cephalopod, allied to the *Sepia*, and which he described as *Archæoteuthis Dunensis* in the 'Palæontographica' and the 'Jahrbuch.' It came from the Lower or Coblentzian rocks of Daun. Afterwards it was again obtained from Wassenach, on the Laacher-see, Lower Eifel. There is no doubt whatever that

* While these pages are writing, Sir Roderick has received specimens, obtained by Mr. C. Peach, from the beds which rise out from under the Caithness flags, at Ulbster Wick. They prove to contain specimens of the Pterygotus-type, and are most satisfactory as proving the succession to be what was before indicated. See Prof. Ramsay's Anniversary Address to the Geological Society, Quart. Journ. Geol. Soc. vol. xix. p. xlv. 1863.

† Palæontographica, vol. iv. p. 72; Leonhard and Bronn's Jahrb. 1858, p. 55.

‡ Quart. Journ. Geol. Soc. vol. xvii. p. 163.

Professor Huxley is right in referring this fossil to the genus *Pteraspis*—than which Ganoid Fish, abnormal though it be, there is no more characteristic fossil of the Lower Cornstones of the Old Red Sandstone. The Lower Devonian is therefore the equivalent of the Lower Old Red Sandstone.

There remain only the "Tilestones," or "Ledbury Shales," which contain a different fauna from all these, but unequivocally (as I believe) Lowest Devonian. But as these should form the subject of a separate memoir, I will not trench upon that ground at present.

§ 8. *Appendix.*

Curtonotus, gen. nov.

It is necessary here to give the characters of a genus of Bivalves, often quoted in the preceding pages, and which has long been known in our lists of fossils without having been sufficiently illustrated.

I believe I proposed the name in the joint memoir by Mr. Jukes and myself in 1855. The genus is intended to include a number of oval thick-shelled bivalves related to *Myophoria* and *Axinus*, but distinct at a glance by the general rounded form, and technically by the simple, not divided, central teeth of the hinge.

The genus is characteristic of the Pilton group throughout, occurring at its extreme attenuated end, or immediately above it, in Pembrokeshire, and abundant throughout the Coomhola grits of South Ireland, while it occurs, though rarely, in the Barnstaple slates.

Some six or eight species are recognizable; some of which are mentioned in the Explanations of Sheets 197, 198 of the Irish Survey, pp. 10 *et seq.*; and one is figured in Professor Jukes's 'Manual,' 2nd edit. p. 508, fig. 14 *f.*

The following names are used in the Explanatory Sheets for the Irish Survey, Sheets 197, 198:—

Curtonotus elegans, Salter, in Jukes's Manual, as above quoted.
C. rotundatus, Salter, Expl. *l. c.* p. 11, Co. Cork, Ardgroom.
C. elongatus, Salter, Old Head of Kinsale, Dunworley Bay.

These are, on an average, $1\frac{1}{2}$ inch wide; and there are some still larger species in the Irish cabinets.

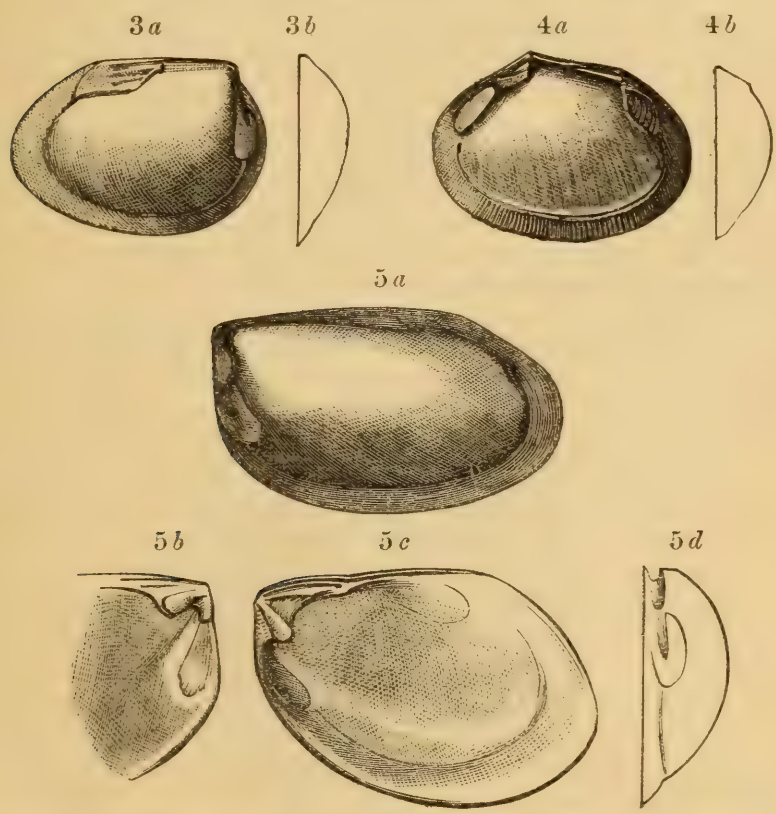
Generic Characters.—In the typical species, *C. elegans*, from Angle Bay, Pembrokeshire, the beaks are prominent and placed at the anterior fourth. In one of the species from Co. Cork they are low and nearly halfway from the anterior end. In *C. elongatus* they overhang the anterior side. However they may be placed, beneath them in each valve is a thickened hinge-plate with a single strong triangular central tooth, smooth-edged, and not indented below as in *Schizodus.* In the left valve this tooth lies behind the deep notch for the corresponding and equally large tooth in the right valve, this being in front of it; and in the right valve only is there an obscure tooth behind the central one. There are no remote cardinal teeth, nor hinge-lamella for the support of a ligament, which it seems must have been external. The anterior muscular scar is deep, the posterior less excavated, and placed far inwards; the pallial impression is entire, at a considerable distance from the edge in most of the species. A thick low ridge extends from the hinge-plate behind the anterior muscular scar.

Curtonotus elegans, Salter. Figs. 3 *a*, 3 *b*. Jukes's Manual, 2nd edit. p. 508, fig. 14, *f*.

An inch wide, gently convex, regularly oval, not very thick-shelled; beak small; nearly overhanging the anterior side; pallial line near the margin. Surface smooth. Cardinal tooth oblique; hinge-plate moderate.

Co. Cork (Pilton group), Dunworley Bay. In the Mus. Irish Industry.

Figs. 3–5.—*Shells from the Pilton Group.*



Curtonotus, three species:—3 *a*, 3 *b*. *C. elegans*. 4 *a*, 4 *b*. *C. centralis*. 5 *a*–5 *d*. *C. elongatus*.

Curtonotus Unio, spec. nov.

Round-ovate, not pointed at either end, about 1 inch high and $1\frac{1}{4}$ long, gently convex, the beak rather prominent and nearly overhanging the anterior end. A broad callosity runs vertically from beneath it within the shell. Anterior muscular scar small, but deep; posterior placed high up, distinct, oval. Pallial border not very near the edge; shell thick about the hinge. Cardinal teeth narrow, nearly direct.

West Angle Bay, W. Pembrokeshire, in the lowest Carboniferous

Shale, or upper part of the Pilton group. In the Mus. Pract. Geology.

CURTONOTUS CENTRALIS, spec. nov. Figs. 4 *a*, 4 *b*.

Transversely oval, rather thick-shelled, convex; the low beak more than one-third from the anterior end. Cardinal tooth direct; hinge-plate moderately thick. Pallial scar rather near the margin.

From the Pilton group, N. of Enniskeen, co. Cork. In the Mus. Irish Industry.

CURTONOTUS ELONGATUS, Salter. Figs. 5 *a*–5 *d*.

Transversely oval, gibbous from the prominent beak, which is terminal, and overhangs the short oblique anterior end. Hinder margin rounded. Breadth to length as 7 to 13. Surface concentrically striate. Hinge-plate triangular, thick, with a large tooth in either valve, and a very small secondary anterior one in the left valve.

From the Pilton group, Co. Cork. Townland of Leheragh, Dunworley Bay. Bear Island, Kerry. Old Head of Kinsale. In the Mus. Irish Industry.

I also subjoin a description of the *Serpula* from the Upper Old Red Sandstone, above mentioned, p. 476.

Fig. 6.—*Mass of* Serpula advena, *from the Upper Old Red of Caldy Island, West side* (natural size).

SERPULA ADVENA, spec. nov. Fig. 6.

Short wavy cylindrical tubes, one-third of a line wide, and about one inch long, closely aggregated, ascending. The surface is smooth, or, at least, not roughly ridged (*a*). The state of preservation does not permit me to say whether the surface is quite smooth, or marked with lines of growth. The tubes are filled with solid carbonate of lime, and lie in a red sandy matrix.

This species occurs 40 feet below the uppermost bed of the Old Red Sandstone, in Sandtap Bay, west of Caldy Island, Pembrokeshire, whence it was collected by me in 1854; also in beds of the same age at West Angle, Pembrokeshire.

June 3, 1863.

The Rev. Richard Wilson Greaves, M.A., Rector of Tooting, was elected a Fellow.

The following communication was read:—

On the Section *at* Moulin Quignon, Abbeville, *and on the* peculiar Character *of some of the* Flint Implements *recently discovered there.* By Joseph Prestwich, F.R.S., Treas. G.S.

A short notice of the age and character of these beds was given by me in a paper read before the Royal Society in May 1859, and I should not have recurred to this small section had not the recent announcement of the discovery of a Human Jaw and of Flint Implements of a peculiar type, by M. Boucher de Perthes, attracted particular attention to these beds, and led to questions being raised respecting both the age of the beds and the genuineness of the remains.

The general grounds on which the antiquity of the Human remains have been questioned are:—1st, the exceptional condition of the Human Jaw; and 2nd, the peculiar character and fresh-looking aspect of the Flint Implements. On the first point I do not wish to make any observations, as the question will be discussed by Dr. Falconer. Nor will I dwell long on the second point, with regard to which I have taken a more active part. Up to the beginning of this year Flint Implements had been rarely found at Moulin Quignon. I had visited the pit at least seven or eight times, sometimes alone, at other times in company with my friend Mr. Evans and others, but we had never succeeded in finding a Flint Implement, nor even in obtaining a specimen from the workmen. I have two specimens given me by M. de Perthes, and Mr. Evans has one given him by M. Marcotte. These, and all those which I had seen in the collection of M. de Perthes, were invariably stained of a dark yellow or brown colour, were generally worn, and had the usual lustre of old specimens. Not only do they possess these characters of Quaternary Flint Implements, but they possess them in a degree more marked than do those from any other spot. Nowhere are they so much coloured, and nowhere so much worn. A number of them are also ruder than any I have seen anywhere else. When, therefore, on the 13th of April last, Mr. Evans and I saw the collection of Flint Implements which M. Boucher de Perthes had obtained from the bed containing the Human Jaw, their characters struck us as being so exceptional as to raise serious doubts as to their authenticity. Before, however, pronouncing an opinion, we went to Moulin Quignon to examine further the section. Unfortunately there had been a fall of the gravel, and the face of the section was almost entirely obscured, so that it was impossible for us to obtain the evidence we required. We went, therefore, to the pit at St. Gilles, and on our way, the workman who accompanied us took two Flint Implements from his pocket and handed them to me, saying he had found them at Moulin Quignon. These specimens were rude, badly shaped, and apparently smeared over with a ferruginous clayey sand. Upon washing one of these at the first cottage we came to, all the soiling came off readily, and left the flint as fresh as though it were the work of yesterday. In sharpness of angles and in form, it also differed widely from all previously discovered at Moulin Quignon. We concluded that these two specimens were forgeries, and to that opinion I still adhere. On our return to M. Boucher de Perthes, we took the opportunity to express our doubts as to the authenticity of the Flint Implements he had recently obtained from Moulin Quignon, and to suggest how serious a doubt this would cast upon the jaw itself. We asked him to wash some of the specimens, and one that he did so wash only confirmed our opinion. At the same time we should have reserved the general expression of this opinion until there had been an opportunity for further inquiry, and study of the section. Our object was merely to caution M. de Perthes. Circumstances led to our being called upon to endorse that opinion before we had had the opportunity of the further examination we could have wished; nevertheless what we afterwards saw of other Flint Implements recently brought from the same place strengthened our first impression. In all these recently found specimens there is an entire absence of all the characters by which we had hitherto distinguished genuine from false specimens. It is true that both at Menchecourt and St. Acheul we had met with Flint Implements sharp and not worn, some not stained, and some rude in form, but, on all, some one character of antiquity was to be found: on one traces of incrustation of carbonate of lime; on another, of dendrites; on a third, of discolouring; and on a fourth, lustre. So also we could find here and there a flint, sharp, fresh, and not coloured. But all these were exceptional characters, whereas in the case of the new Moulin-Quignon specimens these exceptions become the rule. That one or even two specimens might be found exhibiting these exceptional characters might, it seemed, have been possible; but when we found that all, without exception, exhibited these characters, the improbability of such an occurrence became so great as to cause us to believe that some imposition had been practised. There were, it is true, two or three specimens about which I felt more doubt; but, on the whole, the unfavourable evidence outweighed other considerations.

The intrinsic evidence on the two points was therefore in accordance, and equally unfavourable to the authenticity of the case. The objections raised to this conclusion by the French naturalists, who had taken up the subject, led to a friendly meeting in Paris *. Mr. Evans was unable to attend this meeting; it will therefore be understood that I no longer refer to his opinion in conjunction with my own. The inquiry lasted three days, when, unable to agree in a conclusion, we adjourned for further inquiry to Abbeville. The discussion was careful and temperate. Each point was fully gone into at the Paris sittings. Our French allies) not having had, pro-

* The members of the meeting were:—M. Milne-Edwards, president; M. de Quatrefages, M. Desnoyers, M. Delesse, M. Lartet, Dr. Falconer, Mr. Busk, Dr. Carpenter (in Paris only), and the author. For full particulars of the inquiry see the careful account of the "Procès Verbaux," published by Dr. Falconer and others, in the 'Natural History Review' for August 1863.

bably, so much experience as ourselves of the condition of the various gravel-beds, and of the Flint Implements found in them) were not so much struck as we were with the exceptional characters of those recently discovered at Moulin Quignon, whilst, with us, these characters were considered an insuperable bar to admitting them to be genuine.

Thus far on this point there was no difference of opinion amongst the English members of the meeting, and with it some of the French members concurred. The visit to Abbeville led to a change of opinion with several, myself amongst the number.

No notice had been given of our intended visit, and we appeared on the scene quite unexpectedly. Operations were commenced at seven in the morning of the 12th of May, and were continued, without intermission, until five in the evening, during which time some members of the meeting were always present, watching the work and the workmen. The section was first cleared, and a fresh vertical surface from the top down to the chalk exposed. The strata appeared to be in their natural condition, and there was no apparent derangement of the stratification, though it was a good deal confused, as is common in gravel-beds, but nothing remarkable or requiring notice. In the course of the day, five Flint Implements—one of the old and unquestioned type, and the other four of the type which we had considered spurious—were obtained. They were found in the lower part of the gravel, 8 to 12 feet from the surface, and on or a little above the level of the "Black Band," in which the jaw had been found, and at but a short distance from that spot. The finding of every specimen was witnessed by some one or other cause for not accepting the authenticity of the specimens; nor, as it member of the party, although I was not so fortunate as to see one discovered myself; and, notwithstanding therefore the singular and exceptional character of these Flint Implements, I saw no sufficient was the unanimous conclusion that no fraud had been practised, and seeing certain exceptional characters obtaining in this bed and in the Human Jaw, for contesting the verdict respecting the authenticity of the latter, though on this latter point I speak with reserve, especially as my friends Dr. Falconer and Mr. Busk held a different opinion.

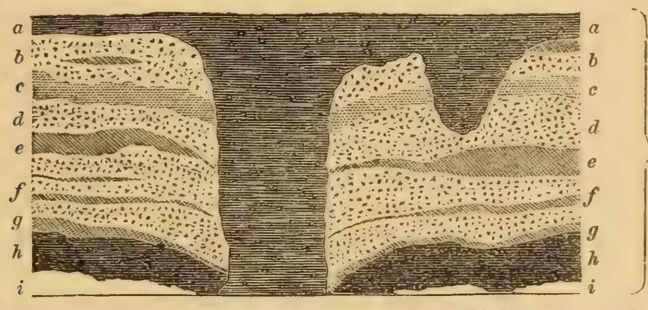
The result of this day's inquiry led me to believe, therefore, that I was mistaken in attaching undue weight to negative characters, and that many of these peculiar Flint Implements were really genuine specimens, thus confirming the researches and opinion of M. Boucher de Perthes, M. de Quatrefages, M. l'Abbé Bourgeois, Mr. Brady, and others, who had examined the section before we had, and arrived at the conclusion that the Flint Implements were genuine. The lately discovered specimens are generally rounded at one end, and with a sharp point at the other; there is another elongated form of a similar character; a third form is spindle-shaped, with sharp points at both ends. This last is a novel form—one which I have met with nowhere else; it appeared to me to furnish one independent argument in favour of the authenticity of the specimens. Some are very narrow compared with their length, others are broader.

This curious discovery has necessarily led to the age of the beds being more closely examined and questioned. M. Elie de Beaumont has recently given the weight of his high authority in favour of their comparatively modern age,—of the age, possibly, of some of the peat-beds of the Valley of the Somme, or of the Swiss lake-dwellings. I cannot at all agree with this view, and it is this consideration that is more particularly the cause of my laying the present paper before the Society. In the first place, it is assumed that at the time of the formation of the beds in question the valley had its present depth and shape, and that the beds at Moulin Quignon result from a secular wave of translation rushing in from the sea, or from the bursting of lakes or the sudden melting of the snow of mountain-chains. The hill at Moulin Quignon is 105 feet above the level of the sea, or 87 feet above the river. I have shown elsewhere how out of the question it is to invoke any river-floods of the present day; for as the Valley of the Somme, between Amiens and Abbeville, is, at a rough estimate, 6000 feet broad and 100 feet deep below the level of the high-level valley-gravels, with which I would connect the beds at Moulin Quignon, the sectional area of the valley at that height is to the sectional area of the present river at periods of flood about as 600,000 to 6000. Therefore, a supply of water 100 times greater than that flowing off during ordinary floods at the present day would be required to produce a flood rising to the level of Moulin Quignon,—an occurrence, in the present climatal conditions, perfectly impossible, as it would require the accumulated rainfall, not of one month or of one year, but of several years, to fill the valley with water, even in a state of rest.

The sudden melting of snow on mountain-chains, or the bursting of inland lakes, is equally untenable, inasmuch as the watershed separating the Somme from the Oise is only six miles broad and 80 feet high, so that any flood coming from the interior would almost inevitably transport the débris of one basin into the other, whereas not a fragment of the oolitic and old rock-débris of the Valley of the Oise has passed over into the Valley of the Somme. With regard to a wave coming in from the sea and throwing up or sweeping down débris of gravel of older Quaternary beds and of the land-surfaces upon the hill-slopes against which it rose, let us see what would be the consequences of such an action. If, as the eminent geologist who offers this explanation supposes, such waves of translation occurred within the Celtic or Roman times, then we ought to have in these high-level valley-gravels remains of Man of that date, whereas no such remains have ever been found.

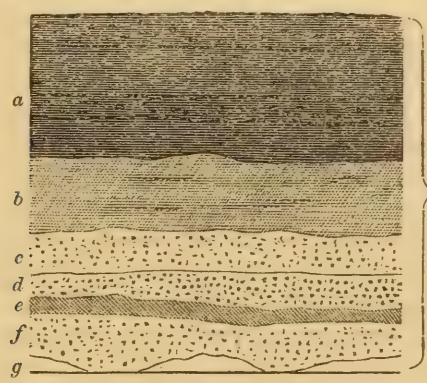
Secondly, whenever this inroad of the sea took place, the retiring water, in sweeping down the slopes, besides lodging the gravel on the higher ground, must necessarily have carried part into the lower levels; and it should be found intercalated with the alluvial and peat-beds of the valley, whereas no such intercalated beds are ever found, the valley-gravels always passing under the entire mass of alluvium and peat. Thirdly, the débris of the extinct Mammalia in such reconstructed beds would necessarily be more or less worn, and always fragmentary, whereas they are often not in the slightest degree worn, and parts and the whole of entire skeletons are not unfrequently found with every bone in place. Fourthly, the small delicate and fragile land- and freshwater-shells would have been generally destroyed, whereas they frequently occur in a state of perfect preservation, and, in the case of the bivalves, with the two valves occasionally not separated. Fifthly, it would behove the supporters of this view to show beds whence the remains of the extinct Mammalia could have been derived, whereas none such exist in the district. I will not occupy the time of the Society longer with other objections, as the subject in other forms has been often discussed.

Fig. 1.—*Section of the Gravel-pit at Moulin Quignon.*



a. Brown sandy clay, with angular gravel.
b, d, f. Ochreous gravel-seams.
c. Yellow sand.
e. Light-green sand.
g. Light-grey sand.
h. The "Black Band."
i. Chalk.

Fig. 2.—*Section of the Gravel-pit at St. Acheul.*



a. Brick-earth, with angular gravel.
b. Whitish sand and marl, with land and freshwater Shells.
c. Light-coloured gravel.
d. Ochreous gravel.
e. White sand.
f. Light-coloured gravel.
g. Chalk.

On the other hand, we have at St. Acheul and Montiers fluviatile Shells in the high-level gravels, and the same occur in the low-level gravels at Menchecourt, and probably at Mautort. For these and other reasons, into which I need not now enter, I have attributed the formation of these beds to river-action continued through a long period of time, and gradually excavating the valley from the level of the high-level gravels (low-water level, fig. 3) to that of the low-level gravels (on and below the sea-level, fig. 6).

In this particular case the shell-evidence is wanting, but I purpose to show that, notwithstanding a certain difference, the beds at Moulin Quignon can be correlated with those of St. Acheul, whilst both have been already shown to hold the same relative position to the modern river, or to be about 100 feet above its present level. Fig. 1 represents the section of the gravel-pit at the former place. The stratification is rude, the beds contorted, and the seams of sand are subordinate. The upper bed (*a*) consists of a coarse brick-earth full of fragments of flint, mostly white and angular, but mixed with some subangular gravel. The under surface of this bed is very irregular, and it often descends in funnel-shaped cavities down into the body of the gravel. If we eliminate the variable ingredients (*i. e.* the subangular gravel) from this bed, the residue will be found to be identical with the coarser bed of brick-earth which overlies the fluviatile beds at St. Acheul (fig. 2, *a*), and which also contains a variable proportion of angular flints peculiar to it, and of subangular gravel derived from the underlying beds. These upper beds I would therefore refer to one and the same cause, and consider as local variations of Loess. The section I have given of the gravel-pit at St. Acheul (fig. 2) represents the different beds in their least disturbed state, but the contact between the Loess and the fluviatile beds is at places as irregular as at Moulin Quignon. The same variations exist in the lower fluviatile beds. At Warean's pits, St. Acheul, the beds of sand (*b*) have almost entirely disappeared, no Shells are found, and the gravel is as coarse and irregular as at Moulin Quignon, and with only occasional seam of sand. At Moulin Quignon itself, however, the beds of sand are always most developed in the upper part of the section, and sometimes they there replace the gravels for a short distance. In both places the intercalated seams of sand occasionally show oblique bedding, none of the beds are persistent, the grains of quartz are worn and rounded, and the bulk of the flints subangular. The difference of colour is one of no importance, that being for the most part a change subsequent to the deposition of the beds. In all the physical conditions there is, therefore, an agreement between the beds at St. Acheul and Moulin Quignon. The presence of organic remains in all gravels of this age is of very local occurrence. Although scarce, remains of the Elephant have been occasionally found at Moulin Quignon, whilst teeth of the Horse and Ox have been found at the adjacent pit of St. Gilles.

On the opposite side of the valley is Mautort, and on the slope of the hill above the village is a deposit of gravel presenting the same general characters as that at Moulin Quignon, and overlain by a bed of Loess, which is here, however, well marked and developed. No Shells are found, but some of the seams of gravel have a more sandy and fluviatile appearance than at Moulin Quignon, arising probably from a somewhat greater depth of water; for the level of this bed is about 10 to 15 feet lower than that of Moulin Quignon. In all probability we have in both these places part of the bed of the old river, when it flowed in a channel higher by nearly 100 feet than the present river-bed. In the diagram-section, fig. 3, I have given what I consider may have been the section of the valley at that period, showing a shallow and broad river with numerous, generally dry, shoals and shingle-banks, but during floods, arising from the melting of the winter snows and a greater rainfall than at the present day, rising to a height of 40 to 50 feet above its ordinary level, flooding the adjacent country, and depositing, out of the course of the main current, the fine silt now forming the Loess. Mixed with this high Loess are angular fragments of flints washed down from the adjacent heights or carried from the shores by floating ice. As I have entered into this question fully in another paper*, I will not go further into it here than is necessary to apply it to this particular case. As the valley was by degrees excavated, such portions of the old river-bed as escaped denudation emerged gradually from the level, first of the river, and later of the river-floods, as shown in fig. 4. At this time the high-level gravels of Mautort and Moulin Quignon (A′ and B′) would have acquired their full thickness, but would, during floods, be subject to disturbance by ice-floes, and would gradually be covered up by Loess. At the same time the draining-off of the water and the percolation of the rain-water through the permeable gravel-beds, acting through a long period on the chalk, would attack and dissolve the weakest parts, and gradually give rise to the numerous gravel-pipes we find on this level, both at Moulin Quignon, Mautort, and elsewhere; whilst the depression formed on the top of the gravel thus let down would in process of time be filled up with Loess by the successive floods, levelling the irregularities of surface thus produced.

Fig. 5 represents the valley at the time of the formation of the low-level gravels, when the excavation had attained nearly its present depth, and when the deposits of Mautort and of Menchecourt, with the many fluviatile and estuarine shells and the abundant Mammalian remains of the latter place, were in course of formation. The section does not traverse Menchecourt, but it intersects the low-level beds of the "Carrée de Six" at the gates of Abbeville, where several fine molars of *Elephas primigenius* and some Flint Implements were found during the making of the moat by M. Boucher de Perthes. Here the high-level gravels, A″ and B″, are dry and out of the reach of the floods which formed the lower-level Loess of Mautort and Menchecourt.

Fig. 6 gives the section of the valley at the present time, showing the relation of the high-level gravels of Moulin Quignon, B‴, and Mautort, A‴, to the lower-level gravels of the valley, and of these to the recent alluvium with peat which has filled up and covered the irregularities left by the latter, the two showing an origin entirely separate, and an existence perfectly independent.

Whatever may be the conclusions drawn respecting the Jaw and the Flint Implements recently discovered at Moulin Quignon, the age of the beds is to me perfectly well determined, as belonging to an early

* Proc. Roy. Soc. vol. xii. No. 49, March 1862, p. 38.

Fig. 3.—*Theoretical Section of the Valley of the Somme at the time of the Formation of the High-level Valley-gravels.*

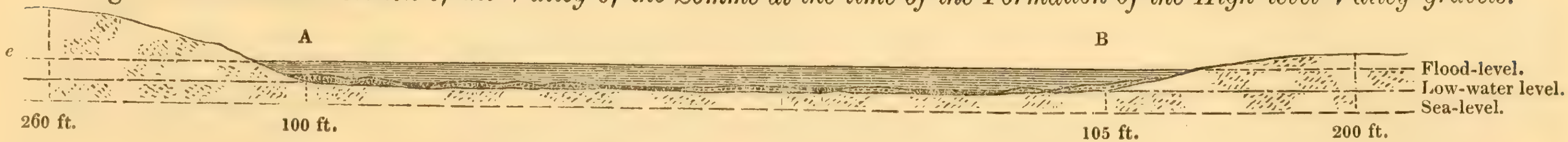


Fig. 4.—*Theoretical Section of the Valley of the Somme at the time of the Emergence of the High-level Valley-gravels.*

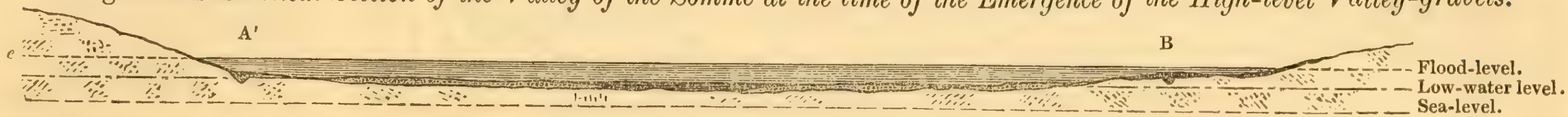
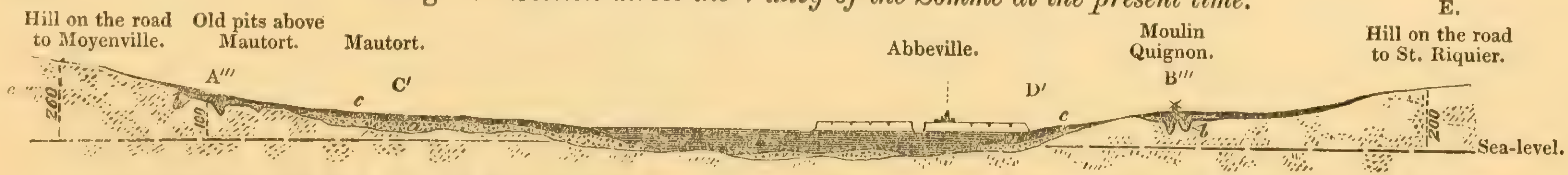


Fig. 5.—*Theoretical Section of the Valley of the Somme at the time of the Formation of the Lower-level Valley-gravels.*

Fig. 6.—*Section across the Valley of the Somme at the present time.*



a. Low-level Gravel. *b.* High-level Gravel. *c.* Loess. *d.* River alluvium and Peat. *e.* Chalk.

In Figs. 3–5 the more darkly shaded portions represent the river at low water; the lighter-shaded portions, the river during floods.

Quaternary or Post-pliocene period, that they are older than the Menchecourt deposits, and that they date before the excavation of the Valley of the Somme. Nor is the question of the contemporaneity of Man with these particular beds affected by any conclusions that may be arrived at relative to this recent inquiry. Whatever diversity of opinion there may be respecting certain Flint Implements, others, the genuineness of which cannot be questioned, have been found from time to time during the last fifteen years, both in the Moulin-Quignon pit and, in more considerable numbers, in the adjacent and equivalent beds of the "Champ de Mars" and St. Gilles, which place beyond dispute the occurrence, *in situ*, of Flint Implements shaped by early Man in these, amongst the oldest of the high-level gravels of the ancient Valley of the Somme.

Note.—Further and more deliberate inquiry, on the part of myself and others, than was possible on the occasion of the conference at Abbeville, leads me now to revert to my original opinion, and to believe that we were mistaken in concluding on that occasion that no fraud had been practised. In addition to the objections originally urged, I found, on washing a portion of the gravel containing the Flint Implements (an experiment contemplated but unaccountably omitted in May last), the discordance between the mineral condition of the flint fragments and the Flint Implements to be so great as to render it evident that the two could not possibly have been subjected during the same time to the same influences. Further, instead of being confined to a special bed and a special level, we found, on a subsequent visit, that specimens had been brought by the men from Epargnette (a bed on a yet higher level and hitherto unproductive); and, again, we were given, at Mautort, at a low-level valley-gravel-pit, three Flint Implements of precisely the same type and in the same condition as those of Moulin Quignon; whilst, from the indications given by the men, the specimens would have been taken from a bed of gravel subordinate to the Loess, and not even part of the mass of fluviatile low-level gravel. Our verdict in this case respecting the Flint Implements (leaving apart the question of the jaw) will, therefore, I fear, have to be reconsidered. The precautions we took seemed to render imposition on the part of the workmen impossible; still, although it remains undetected, I cannot, with the strong and increased doubts (not one of them since removed) attached to the point, continue to accept the authenticity of these specimens. The essential fact, however, of the occurrence of genuine Flint Implements at Moulin Quignon, the Champ de Mars, and Menchecourt receives additional confirmation from every fresh investigation, and places M. Boucher de Perthes's important original discovery beyond all doubt.—[J. P., Oct. 1863.]

June 17, 1863.

Frederick George Finch, Esq., B.A., Tudor House, Blackheath, was elected a Fellow.

M. Boucher de Perthes, of Abbeville; Dr. M. Hörnes, Keeper of the Imperial Mineral Cabinet of Vienna; M. N. von Kokscharow, of St. Petersburg; M. S. Lovén, of Stockholm; General della Marmora, President of the Imperial Academy of Sciences of Turin; F. A. Graf Marschall von Burgholzhausen, Archivist of the Imperial Geological Institute of Vienna; M. H. Nyst, of Antwerp; Dr. F. A. Quenstedt, Professor of Geology at the University of Tübingen; Dr. F. Senft, of Eisenach; Prof. Edouard Suess, of the University of Vienna; Dr. B. F. Shumard, of Louisville; and the Marquis de Vibraye, of Paris and Abbeville, were elected Foreign Correspondents.

The following communications were read:—

1. *On the* Relations *of the* Ross-shire Sandstones *containing* Reptilian Footprints. By the Rev. George Gordon, LL.D., and the Rev. J. M. Joass. With an Introduction by Sir R. I. Murchison, K.C.B., F.R.S., F.G.S.*

[Communicated by Sir R. I. Murchison, K.C.B., &c.]

In the introduction Sir R. I. Murchison gave a sketch of the geology of the Tarbatness promontory, which is composed of variously coloured sandstones, having a conformable dip to the N.W. In these strata the authors had found footprints † (of animals believed to be Reptiles) similar to those found in the sandstones on the coast of Elgin; and it was therefore desirable to prove whether these rocks really belonged to the Palæozoic series, or, as some geologists suppose with regard to the Elgin sandstones, to the Trias. In order to solve this problem, if possible, the Rev. Mr. Joass made a careful survey of the coast from Geanies to Tarbatness Lighthouse, and round along the north shore of the promontory to the inlet at Inver; and he found a conformable succession between the undoubted Old Red Sandstone of Geanies and the track-bearing sandstone of Tarbatness.

The Rev. Dr. Gordon gave a description of the various tracks: the smaller kind were referred by him to an unknown Crustacean; the larger and more definite impressions, however, he considered to be the footsteps of some kind of Reptile. He also stated, as confirmatory of the 'Old Red' age of the beds, that the Oolitic beds of Shandwick are unconformable to the Old Red Sandstone.

Mr. Joass then described the beds and their stratigraphical relations as follows:—In a paper published in the 'Transactions of the

* The description of the beds by Mr. Joass, and a statement of their relation to the Oolitic deposits by Dr. Gordon, are given in full, the Introduction and the remainder of the paper in abstract.

† Footprints in the Tarbatness Sandstones were first discovered by the Rev. G. Campbell, in the summer of 1862.

Geological Society of London,' 2nd ser. vol. iii. part i. p. 150, 1828, I find it stated, on the authority of Sir R. I. Murchison and Prof. Sedgwick, that "Under Geanies' Mill are seen some grey, brownish-grey, and greenish-grey calciferous sandstones, alternating with some bituminous, laminated, calcareous beds, on one of which were some Fish-scales, and some fragments" (since found to be plates of the *Coccosteus*); that "between Geanies' Mill and Balloan Castle the phenomena are of less interest, the beds in the ascending order preserving nearly the same characters;" and that "from Balloan Castle to the extreme point of Tarbatness no subordinate calcareous beds like those above described" had been observed, "although some of the greenish-grey sandstones were calciferous."

To the above I have nothing to add by way of general description, as its accuracy has been but confirmed by subsequent investigation; but I hope that the following detailed remarks may be of interest in connexion with the recent discovery, by the Rev. Mr. Campbell, of Tarbat, and myself, of undoubted Reptilian footprints, and probable Crustacean tracks, in the sandstones of Portmahomack (Tarbat).

In the cliff at the western boundary of Geanies (fig. 1, A), superior to a well-defined ferruginous bed of red sandstone, there occur several bands of calcareous shale, with subordinate belts of grey and brownish sandstone, dipping nearly N.W., as indicated by the arrows on the map.

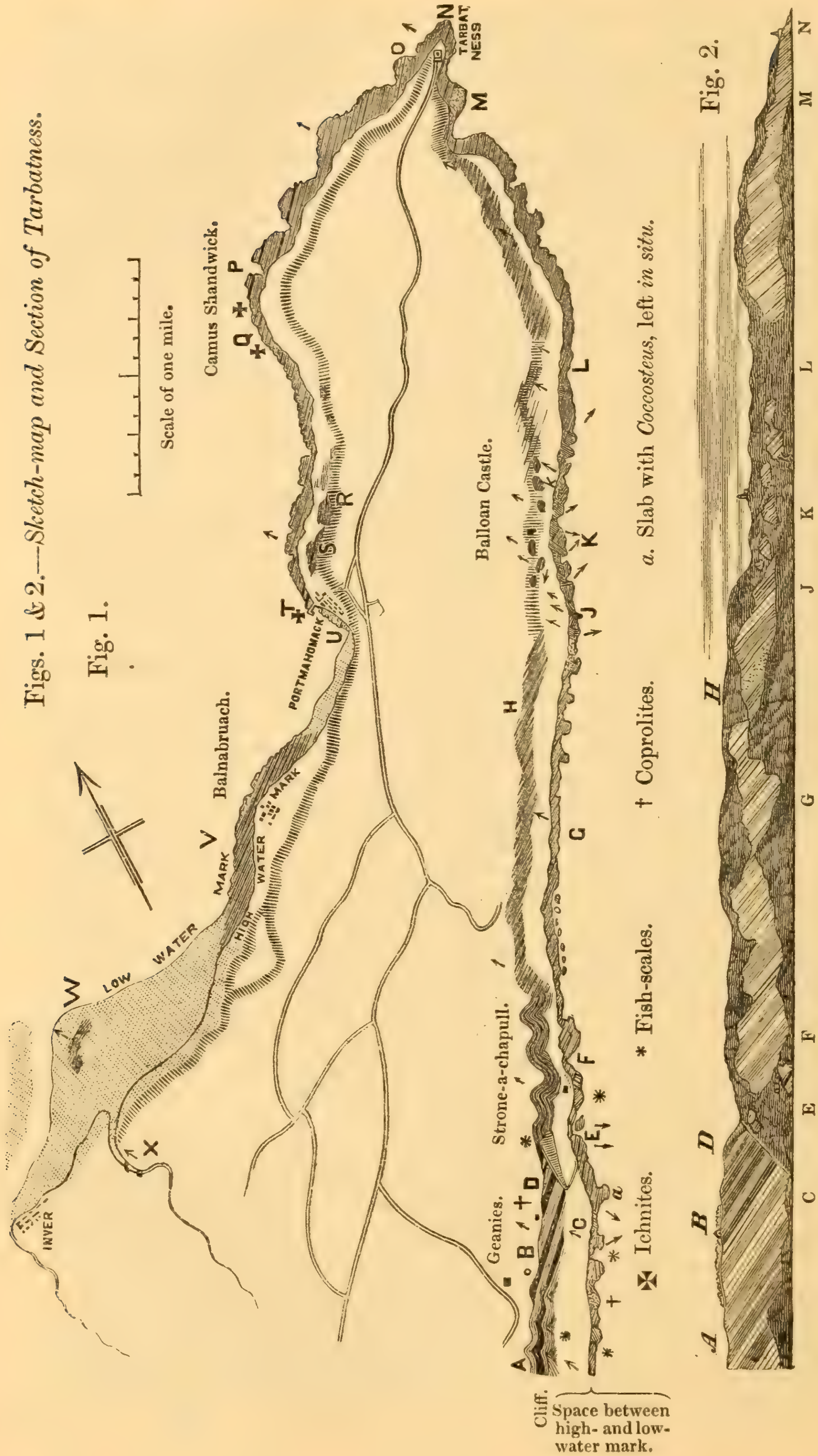
Throughout these beds fossil remains of Devonian age occur in abundance, such as Fucoids, Fish-scales, and Coprolites, especially at the undernoted localities and among the débris at the foot of the cliff.

The uppermost of these fossiliferous shale-beds dips under the Drift at the top of the Strone-a-chapull road, at the site of the old Mill of Tarrel, near D (fig. 1), but is continued on the beach at F. At this point undoubted Old Red Fishes have been found, while a nearly entire specimen of *Coccosteus* has been left *in situ*, at the point marked *a* on the Map (fig. 1).

By the kindness of Mr. Murray of Geanies, who placed some men at my disposal, a collection of fossils has been made from the débris of the cliff at A, from the shale-beds *in situ* at B and D, and from the beach-rocks at C, E, and F. Some of these fossiliferous rocks, as seen on the shore, although dipping in an opposite direction to the cliff-beds, are yet believed to be undermined and fallen masses, from their identity of lithological structure with the calcareous beds in the cliff at the base of which they lie. The above collection, now at Geanies' House, for the inspection of all interested in the matter, will, it is believed, be sufficient authority for regarding this portion of the section as of undoubted Devonian age, and therefore a proper starting-point for an upward examination of the beds with a view to establishing their conformable stratigraphical sequence onwards to the Ichnites of Camus Shandwick and Portmahomack.

From F eastwards, to G, the cliff presents a good section of conformably bedded, reddish, yellow, and particoloured sandstones; and where the reading of this is partially interfered with by drift, the beach-rocks, in normal dip, carry us easily onward to the village of

Figs. 1 & 2.—*Sketch-map and Section of Tarbatness.*



Rockfield, J, at which point the cliff is nearly obscured by drift, and the shore-beds much broken and rolled, as shown in the Map and Section, figs. 1 and 2. This is especially the case below Balloan Castle. Throughout all this irregularity, however, the beds are easily traceable as persistent, by walking along their exposed surfaces between high- and low-water mark; and in proceeding eastwards the normal dip becomes distinctly visible in the cliff. Where this is partially obscured by drift, as at L, the beach-rocks carry us clearly forward, through conformable strata of yellowish sandstone, to the thinly bedded and more ferruginous rocks of Wilkhaven. At this point, M, there occurs a well-defined pebbly band, which differs from a previous belt of similar nature west of Rockfield, at H, in containing pebbles of a purer quartz; whilst among the rolled stones on the beach there are many hard felspathic pebbles, together with numerous cherty fragments like calcedony, resembling the more highly indurated portions of the Lossiemouth Cornstones on the opposite coast.

From this point onwards to the Lighthouse the rocks become more ferruginous in their appearance, which character they present over a well-exposed beach round by the north shore up to O, where there is a band of gritty sandstone containing gneissose and quartzose pebbles.

Interstratified with a few belts of light-coloured and good building-sandstone, the flaggy red beds continue, with little variation of colour or character, to P, maintaining the normal N.W. dip, at an average angle of 25°.

Here, and at Q, in red and thinly bedded sandstones, there occur distinct Reptilian tracks, persisting over considerable surfaces. Without important variation of lithological character, save the normal recurrence of the gritty bed O, the beach presents a regular descending succession of beds to T, where Ichnites of similar appearance to those at P and Q occur in considerable numbers. The specimen already forwarded to the Museum of Practical Geology was found at S, and the Crustacean tracks previously mentioned occur at R.

At U there is a recurrence of the pebbly bed M, as also in the line of strike of the rocks, at Balnabruach. To the westward, for about a mile, the beds are concealed by sand; but near the inlet to Inver, a few detached outcroppers at W show the northerly dip and normal inclination, which are also observable at X, in the bed of a streamlet running nearly north from the steading at Arboll.

To the above I have but to add that the excavation of Ichnites was carried on under the superintendence of the Rev. Mr. Campbell of Tarbat. There is now at the Manse of Tarbat a large collection, of Crustacean and Reptilian tracks, on blocks too unwieldy for carriage to a distance, but which will be gladly submitted to the inspection of all whose interest in the important question at issue induces them to visit the locality.—[J. M. J.]

The Rev. Dr. George Gordon then gave the following description of the unconformity existing between the Oolites and the Sandstones of Cromarty:—Accompanied by Mr. Stables, Mr. Joass, and Major H. Drummond, of the Bengal Engineers, I spent the whole of one day on and around the Nigg, or North Sutor of Cromarty. We examined it minutely in reference to the sketch sent to Sir R. I. Murchison by Miss C. Allardyce. This sketch represents the Oolites lying conformably to the Old Red Sandstone, and as if they occurred on the *west or inner side* of that Sutor, namely the northern one*.

We examined all the bits of rock or strata that were to be seen cropping out along the Cromarty Firth shore of the North Sutor, and found in them nothing but Old Red Sandstone.

We then proceeded down the Moray Firth as far as Shandwick, landing at different points, and walking along almost the whole shore, spending a considerable time at Gaan Righ. Here, so far as we could see, the Oolites *first* appear. Covered at high water, and lying at the base of a cliff about 250 feet high, these Gaan-Righ Oolites are evidently an extension of the well-known deposit of the same series at Shandwick. The tide was low, and most favourable for our work over this part of the coast.

The complete *unconformity* of the Shandwick Oolitic beds to the Old Red Sandstone is acknowledged on all hands; and the seeming conformity of the Oolitic beds at Gaan Righ to the Old Red arises from the accidental change of dip (caused by a fault, or rather by a slip or slide) in a large mass of the rock (Old Red) in the overhanging cliff. The strata of this mass, if projected on their present plane, would most probably *overlie* the Oolites! The persistent northern dip of the Old Red Sandstone, in this line of coast all the way down to Shandwick, comes out distinctly, when seen, as on our return to Cromarty, from the boat when sailing in the offing.

Faults and slips there are in many places, but they do not present any difficulty. I am, therefore, convinced that the great question at issue—the age of our Reptiliferous beds—is not in the least affected by any appearance presented by the Oolites at Gaan Righ—the locality, I am persuaded, alluded to by Miss Allardyce in her note to Sir R. I. Murchison.—[G. G.]

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2. *On some* Tertiary Shells *from* Jamaica. By J. Carrick Moore, Esq., M.A., F.R.S., F.G.S. *With a Note on the* Corals; by P. Martin Duncan, M.B., F.G.S.: *and a Note on some* Nummulinæ *and* Orbitoides; by Professor T. Rupert Jones, F.G.S.

The late Mr. Barrett formed a collection of Tertiary fossils in Jamaica from some beds which were referred to in the 'Geologist' for 1862, p. 373. The collection was forwarded to Mr. Woodward, who, seeing their relation to the San-Domingan fossils, asked me to examine the Mollusca, while the Corals were submitted to Dr. Duncan. In comparing the Shells with fossil and recent forms, I

* The examination of the North Sutor was made on May 14, 1863. The sketch referred to is one by the late Hugh Miller, in the possession of Miss C. Allardyce, Cromarty.

have been kindly assisted by Mr. Woodward, Dr. Baird, Mr. Hamilton, and Mr. Lovell Reeve, and now lay the results before the Society.

Excluding such shells as are too small or too imperfect for determination, the collection contains 71 species, referable to the following genera:—

	SP.		SP.		SP.
Cassis	2	Turbinella	1	Solarium	1
Cassidaria	1	Fusus	1	Cyclostrema	1
Strombus	2	Marginella	1	Dentalium	1
Malea	1	Columbella	2	Vermetus	1
Conus	7	Cancellaria	2	Venus	7
Murex	1	Pleurotoma	7	Lucina	2
Triton	1	Terebra	1	Cardita	1
Ranella	1	Phos	2	Cardium	3
Oliva	1	Cerithium	1	Corbula	1
Ancillaria	1	Natica	4	Pectunculus	3
Mitra	2	Turbo	1	Arca	3
Fasciolaria	1	Trochus	1	Chama	2
					71

Of these, the following 19 are found in the San Domingo beds, and are not known in a recent state:—

Conus validus, *Sow.*
—— planiliratus, *Sow.*
Murex Domingensis, *Sow.*
Triton simillimus, *Sow.*
Mitra Henekeni, *Sow.*
——, spec. unnamed.
Fasciolaria semistriata, *Sow.*
Terebra bipartita, *Sow.*
Phos, spec. unnamed.
Natica subclausa, *Sow.*
——, spec. unnamed.
——, spec. unnamed.
Solarium quadriseriatum, *Sow.*
Turbo, spec. unnamed.
Cardita, spec. unnamed.
Venus, spec. unnamed.
Cardium Haïtense, *Sow.*
Corbula, spec. unnamed.
Arca consobrina, *Sow.*

Twelve others have been identified with recent species† inhabiting West Indian seas:—

Strombus fragilis.
Ranella crassa.
*Turbinella infundibulum.
*Oliva reticularis.
*Marginella coniformis.
*Natica sulcata.
*Natica mamillaris.
*Venus Paphia.
*Lucina Pennsylvanica.
*Pectunculus pennaceus.
*Arca Noæ.
*Chama arcinella.

It thus appears that, of the whole 71 Jamaica shells, 12 are still living, and 28 are common to Jamaican and San Domingo.

Dr. Duncan, in his Memoir lately read before the Society‡, finds the same relations between the Jamaican and San-Domingan beds from a comparison of the Corals,—three of the seven Jamaican Corals being common to both formations, whilst the number of extinct forms justifies the age formerly attributed to the San-Domingan Tertiaries. It will be remembered that the Miocene date was assigned to the latter from the great proportion of extinct species of Mollusca, and also from the presence of four species of Fish, all known in the Miocene beds of Europe and America, and in no newer formation. Here the proportion of extinct Mollusca and Corals is about the same as in the San-Domingan beds; and the number of fossils common to

† Those marked with an asterisk are also found in San Domingo. ‡ See p. 406.

both is sufficient to prove their synchronism. But we are able still further to extend the limits of this Miocene Sea. In the cutting for the Panama Railway, shelly beds were passed through near Navy Port, at a height of 15 feet above the sea, from which Mr. Saunders collected some fossils which he presented to this Society. Most of them are too imperfect for determination; but out of less than a dozen, which are tolerably distinguishable, five are certainly identical with San Domingan Shells: they are, *Conus Domingensis*, a *Malea*, a *Natica*, a *Venus*, and a *Cardium* *.

In my Reports on the San-Domingan Shells †, I mentioned that one or two seemed identical with Shells now living in the Pacific, and that the nearest analogues of several others were to be found in the Pacific, and not in the Atlantic Ocean: several striking instances of these resemblances were mentioned. The collection now before us also presents the same feature; for although all the specimens I have identified with recent Shells are now living in the West Indian seas, yet the affinities of several others are decidedly with Shells of the Pacific Ocean. I may mention a *Venus* belonging to a group confined to Australia; a *Corbula* scarcely distinguishable from *C. modesta*, Philippine Islands; a *Pleurotoma* very near, if not identical with, *P. nigerrima*, Panama; and another very close to *P. gibbosa*, Cumana; besides which, some of the San-Domingan Shells which presented this character in a marked degree also occur in Jamaica. Observing this in the San-Domingan collection, I formerly threw out the conjecture that the separation between these seas may not have been so complete in early Tertiary times as at present. Dr. Duncan's Memoir, just quoted, throws great light on this question. It results from his studies, that the relation between these fossil Corals and those now living in the Pacific or China seas is even more intimate than that indicated by the Mollusca. Some of these species are actually now living in the Pacific, and others belong to genera of which all the living species are confined to that ocean.

M. d'Orbigny, in his great work, 'L'Amérique Méridionale,' shows that five of the Cretaceous fossils from the western side of South America are identical with five in the Paris Chalk, while of all the Tertiary fossils on the two flanks of the Cordilleras not a single one is common to both formations; and he thence infers that a communication must have subsisted between those two oceans during the Cretaceous period, and that at its close the upheaving of the Cordilleras effected that separation which has subsisted to this day. But it is to be observed that the Tertiary fossils collected by M. d'Orbigny were all found south of latitude 30° S., whereas those from Jamaica and San Domingo are in latitude 18° N. Even if some connexion had existed between the two oceans in the district of Panama, as is now supposed, the Mollusca living on the two flanks of South America, 40° to the south of that opening, might be expected to be distinct, just as those at present living on the

* See Quart. Journ. Geol. Soc. vol. ix. p. 132.
† *Ibid.* vol. vi. p. 40, and vol. ix. p. 129.

opposite coasts of Chili and of Patagonia are distinct, though there is free communication by Cape Horn. No negative evidence can counterbalance positive facts; and when it is recollected that the summit of the Panama Railway is but 250 feet above the sea,—that that inconsiderable height must have been less when the shelly beds of Navy Port (contemporaneous with those of Jamaica and San Domingo) were formed,—that some few of these Mollusca and Corals are now living in the Pacific,—and that the nearest allied forms of several more are to be found on the western side of America, it will be admitted to be most probable that the complete separation of these oceans did not take place until after the commencement of the Tertiary period.

P.S.—Dr. Duncan has kindly supplied me with the following facts, which he has ascertained since the reading of his Memoir on the Corals:—"The Foraminifer so common in the European Miocene and in the San-Domingan beds, *Amphistegina Haueri*, is found in abundance in the Jamaican Corals; also the Coral sent over by Mr. Barrett, and known as *Montlivaltia ponderosa*, is amongst a collection from Travancore, with *Trochocyathus cornucopia*, a San-Domingan and common Viennese Miocene species. The occurrence in Jamaica of *Astrocœnia decaphylla*, a Gosau fossil, is very remarkable; but the same kind of thing occurs in San Domingo, where *Phyllocœnia sculpta* and a *Barysmilia* very little differing from *B. tuberosa*, Reuss, both Gosau fossils, are noticed."

Note on the Fossil Corals *accompanying the* Testacea *from* Jamaica. By P. Martin Duncan, M.B., F.G.S., &c.

The majority of the Corals have been described in my communication, referred to by Mr. Moore, and published in this Number of the Society's Journal, on the Fossil Corals of the West Indian Islands.

1. Montlivaltia ponderosa, Edwards & Haime.

Two specimens of this great simple Coral, which is found both in the Miocene of Guadaloupe as well as in that of San Domingo, are amongst the collection; the San-Domingan specimen is in the British Museum.

2. Placocyathus Barrettii, nobis. "Fossil Corals of the West Indies," p. 437. Pl. XVI. fig. 1.

From San Domingo and Jamaica.

3. Placotrochus alveolus, nobis. "Fossil Corals of the West Indies," p. 438. Pl. XVI. fig. 2.

4. Astrocœnia decaphylla, Michelin, sp.

The specimen can only be considered as a very slight variety of the well-known *Astræa decaphylla*, Michelin, of Gosau. The *Astrocœnia ornata* of Turin and Antigua is only distantly allied. *Astrocœnia decaphylla* is a very marked species, and its occurrence in the

Jamaican Tertiaries is very remarkable: like *Phyllocœnia sculpta* in San Domingo, and the Isastræans in Antigua, it belongs to a Coral-fauna which died out in the Miocene period.

5. THYSANUS EXCENTRICUS, nobis. "Fossil Corals of the West Indies," p. 439. Pl. XVI. fig. 3.

These beautiful Corals are allied to the *Thysani* of San Domingo. From Jamaica and San Domingo.

The other Fossil Corals from Jamaica, in this collection, and which I have described already, are *Alveopora Dædalæa*, Dana, and *Siderastræa grandis*, nobis.—[P. M. D.]

Note on some NUMMULINÆ *and* ORBITOIDES *from* JAMAICA. By Professor T. RUPERT JONES, F.G.S.

In connexion with Mr. J. C. Moore's researches on the Tertiary Molluscs of Jamaica, the following remarks on some specimens of Nummulites * and *Orbitoides* from the same island will be of interest.

Some time since, Mr. S. P. Woodward, F.G.S., submitted to my examination a water-worn piece of Orbitoidal limestone from Healthful Hill, St. Thomas-in-the-East, collected by the Hon. Edw. Chitty. Among the *Orbitoides* constituting the mass of this hand-specimen (6 inches $\times 2\frac{1}{2} \times 2$), three or four *Nummulinæ* are visible on the surface, and their internal structure has been sufficiently well exposed by weathering. The *Orbitoides* are similar to those found fossil in the Upper Chalk of Southern France and the Pyrenees, and in the Nummulitic beds of Scinde (*O. media*, *O. dispansa*, &c.). The *Nummulinæ*, differing only in size one from another, belong to the sinuo-radiate group †, and are near to the forms known as *Nummulina perforata* and *N. Rouaulti*. The largest is about $\frac{1}{4}$ inch in diameter and $\frac{1}{12}$ inch in thickness.

Orbitoides are not confined to this nodular limestone in Jamaica, but are there found as low down as the Cretaceous Limestone, with *Nerinæa* and *Barrettia* ‡; and here the thick variety (*O. Fortisii*) and the thin (*O. papyracea*) are both abundant.

When Mr. Barrett, the late Director of the Geological Survey of the British West Indian Isles, was in England last year, he showed me, by the following diagram, the position of this Orbitoidal Limestone in the geological series of Jamaica. He stated that it occurred as nodules in clay just underneath the great "White Limestone," which, with overlying shaly and sandy beds, I understood him to refer to

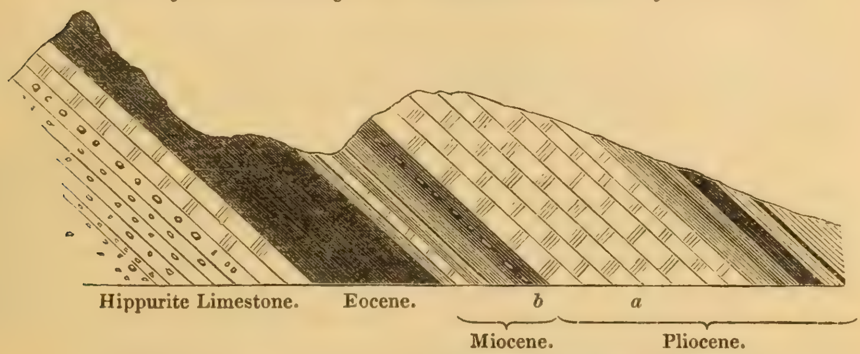
* De la Beche has recorded the occurrence of "Nummulites" in Jamaica (Geol. Trans. 2nd ser. vol. ii. p. 170); but it is doubtful whether the fossils he alludes to may not have been *Orbitoides*, which are common in that island.

† See Ann. Nat. Hist. 3rd ser. vol. viii. p. 233, and Carpenter's Introd. Foram. p. 275.

‡ See Mr. Woodward's paper on "*Barrettia* and other Hippurites," in the 'Geologist,' vol. v. p. 373. De la Beche seems to have regarded some of the *Orbitoides* as "Encrinal remains" (Geol. Trans. 2nd ser. vol. ii. p. 158), as Mr. Woodward has remarked.

the Pliocene *. The nodular limestone he regarded as forming, with some underlying beds, the Middle Tertiary series †; whilst the Plant-bearing shales, still lower down, are of Eocene age, and overlie the

Section of the Tertiary and Cretaceous Rocks of Jamaica.



a. White Limestone. *b.* Nodular Orbitoidal Limestone.

Cretaceous Hippurite-limestone, containing *Nerinæa*, *Actæonella*, *Radiolites*, *Barrettia*, *Inoceramus*, *Ventriculites*, and *Orbitoides*. The last-mentioned limestone, with its flint-nodules and intercalated shales, as well as the underlying porphyries and conglomerates, were described by Mr. Barrett in the Quart. Journ. Geol. Soc. vol. xvi. p. 324 ‡.

It may be remarked as a point of interest, that the *Nummulinæ* and *Orbitoides* above alluded to are such as are found in the South of Europe and in India; whilst in the neighbouring continent of America *Nummulinæ* are, it seems, wanting; and the *Orbitoides* (in Alabama §) is *O. Mantelli*, which occurs also in Scinde, but is not dominant there.—[T. R. J.]

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3. *Notes on the* Mineralogy *and* Geology *of* Borneo *and the* adjacent Islands. By Mijnheer Corn. de Groot, Chief of the Mining Department in the Dutch East Indies.

(Extracted from a letter to Sir R. I. Murchison, K.C.B., F.G.S.)

The steam-coal formation of Borneo underlies the Nummulitic Limestone, and, so far as I am at present able to judge, belongs to the "Étage Suessonien" of D'Orbigny. From the Nummulitic Limestone the following fossils have been obtained, namely, *Nummulina depressa*, *N. lenticularis*, *N. mamilla*, and *N. polygyrata*; also *Eupatangus ornatus* and *Phaculina Faujasii*. The last-named fossil is,

* In Mr. Woodward's paper above referred to, this limestone is termed "Miocene."

† In the Western Hemisphere, *Orbitoides* and *Nummulina* are very rare in beds above the Eocene group.

‡ The woodcut at p. 325 incorrectly represents the shales and limestone-bands as unconformable.

§ See Lyell on the so-called Nummulitic formation of Alabama, Quart. Journ. Geol. Soc. vol. ii. p. 409, and vol. iv. p. 11; and Manual Elem. Geol. 5th edit. p. 233.

I know, found in the Maestricht Beds; but, according to Bronn, it occurs also in the 'Étage Suessonien.'

In a search for lodes of copper in the western part of Borneo, north of Pontianak, made on behalf of private adventurers by Mr. Everwijn, the strings of copper that were found, though very rich, were too small to pay for working. There are also some poor copper-lodes near the Singkarah Lake, in the mountains east of Padang, in the Island of Sumatra; but the veins, though large, are too poor to be worked.

A search for tin-veins was made in the Island of Blitong (Billiton), by Mr. Akkeringa, one of our mining-engineers, in 1860–61, with the following result:—at Brang no metalliferous veins were found; but on the Tadjouw Hill (goenoeng Tadjouw) a vein 4 to 5 feet wide, and containing much tin-ore, was discovered; its exploitation was commenced last year. Granite and elvan were found on the south, and eurite (elvan) on the north of Tadjouw Hill.

A large vein of manganese-ore (pyrolusite) occurs in porphyry, close to the Nummulitic Limestone, in the south-eastern part of Borneo. This manganese-ore would have been extracted for the European market more than two years ago, had it not been for disturbances in that part of the island.

A limestone occurs in Timor Island (near Timor koeping) containing Encrinites in abundance*.

Twelve years ago, when I first arrived in India, it was generally considered that the stream-tin found in the Island of Banka was not derived from veins in the granite of the island, but from mountains on the continent of Asia, whence it had been washed down to the bottom of the sea; and that the sea-bottom had been subsequently upheaved so as to form the Island of Banka. This supposition appeared to me erroneous, and I therefore endeavoured to collect facts bearing upon the question. In 1853 I inspected all the stream-works in the island, and found, in the district of Pankalpinang, three parallel veins running nearly east and west, one of them containing tin-ore in grains, like those found in the stream-works. In 1855, Mr. Akkeringa surveyed the Jeboes district, and found grains of tin-ore disseminated in granite. I also found that in every river which was streamed for tin the largest grains were found nearest the hills, and that further away towards the sea they gradually became smaller. Now, as the rivers of Banka run from the interior in all directions towards the sea, these facts proved that the stream-tin is the detritus of the rocks and veins containing tin-ore occurring on the island.

* M. de Groot has sent a specimen of this limestone, and specimens of the rocks and minerals he mentions, as well as of some fossils from the clay and the marly sandstone of the tertiary formation of Java. The last-named specimens were found near the Seela Hill (goenoeng Seela), in the Preanger regency, about 2000 French feet above the level of the sea. He has also sent some specimens of fossil Mollusca from the clay separating two beds of workable coal in Borneo. The rocks and minerals are in the Museum of Practical Geology, and the fossils in the Museum of the Geological Society, having been presented by Sir R. I. Murchison, K.C.B., F.R.S., &c.—Edit.

The Government Surveyors publish their papers in the 'Natuurkundig Tijdschrift voor Nederlandsch Indië,' and at present they only map what is actually seen. They are now engaged, under my direction, in surveying the Island of Banka.

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4. Description *of a new fossil* Thecidium (Thecidium Adamsi) *from the* Miocene Beds *of* Malta. By J. Denis Macdonald, Esq., F.R.S., Surgeon of H.M.S. 'Icarus.'

Amongst the many interesting fossils occurring in the lower part of the calcareous sandstone of Malta, there is a beautiful little *Thecidium*; and as I believe it has not yet been described or named, it may be worthy of a brief notice.

It appears to me that the nearest ally to the little Shell which I am about to describe is the recent *Thecidium Mediterraneum.* The species about to be described is, however, very much smaller, being only $\frac{1}{6}$th of an inch in length; besides which many other decidedly specific differences present themselves on closer inspection. As to its general figure, it much resembles a horse's hoof in miniature, the fixed ventral valve corresponding to the unguis or body, the hinge-area to the soft posterior part of the "frog," and the dorsal valve to a shoe-plate. This comparison gives a good idea of the obliquity of the shell in the longitudinal plane, the great depth of the ventral valve, and its lengthened surface of attachment (figs. 1–3).

The dorsal valve (fig. 1, *b*) measures rather more transversely than longitudinally. The hinge-line is straight, but interrupted in the middle by a small subquadrate cardinal process (fig. 3, *a*), fronted above by a depressed but very distinct umbo, and below by a deep excavation (*b*) receiving a trifid process (fig. 2, *b*) of the ventral valve for the attachment of the adductor muscles. From the hinge-line forwards the margin of the dorsal valve (fig. 3) is rounded, but it is slightly cut off or sinuated in front. It is, moreover, as a character of the genus, minutely granulated inferiorly (*d*). The tooth (*c*) on either side of the base of the cardinal process (*a*) is rather small, and received into a corresponding dental socket in the opposite valve.

The internal calcareous framework is very complex in appearance, consisting of the following parts, namely:—first, an outer simple loop (fig. 3, *e*) following the contour of the shell, but lying a little within the granulated margin; 2ndly, two half-loops or hook-like processes (fig. 3, *f*) included by the former, and turning inwards and forwards posteriorly; and 3rdly, an inner perfect loop (fig. 3, *g*), with the free central portion, or bight, reflected downwards and forwards, and giving off from its concavity a median crest (*h*), which projects backwards, and is flanked on either side by the inverted hook-like ends of the intermediate half-loops. The attached surface of all the parts just mentioned is very considerable, and the simple and reflected portions of the inner loop are connected by a more or less perfect calcareous expansion.

Just below the hinge, and connected with the ventral valve, there is a trifid shelly process (fig. 2, *b*), noticed above as giving attachment to the adductor muscles; but as this lies above the middle portion of the outer loop (*c*), while it occupies the hollow (fig. 3, *b*)

Figs. 1–3, *illustrating* Thecidium Adamsi.

Fig. 1.

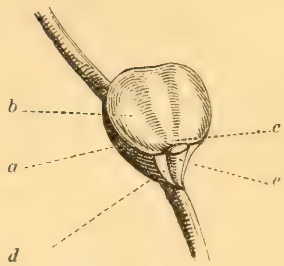

Fig. 2.

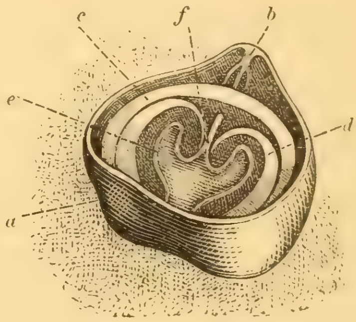

Fig. 3.

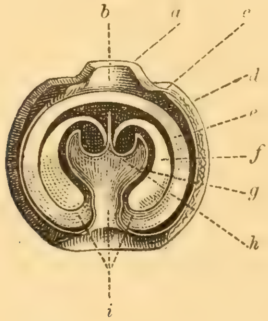

Fig. 1. Superior view of the exterior.
a. Ventral valve.
b. Dorsal valve.
c. Umbone.
d. Hinge-area
e. Deltitium.

Fig. 2. Inferior view, with a portion of the ventral valve (*a*) broken away to show the adductor process (*b*), the outer plain loop (*c*), the intermediate half-loops (*d*), and the median crest (*f*).

Fig. 3. Interior view of the dorsal valve.
a. Cardinal process.
b. Recess for the adductor process of the ventral valve.
c. Hinge-tooth.
d. Granulated margin.
e. Outer simple loop.
f. Intermediate half-loops.
g. Inner reflected loop.
h. Median crest.
i. Points of origin of the parts composing the internal framework.

in front of the cardinal process (*a*) of the dorsal valve, it follows that when the shells are intact they cannot be forcibly separated without breaking the loop (fig. 2, *c*) upon the adductor process (*b*). I therefore, very cautiously, broke away the ventral valve from below, as shown in fig. 2, and by simply studying the relations of the parts, I was enabled to perfect the scheme of the loop-apparatus, as given in fig. 3.

The hinge-area (fig. 1, *d*) slopes downwards and a little backwards from the line of union of the valves to the beak; and the deltidium (*e*), which is rather prominent, may be said to occupy a little more than the middle third of its surface. It only remains to be remarked that the originally attached part in all my specimens is indicated by a longitudinal groove on the inferior surface of the ventral valve,—being evidently moulded upon a stem or branch of some dendritic animal or algal form (fig. 1), and often extending to within a third of the anterior margin. I have named the species after my friend Dr. Leith Adams, of the 22nd Regiment, who first pointed it out to me in an evening ramble.

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5. *On the* Sandstones *and* Shales *of the* Oolites *of* Scarborough, *with* Descriptions *of new* Species *of* Fossil Plants. By J. Leckenby, Esq., F.G.S.

[The Publication of this Paper is deferred.]

(Abstract.)

The true position of the well-known Plant-bed at Gristhorpe Bay, below the grey limestone, was first pointed out by Prof. Williamson, and afterwards by Dr. Wright; and Mr. Leckenby showed that all the Plants hitherto referred to the Upper Sandstone, Shale, and Coal belong to the Lower Sandstones and Shales, but few Plants having been found in the true Upper Sandstones and Shales overlying the grey limestone. The author gave lists of fossil Plants occurring in the two sets of strata, as well as of those occurring at the separate localities; and he concluded by describing some new and some imperfectly known species of Ferns.

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6. *A Monograph of the* Ammonites *of the* Cambridge Greensand. By H. Seeley, Esq., F.G.S.

[The Publication of this Paper is deferred.]

(Abstract.)

The excavations in the Upper Greensand of Cambridge have furnished Mr. Seeley with an opportunity of examining a great number of specimens of the different species of Ammonites occurring in that formation, and he now communicated the results of his examinations to the Society, giving detailed descriptions of the species.

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7. *On a new* Crustacean *from the* Glasgow Coal-field. By J. W. Salter, Esq., F.G.S., A.L.S.

In a previous memoir* I endeavoured to collect together what was known of the long-tailed Malacostraca of our coal-fields,—fields, it may be observed, almost untrodden by the palæontologist. My friend Mr. James Russell has since found a new species, which I call *Palæocarabus Russellianus*.

It is from the Palace Craig "Black band," in the Upper Coals,

* Quart. Journ. Geol. Soc. vol. xvii. p. 528.

above the "Rosslyn Sandstone or Moor Rock," and lies some 20 or 24 fathoms above the Ell Coal. *Anthrapalæmon Grossarti*, described by me in the above-quoted memoir, was from a bed 960 feet below that coal.

PALÆOCARABUS RUSSELLIANUS, spec. nov.

P. *biuncialis. Cephalothorax oblongus, quadratus, ad latera scaberrimus, haud divisus, nisi a sulco cervicali punctato vix conspicuo transverse sectus. Rostrum latum, profunde serratum. Antennæ parvulæ. Antennulæ ad basin late expansæ, spinulosæ. Abdomen? Cauda?*

Figs. 1 & 2.—*Carapace and portions of the Appendages of* Palæocarabus Russellianus.

Fig. 1. Fig. 2.

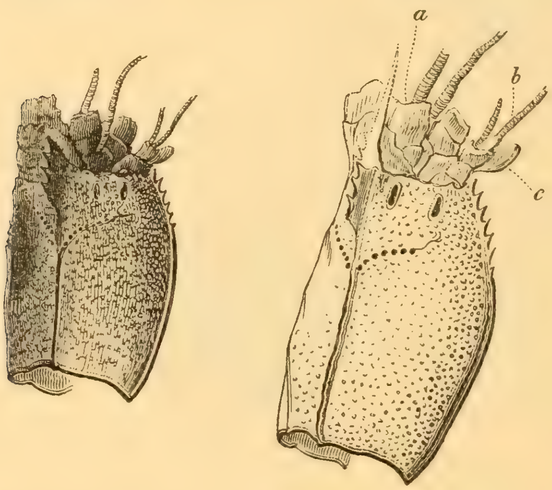

Fig. 1. Natural size.
Fig. 2. Outline slightly enlarged: *a*. Antennule; *b*. Antenna; *c*. Scale of the Antenna.

Description.—The carapace is convex, for it is partly pressed on one side. The serratures are as in the other Glasgow species, *Anthrapalæmon Grossarti*, but the central keel reaches the posterior margin, and joins as strong a cervical furrow as in *A. dubius*. This cervical furrow is marked out by a line of deep punctations, not furnished with spines; and a rather deep depression occurs near the anterior angle of the gastric (?) space (where a spine is present in *A. dubius*). The rostrum appears to be a very prominent and triangular mass, with a broad, strongly serrate, plate-like crest running down its lower part as far as the cervical furrow. The front part (if I do not deceive myself) is destitute of this crest, and is moreover separated by a rather deep furrow from the hinder portion, so as easily to break off and present the appearance given by *A. dubius**. I do not, however, speak with certainty concerning this rostral portion—it is much obscured. The general surface is punctate, the punctations small and scattered; but towards the margin and front the carapace is roughly and closely granular.

* Quart. Journ. Geol. Soc. vol. xvii. p. 531, fig. 6.

The appendages are well preserved, both inner and outer antennæ at least; and the latter, strange to say, are smaller than the antennules*. Both have widely expanded basal joints, with short spines overhanging the front border of the carapace. The antennules (fig. 2, *a*) have at first *four* large joints: the first is narrow; the second almost square, with a projecting subspinous outer angle; the third triangular; the fourth broader at the base, wider than long, and followed by a single, long, filiform appendage of short close joints. The antennæ (fig. 2, *b*)—for they cannot be the interior pair pushed outwards by pressure—have also broad basal joints, *three* in number, but not more than half the diameter of those of the antennules. The basal joint is broad, the next longer than wide, the third wider than long, and bearing two filamentary antennæ, with some remnants of the protecting scale (*c*). The latter is small and not very definite; the filament is more slender than that of the antennule, but double, and of longer joints. As I have not seen more of any of the filaments than 3-10ths of an inch, nothing more can be said of them.

But there is enough of this beautiful Crustacean to show that it belongs to *Palæocarabus*, and not to *Anthrapalæmon*, and to show also that the genera may be now more clearly defined. In addition to the characters given in my former paper†, I have to add that *Anthrapalæmon* has the antennæ with large basal joints, the antennules with small joints, the carapace with but a faint cervical furrow, and the ridge incomplete.

Palæocarabus has the antennæ smaller than the antennules, but with expanded basal joints (and the usual scale of the *Palæmonidæ*), and the antennules with broad large basal joints; the cervical furrow and carapace-ridge are complete.

The species just described is certainly new; and I have great pleasure in dedicating it to Mr. J. Russell‡, of Chapel Hill, Airdie, who kindly forwarded the specimen to me.

Addendum.

Macrura in Bohemian Coal.—Since this paper was read, my friend Mr. H. Woodward has shown me two specimens of a Macrurous Crustacean from the Upper Coal-measures (overlying Lower Silurian rocks) of Beraun, Bohemia. They show the five pairs of limbs and the bases of the maxillipedes, with the terminal portions of the abdomen; but they are too imperfect to prove the exact nature of this latter portion. Both specimens expose only the ventral surface, and both are so flattened as to be little more than black stains in a brownish-grey schist. The chelæ are small; and from the general aspect of the fossils, I should think them *Palæmonidæ* rather than *Astacidæ*. The surfaces are covered with tubercles.—[J. W. S.]

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* In *Thenus* and such genera the outer antennæ are largely expanded, but the antennules are very small in comparison.

† *Loc. cit.* pp. 529, 530.

‡ Formerly of the Borneo Antimony Company.

8. *On the* Occurrence *of a* Bituminous Substance *near* Mountgerald. By Dr. G. Anderson.

[In a Letter to Sir R. I. Murchison.]

(Abstract.)

The section exposed by some deep cuttings for the Ross-shire Railway, two miles north of Dingwall, was described by Dr. Anderson in this letter. The rock in these cuttings is a grey, micaceous, regularly bedded, and almost horizontal conglomerate, but exhibiting enormous convolutions and twistings of the beds. The strike is N.W. to S.E., and the rock, in some places, passes into a fine compact sandstone. It is traversed at intervals by what appear to be perpendicular veins or fissures, lined for the thickness of an inch or two with a black, shining, compact, bituminous substance having a black streak and a conchoidal fracture. It burns with smoke and flame, and becomes electrical when rubbed; and it does not exhibit any trace of organized matter. Its composition is said to be similar to that of the Albertite of New Brunswick.

A bituminous substance has long been found in veins at Strathpeffer in quantities sufficient for burning in the neighbouring cottages. To what extent these veins may go down in the adjoining rocks is not known. At Mountgerald the seams are not thicker than an inch or two; but in the beds of the Boulder-clay, immediately above the sandstone-conglomerate, small pieces of the coaly matter occur in abundance. The bituminous shale comes in near the sandstone-conglomerate in which the black matter occurs, and, as the author believes, *above* it; and he traced the former thence over the ridges looking down on the Cromarty Firth as far as into Strathskea.

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9. *On the* Occurrence *of a* Bituminous Mineral *at* Mountgerald, Scotland. By A. C. Mackenzie, Esq.

[Communicated by Professor Tennant, F.G.S.]

(Abstract.)

The author first gave a history of the discovery of this bituminous substance at Mountgerald, stating that it was first noticed about fifteen years ago, by the tenant of the farm of Woodlands (Mr. M'Ewan), whilst making a drain. The farmer followed the seam as far as he was able, and procured several cartloads of the mineral, which he used as fuel.

Mr. Mackenzie then noticed the similarity of this substance to the Albertite of New Brunswick; he also stated that he first saw it, about five years ago, in a field on the farm of Woodlands, and that, more recently, a railway-cutting on the farm of Mount Rich, 400 yards south-east of the former locality, enabled him to make the following observations regarding its mode of occurrence.

The line of railway here passes through a cutting in what is called the Craig, and it was in this cutting that further quantities of the mineral were discovered, from which the specimens in the Society's possession were taken.

Where the cutting commences, about $1\frac{1}{4}$ mile from Dingwall, the rock consists of a grey sandstone similar to that of the Tulloch Quarry, and having a north-west dip; but the strata are much disturbed and broken. The beds continue for about 18 yards, at the end of which space there appears a shaly rock mixed with clay, dipping north at a sharp angle, and underlying the sandstone for about 12 yards.

Where the shale disappears below the cutting, the sandstone recurs for about 20 yards, also dipping north; and it was here that the first vein of the mineral appeared, running S.E. to N.W. through the bed of sandstone. For these 20 yards the rock is much broken and arched, in rather thin beds, bending from south to north; after which the shaly rock reascends, alternating with the grey sandstone, and with occasional clay-seams between the beds of shale and sandstone, between which the mineral is again found in veins varying in thickness from $\frac{1}{2}$ inch to $1\frac{1}{2}$ inch. The arched strata of shale and sandstone somewhat resemble the fig. 21, p. 199, of Dr. Dawson's 'Acadian Geology.' Occasionally the clay rests behind the mineral, and between the shale- and sandstone-strata.

Similar rocks continue for 60 yards, during the whole of which portion of the cutting they are much disturbed and contorted, and the mineral lies in thin veins. The dip of the rocks is here still N.W., and the veins of the mineral run through them W. by N. The sandstone appears by itself for about 8 yards, and then the shaly rock. Here the mineral has been found in greater quantities and thickness, running in veins of 1, 2, and 3 inches, and adhering very firmly to, and intimately blended with, the exterior face of the sandstone. It also outcrops at the surface of the sandstone-rock under the clay which covers the surface of the hillside. The mineral found adhering to the sandstone is very fine and pure, and superior in quality to that found in the shale and clay.

Shaly rock continues after this for 6 yards, dipping S.W. to N.E.; after which the uplifted sandstone appears for 20 yards, in much thicker beds and less broken than the previous rock, and dipping S.; but no mineral appears. The shaly rock then reappears for 22 yards, also dipping S.; but about 5 feet behind the face of the railway-cutting the sandstone shows itself, overlapping the shale; and at the junction a thin vein of inferior mineral, about $\frac{1}{2}$ inch thick, lies like packing between the two strata. Conglomerate next appears upon the top of the sandstone, and the vein of mineral goes quite through it.

From where the sandstone overlaps the shaly rock, the conglomerate appears alone for about a quarter of a mile, at the end of which distance the cutting is continued through clay.

The conglomerate strikes east and west, and has a slight dip to the north, whilst the veins of the mineral, which are very numerous, varying from $\frac{1}{4}$ inch to 3 inches in thickness, traverse the conglomerate at an angle of almost 45° in the direction S.E. to N.W.

Whenever the mineral appears between walls of conglomerate, the faces of the latter are perfectly smooth. There are several other breaks in the beds of conglomerate, running N.E. to S.W., but in none of them was any mineral discovered.

The cutting varies from 12 to 25 feet in depth, and is throughout about 200 yards from the shore. In several places, when, in blasting the sandstone, rock was reached below the conglomerate, finer and thicker specimens of the mineral were discovered closely adhering to the sandstone, and reaching $3\frac{1}{2}$ inches in thickness.

No boring has as yet been attempted; but during the length of the cutting above mentioned, as many as thirty-six separate veins of the mineral were met and cut through.

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10. *On the* Occurrence *of* Rocks *of* Upper Cretaceous Age *in* Eastern Bengal. By T. Oldham, LL.D., F.R.S., F.G.S., &c.

During the years 1851-52, I had an opportunity of visiting the Khasi Hills, in Eastern Bengal, and made a tolerably large collection of the fossils occurring in the rocks there. At that time the Geological Survey of India had no office or place in which these fossils could be opened out for examination, nor were there in India any collections sufficient for comparison, or any libraries containing the books necessary for reference. I was, therefore, compelled to be satisfied with such a cursory examination as could be made during the packing up of the specimens. This examination was even more cursory than it would otherwise have been, inasmuch as my deeply regretted friend Edward Forbes had promised to go carefully over all these fossils and to describe any that proved new or interesting. I had, by letter, pointed out to him the great interest which attached to them, inasmuch as many of them strongly recalled some of the forms which he had then recently described from the beautiful collections of Messrs. Kaye and Cunliffe from South India, while other beds contained undoubted Nummulites and several known "Nummulitic" fossils. The collection which I had made was chiefly from the Nummulitic Limestone, close to the station of Cherra Poonji; but there was also a good number from the sandstones underlying this limestone, to which I especially requested Prof. Forbes's attention, as they appeared to me to be of Cretaceous rather than Tertiary age.

These latter were, however, much fewer in number, because the only season of the year during which I could visit these hills being that of "the rains" (during which the average fall of rain at Cherra Poonji is about 600 inches, concentrated in these four or five months), it was not safe to do more than pay an occasional visit to the lower country. But there was a sufficient number to have yielded, on careful examination, a decisive result.

I anxiously waited the result of this examination by Prof. Forbes, and deferred the publication of any report on the geology of these hills, hoping to have his conclusions. But, unfortunately, the whole of this collection, which had cost much time and trouble, was lost in its transmission to England.

I could, however, no longer delay the description of these hills, and in 1854 a short account of them was published in Calcutta. In this I pointed out how incomplete any report on their structure must unavoidably be, until the final results of the comparison of the fossils were known. And I also said, "It is to me a source of great regret that, owing to the season of the year during which I visited these hills, I was unable to examine the lower parts of the ridge, or to proceed along the base, where many points of great geological interest still await solution. Densely covered as these portions are with close grass-jungle, a sojourn there during the wet and hot months of summer would be almost certain death to a European; and I was, therefore, obliged to forego my desire of visiting these districts. It will be seen that in consequence several questions of interest have been left still unsolved."

This being the case, and all the valuable fossils, on which alone any sound conclusions could be based, having been lost, I was compelled to leave the question of their age undecided. The only section I could, at that season, examine seemed to show continuous sequence and conformity of the beds. And in describing this I added, "It is possible that some of the sandstones may have been geologically coeval with the upper or latest portions of the Cretaceous group of Europe," thus leaving the age of these sandstones undecided, while, from the abundance of Nummulites, there was no question as to the age of the limestone resting on them.

Further, at that time (1853), the knowledge of the fossils of the beds forming the upper limits of the Cretaceous era, and of those constituting the lowest limits of the Tertiary period, was infinitely less perfect than it now is.

I did not, however, forget the impression which those fossils had left on my own mind, that they were Cretaceous, and I failed not to take every opportunity to replace, so far as possible, the collections which had been lost. I got, from year to year, some additions through friends who had visited the place; and in 1859 I despatched one of the staff of the Geological Survey to these hills, in the hope of being able to obtain a good collection. But the prevalence of cholera drove him from the place; and as with myself, so with others, the extreme nature of the season during which they visited the hills prevented much being done in the lower grounds. And, therefore, almost the only additions I received were of fossils, often extremely imperfect, from the *limestone*, which, occurring at the upper levels, is easily accessible, but regarding the geological epoch of which there was no doubt.

During last year (1862), however, I received from W. L. Atkinson, Esq., a small collection from Cherra Poonji, among which, in addition to the ordinary Limestone fossils, there were a few from the lower sandstones; and a few months later Dr. T. C. Jerdon brought down another small collection, almost entirely from these sandstones.

Among the first (those brought by Mr. Atkinson) there was one small fragment of an undoubted *Turrilite*; and it was therefore with no small interest that I opened Dr. Jerdon's collection and found in it specimens of *Ammonites* and *Baculites*, together with other distinctive fossils.

It was thus conclusively established that these sandstones were really, as I had always suspected, of Upper Cretaceous age.

I shall not dwell on the immense importance of this result, as bearing on Indian geology; it will be obvious to all who have made themselves acquainted with the results hitherto published; and to make it clear to others would require a much more lengthened explanation than could now be given.

I shall simply give a list of genera, and a few species, which have been distinguished in the small collections we now have, and hope soon to be able to obtain better and more complete data. I have had the valuable aid of Dr. Stoliczka in going over these fossils.

Ammonites.
Turrilites.
Baculites.
Pterocera, very near *P. angulata*, Zekeli, from Gosau.
Tritonium loricatum, *Sow.*
—— sp. (?).
Fusus Dupinianus, *D'Orb.*
——, four species.
Rostellaria carinata (?).
—— granulata, *Sow.*
—— palliata, *Forbes.*
Pleurotoma subtilis, *Zekeli.*
——, near P. costata, *Sow.*
Voluta septemcostata, *Forbes.*
—— Camdeo, *Forbes.*
Mitra cancellata, *Sow.*
Cypræa, two species.
Eulima.
Natica lyrata, *Sow.*
—— pagoda, *Forbes.*
Cerithium scalarioideum, *Forbes.*
——, probably *C. provinciale*, Sow.
——, a species not yet published, but which occurs at Gosau.
Turritella Pondicherriana, *Forbes.*
——, two species.
Vermetus.
Trochus.
Turbo.
Cynulia decurata, *Sow.*
——, two species.
Bulla, or Ovula.
Terebratula, very near T. arabilis.
——, very near *T. tamirandus*, Sow.
Rhynchonella, two species.
Gastrochæna.
Pecten, two species.
Janira, sp.
Ostrea.
Plicatula.
Spondylus tenuistriatus, *Sow.*
Anomia.
Cardium, two species.
Lima Heriana, *D'Orb.*
——, sp., probably *L. parallela*, d'Orb.
Echinoconus.
Cidarites.
Toxaster.
Ananchytes.

It is certain that these rocks extend considerably to the east, beyond the parallel of Cherra Poonji. And it is not improbable that a large area in Munnipore and Burmah, hitherto supposed to be of Tertiary age, will prove on closer examination to be of the same Upper Cretaceous age as the rocks now referred to.

Among the fossils from the Nummulitic Limestone, most of which were imperfect, were

Natica longispira, *D'Arch.*
Cypræa depressa, *Sow.*
Oliva, probably *O. virginea*, D'Arch.
Pecten, probably *P. Fauvei*, D'Arch.
Nummulites Beaumontii, *D'Arch.*
—— obtusus, *Sow.*

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TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Pleistocene *and* Recent Phenomena *in the* South-east *of* Europe. By Dr. Joseph Szabó.

[Egy continentális emelkedés és sülyedésröl Európa délkeleti részén. Szabó József, &c. Magyar Tudom. Akad. Évkönyvei, Tizedik Kötet, 6 Darab.]

Introduction.—In this paper the author endeavours to show that in the South-east of Europe, and especially on the northern and western parts of the basin of the Black Sea, the elevation and submergence of that part of the continent, and the subsequently modified action of the denuding agents, were forces competent to effect the changes which distinguish the present geological conditions from those immediately preceding, and, especially, to produce the present physical configuration of the surface of the diluvial and alluvial deposits.

Recent Geological Phenomena.—His researches were first based on the present conditions of the river-system of the area now drained by the middle and lower portions of the Danube; and he afterwards considered in succession the physical history of geological periods of a gradually increasing age, until finally a period was reached when the geological phenomena were essentially different from the present.

By the first series of observations which he recounts, it is proved that the beds of the great majority of the existing rivers have been excavated out of pleistocene deposits, and that, more especially in Hungary, the Danube and all its tributaries, as well as the Russian rivers which empty themselves into the Euxine, have very deeply excavated the diluvial strata; while the Theiss and its confluents flow between lower banks, and have not cut so deeply into the mass of the pleistocene formation.

The author then brings forward data to show that the present areas of inundation are surrounded by older ones, which are in all respects similar, but lie higher and are more extensive; they are, therefore, indications of a former period when the beds of the rivers were not so deeply excavated as they are now—that is, when the water flowed nearer to the level of the surface of the adjacent plains, and consequently flooded a larger area. The deposits of the older inundational areas are of alluvial origin, as also are those now being formed; therefore, in determining the limits between the pleistocene and modern formations, the outlines of the former may prove to the geologist a valuable guide.

He also describes old, and now abandoned, river-beds; the best opportunity of examining which is afforded in the tract of land in Hungary between the Theiss and the mountainous western boundary of Transylvania. Similar ancient river-beds are to be found along the Danube, and especially on the plains of Moldavia, where they appear as valleys of erosion having connexion with that river; and they also occur along the Pruth and Sereth. All these channel-like depressions are now dry, or if they are sometimes conveying water, yet it is in a quantity quite inadequate to the dimensions of the excavation, which are greater than those of the beds of the adjacent rivers; and being as regards the direction identical with the latter, they must be regarded as constituent parts of the present river-system: and they may also be considered as relics of a period subsequent to that in which the existing mountains and valleys were formed, but when the water flowed at a higher level, that is, nearer to the surface of the plains, and was also conveyed in a greater number of channels than it is now. The beds of the present rivers were developed from these in such a manner that, as the water sank gradually in a deeper basin, its fall became greater, its current more rapid, and therefore it was enabled to cut out deeper beds. It selected, out of the many shallow channels, those few which offered the least resistance to the excavating power. The ancient river-beds on the left bank of the Theiss are as curvilinear as the modern ones; while those on the Moldo-Wallachian plains are as straight as the present rivers of that district. This coincidence may be regarded as indicating that the collateral circumstances are the same now as they were during those periods when the ancient river-beds were in full request.

Dr. Szabó then refers to the chief points of interest in individual localities, not only in the course of the Danube, but in its basin further inland, where, on heights that are now quite unattainable by floods, incontestable traces of alluvial deposits are found superimposed upon the Loess. The most remarkable of such places are Zimony (Semlin) and Csernavoda. On the former, situated opposite Belgrade, the loose deposits forming the precipitous sides of the Danube consist, for the most part, of diluvial strata; in the lower portion of which bones of *Elephas*, *Rhinoceros*, *Bos*, &c., are met with. The upper portion is the true Loess, and it is covered with newer strata consisting partly of sand of about 15 ft. in thickness and containing pleistocene fossils, partly of clayey materials, from 5–9 ft. thick, with fragments of earthenware, bones of *Bos* and *Cervus*, charcoal, flint worked by man, and, in some places, fresh-water shells such as *Unio pictorum* and *U. Batavus*. The whole formation becomes thinner inland, and thicker towards the Danube, where it also becomes abruptly cut off.

Beyond an enormous tract of marshy land which lies upon the left bank of the Danube, and upon the opposite side of that river, but many miles off, precipitous walls of Loess are again met with of the same character as before, the connecting portions having occupied the place where the Danube now flows. At Csernavoda*, the valley through which the railway passes was formed by erosion; and the surface-configuration of its side suggests that it must once have been filled with water, and that this was the water of the Danube itself, towards which the valley opens. This conjecture is rendered almost certain by the examination of the bottom, which is covered by an immense quantity of shells, all belonging to species now living in the Danube and on its banks (*Tichogonia Chemnitzii*, Fér., *Melanopsis acicularis*, Fér., *Neritina Danubialis*, Ziegl., *Paludina achatina*, Brug., *Melanopsis Esperi*, Fér., &c.).

Besides this, there is another place in the same valley which contains some of these Mollusca, and also remains of human art of a more recent age, at a height of about 100 ft. above the level of the Danube. These human remains consist of fragments of urns, roof-tiles, bones of domestic animals, and, what is more significant than all, a piece of laminated metal which proved to be lead.

The systems of plains forming the steppes or the large valleys are then treated of; and in concluding this portion of his subject the author describes the present shores of the Black Sea, to which the pleistocene deposits are continued, stating that the Loess forms the shore on the Kilia arm, where it constitutes cliffs of from 42 to 50 feet above the sea-level, but that towards Odessa the cliffs rise gradually to a height of more than 200 feet, of which the upper portion is typical Loess, while the lower consists of the well-known Neogene limestone.

On the St. George arm, portions of the secondary rocks of the Dobrudscha Mountains are visible as far as the banks of the Danube; but in places a mass of Loess, forming a range of hills, occurs; and at Kustendje the cliffs are composed in some places entirely of Loess, in others partly of it and partly of older formations. The latter rocks gradually crop out towards the Balkan range, and in the same ratio the Loess thins out; so that at the Cape of Kalakvi (Gulgrud), near Varna, the tertiary limestone forms the surface and the entire cliff; this limestone is probably the Leithakalk of the Vienna geologists. It may be therefore inferred that the Loess forming the sea-shore obeys, in thinning out, the same law as that of the plains: in other words, it thins out only towards the mountains, and above a certain level large masses of it are never found; but towards the Black Sea it does not thin out at all. The interruption of it on the shore must have been, of course, posterior to the time of its formation. Commencing from Odessa, and proceeding as far as the mouth of the Danube, and again from here to Kustendje and the Bay of Varna, the Loess is never found covered by a marine deposit.

From the above observations the author infers that the water

* The Danube station of the Danube and Black Sea Railway.

formerly flowed in the Hungarian rivers at a level of from 10 to 30 feet higher than it does now, viz., when their floods were able to rise to the height of the old inundational areas and to occupy the ancient river-beds.

Again, the beds of the rivers must have been from 30 to 70 feet higher than they are now, when land now lying at that height above the present level of the Danube was covered with its water, and in which, for instance, the alluvium of Csernavoda was deposited.

Also the land must have been raised from 100 to 130 feet since the deposition of the old alluvial deposits at Zimony (Semlin), Gomba, Kis-Terenne, &c.

And, lastly, there has been an upheaval of the district under consideration to the extent of from 130 to 200 feet since the terrace-system was formed; these terraces, however, are not the result of the action of rivers, but of that of a vast expanse of water, which covered the whole area of the diluvial deposits.

Pleistocene Period.—Towards the margin of the Hungarian basin the Pleistocene (diluvial) deposits consist of gravel overlain by sand. In the central portion of the great basin bordering the course of the Theiss, the lower beds are formed of a bluish mud and sand, but the upper portion consists of Loess. Frequently, however, the latter lays immediately upon the older formations. Besides this, a calcareous tufa occurs under interesting circumstances, though not over any considerable area. The average thickness of the diluvial deposits may be estimated at 200 feet; they are overlain by alluvium, and repose upon the highest pliocene deposit, and especially the Congeria-beds.

The gravel is characterized by boulders of trachyte, basalt, and the opaline minerals pertaining to the rhyolite-group. By the decomposition of some felspathic minerals the natural soda of Hungary and a calcareous tufa are formed, either immediately upon the surface or under a thin cover of soil. At a very typical spot, between Szeged and Dorozsma, where a great quantity of soda is obtained, and at a depth of 3 to 4 feet in the Soda-lake, the author found grains of the size of a pea, and all of the same external appearance. The analysis proved them to be labradorite; and, in ascending towards the surface of the lake-bed, they are found to be more and more decomposed. The origin of this volcanic ejection must be attributed to a volcano which was discovered by the author some years ago in the basin of the Theiss, north of the Mátra Mountains, near Ajnácsko.

The Loess occurs not only in Hungary, covering the greatest part of the central plains and the adjacent valleys, but it is also found greatly developed in the Danubian Principalities, and on the shores of the Black Sea, as far as Odessa; further the author has not carried on his investigations, but there is every reason to believe that it covers a great part of the northern Pontic plain. Southward from the mouth of the Danube it forms the upper stratum towards the Balkan Mountains. In some localities, cliffs of from 80 to 100 feet appear quite homogeneous, but in most instances distinct lines of stratification may be followed uninterruptedly for several miles. The *Nummulites* at one locality, not far from Gran, form a layer nearly 1 foot thick; at another place the true Loess-shells are mixed with *Melanopsis*, *Cerithium*, and other fossils of the Congeria-beds. The Loess strata are nearly horizontal.

According to the evidence of the organic remains, the Loess may be divided into two portions. The great *Mammalia* occur in the lower, while the Loess-shells are only exceptionally found in that portion. The upper division abounds with Loess-shells, but the remains of *Pachydermata* are absent, and even the *Cervus*, *Bos*, and *Equus* are only occasionally found. This distinction refers only to districts where the formation is well developed, the thickness being not less than 100 feet; but in other cases, both portions sometimes appear to be confusedly brought together.

The Surface in the Pleistocene Period.—As regards the deep channels of the rivers, it is quite certain that where the banks are more or less vertical, and the beds on each side correspond, the place occupied now by the river was originally filled up by a continuation of the same strata which now constitute the banks, and that the uninterrupted plain thus formed was furrowed posteriorly. The restoration must be effected on a much greater scale where two or more great rivers joined. An example of this kind occurs at the southern end of the boundary-line between the Danube and the Theiss, where, in the midst of an extensive area formed by alluvium (of both ages), a small egg-shaped plateau, consisting of typical Loess, and having vertically broken cliff-like walls, remains like a column of earth to mark the extent of former denudation.

Having thus restored to one continued plain the Pleistocene deposits in Hungary and in the Danubian Principalities, the author proceeds to consider the similar phenomena in the neighbourhood of the Black Sea; and he states that the Loess does not thin out towards the sea, but, on the contrary, becomes more largely developed, and that the shore is formed by abruptly broken cliffs.

The method of restoration hitherto pursued by Dr. Szabó reclaims from the sea a large portion of the areas now occupied by it, and proves that, at some period after the deposition of the Loess, that part of the Euxine which is necessary for the restoration of the Loess-plateau was not covered by water, but was so much elevated that the Loess-strata now wanting touched each of the corresponding ones which now form the shore. Now, if we suppose that water has covered the whole area over which, at the same low level, the Loess would be found as an uninterrupted mass, we obtain a lake, the water of which covers, besides the Pontic lowland, probably the whole Arabio-Caspian depression, as suggested by Pallas, Humboldt, and all the naturalists who have travelled there.

But such a sea was possible, in the Pleistocene period, only upon the supposition that the present Black Sea did not then exist as such, but that its present bottom was elevated to such an extent that the Loess plateau could exist in its original completeness. A natural consequence of this condition is, that it was not in connexion with the ocean, but was a constituent part of the great Arabio-Ponto-Caspian or mediterranean lake. At one place the boundary of its basin is decidedly known, and has been described by Herr Stur *, who states that "the dividing-line of the pleistocene plateaux is not only such a one for the Rivers Bug and Dneister, but it is at the same time part of the great dividing-line between the Black Sea and the East Sea. South of this limit all the strata are covered by Loess, while north, on the plain, sand, black soil, and erratic blocks are spread. The same dividing-line acted as such even previously to the Pleistocene period." The lowland of Hungary was a great bay of a Pleistocene lake, and was connected with it by the "narrows" (or "straits") of the Iron-gate, in the same manner as the Euxine is, by the Bosphorus, connected with the Sea of Marmora.

The author then enters into the details of the configuration of the bottom of this lake, of which some remains are to be met with. Such are certain hills, commonly called tumuli, but of which only a small number are real tumuli, the greatest number being geological mementos of the Pleistocene period. He is acquainted with about 130 tumuli erected by man, but with above 600, in Hungary alone, which have been formed by successive depositions of the same strata as those which form the lowland of that country. The left bank of the Theiss may be considered a classical ground for the study of these remarkable formations. Guided by the geological tumuli, and the law of their distribution, he points out that the original depressions are remains of the bottom of the Loess-lake, and of the depressions formed subsequently by denudation. This statement refers especially to one of the bays of the Pontic depression, and perhaps has a further bearing upon the question of the probable form of the bottom of the Pleistocene lake.

Three great depressions may be distinguished, which were divided by two longitudinal elevations. Of those basins the middle (the Caspian) was the deepest. The water of the lake having been by some means carried off, the dividing-lines were rendered dry; and they act as natural barriers between the basin of the Aral and the Caspian Seas on the one side, and between the basin of the latter and that of the Euxine on the other, to the present day. The level of the Caspian is reported as being, in some places, only 23 feet above the level of the Black Sea.

Inauguration of the Recent Period.—Having sufficient proof that the Loess, notwithstanding its local uniformity, is in most cases stratified, it follows that it was deposited in water, and was not the result of any form of ice-action; and, the strata being nearly horizontal, the water must have occupied the adjacent depression of Europe and Asia after the formation of the general configuration of the territory.

The general outline of the land was formed during the period of the trachytic and basaltic eruption which also destroyed the Congeria-sea. The end of this period is marked by great movements of

* Jahrbuch der k. k. geol. Reichsanstalt. Wien, 1860 (On the Pleistocene Plateaux in Gallicia).

upheaval and subsidence; and consequently the first stratum of the Pleistocene formation consists of a specifically heavy material, especially near the mountain-borders; and the higher we ascend in the series, the finer do the particles that were carried in appear to be, and at last the finest detritus, forming the Loess, was deposited. The Loess-sea was an inland lake, of which the area now occupied by the Euxine was a constituent part. The author infers that two branches were then extended from the Caucaso-Crimean chain towards the west, the principal one connecting the Balkan with it, while the others stretched towards Fidonisi, the only island in the Euxine, and continued as far as the Dobrudscha Mountains on the right bank of the St. George arm of the Danube: the existence of the former was proved by Capt. Spratt, by sounding the Black Sea. That geologist found a submarine elevation on the line connecting the Crimean and the Balkan Mountains. These branches may have constituted the coast of the Loess-sea.

A considerable difference in the relative position of the whole of the basin of the Loess-sea, and that part of it which is now occupied by the Euxine, was caused by the subsidence of the latter. Thus the Loess-sea and the ocean were brought into communication, the water of the former was emptied into the latter, while, on the other hand, that enormous land of steppes was formed of which Ritter, the great geographer, says, it is, with its negative levels*, of all Asiatic plains the most continental, being on no side open towards the ocean†.

The author then enters into the changes in the surface-configuration of the sea-bottom of that period, of which some unmistakeable traces on a large scale are to be met with, especially in Hungary. He explains the mode of formation of the best soils which occur in Hungary under similar circumstances, as the black soil in the Danubian Principalities called by the proprietors "Tschernosem."

The best soil is always to be found most largely developed on the slowly inclined plain of the Pleistocene basin, which at one time formed the gradually sloping bottom of the Loess-sea; while towards the line of greatest depression the particles become more and more decomposed, both chemically and mechanically, and the fitness of the soil for the support of a luxurious vegetation decreases, and a peculiar kind of soil, called in Hungarian "Szek," is found on the banks of the Theiss: in this soil spots occur which are quite barren.

The Bed of the Danube occupies the line of a fault.—Commencing at Vacz, about sixteen miles above Pesth, and proceeding towards the Black Sea along the sinuous course of the Danube, it may be observed that the right bank is always the higher. The most striking instances of this peculiarity are afforded beyond the Iron-gate, near Orsova;

* The signs + and − being sometimes used to distinguish between areas above and below the level of the sea, the levels of the latter are consequently termed "negative."—Ed. Q. J. G. S.

† De Verneuil, in his "Mémoire Géologique sur la Crimée" (Mém. Soc. Géol. France, 1838), makes a distinction between freshwater, brackish, and marine deposits, and, though chiefly treating of the older formations, infers that the change of the freshwater lake into dry land, and the formation of the Euxine, have both taken place in the most recent, even perhaps in historical times.

while above this point, between Baziás and Pesth, interruptions are often met with. The bed of the Danube may be regarded as a curved line marking the direction of a fault, the plan of which is somewhat inclined, and on which a movement of upheaval has taken place on the right bank, and of subsidence on the left; while the Danube itself occupies the depression thus caused. This statement is based upon the fact, that wherever any trace of a formerly higher level of the present river-system is found, it is always upon the right bank, without any corresponding elevation on the left. The author refers here especially to Csernavoda and other localities enumerated on p. 2.

The relation of the History of Man to the Pleistocene Period.—From the fact that in Pleistocene deposits, as well as in bone-caverns, in Hungary and the South of Russia no human remains have hitherto been found; and as the relics of human industry date also from a later period, the author infers that during the flint-period, and even the subsequent stone-period, this part of Europe was not inhabited, but that it became peopled during the bronze-period, and that its first inhabitants witnessed the draining of the great freshwater lakes. From written history we may only infer that since the time of Trajan no considerable change has taken place respecting the levels of the two banks of the Danube and its affluents; but changes that might have taken place previous to this date would not have been recorded. Nevertheless, the recollection of the tradition of such an event as the draining of a great lake going on successively before the eyes of several generations remained for a long time deeply impressed upon the minds of the inhabitants of the district, and is not yet totally effaced—the view still prevailing among the inhabitants of Hungary being "that these plains were once covered by a freshwater sea (*mare dulce*), the water of which afterwards found its way through the 'narrows' of the Iron-gate." [J. S.]

On the Upper Nummulitic Strata *of* Hungary. By Dr. Zittel.

[Proceed. Imp. Acad. Vienna, October 9, 1862.]

According to the observations of Prof. Peters, these strata rest on the great wide-spread Nummulitic Limestone. Palæontologically they are equivalent to the strata of Ronca, forming, with other coëval beds, a distinct geological horizon, generally known as the Upper Nummulitic formation. Among 68 species of organic remains occurring in this formation in Hungary, 19 are new; 23 are met with at Ronca and in the Vicentin; 22 in the Calcaire grossier of Paris; only 4 in Oligocene deposits: and of these last, 3 species have also been found in decidedly Eocene beds.

Dr. Zittel hence infers that the freshwater and marine deposits around Gran, including some coal-seams, together with the fossiliferous sands near Stuhlweissenburg, belong to the Upper Nummulitic formation, and are far more nearly allied to the deposits of the Eocene than to those of the Oligocene periods. [Count M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Coal-pits *of* S. Pedro da Cova, *in the* Concelho de Gondomar, *District of* Oporto. By Senhor Carlos Ribeiro.

[Die Steinkohlen-Grube von S. Pedro da Cova im Concelho de Gondomar, Distrikt von Porto, von Herrn Carlos Ribeiro. Aus dem Portugiesischen übersetzt und bevorwortet von Herrn W. Reiss.* Neues Jahrbuch für Min. u. s. w. Jahrgang 1862. Drittes Heft, pp. 257, &c.]

Proceeding from the granite of Oporto beyond S. Pedro da Cova, towards the east, the following systems of beds appear successively:—

1. Gneiss, alternating with mica-schist, extending laterally from Campanhã to the neighbourhood of the Serra de Fanzeres. The strike is from N. 10°–20° W. to S. 10°–20° E., and the dip is very rapid towards E. 20° N.
2. Greyish-green, silky-looking slate, and clay-slate of various colours, having the same inclination as the preceding system.
3. Breccia made up of fragments of the before-mentioned rocks; black clay-slate with impressions of Plants; sandstone; and coal-beds. All these beds strike from N. 20° W. to S. 20° E., and dip E. 20° N.
4. Quartzite, clay-slate, and unfossiliferous greywacke, overlying the foregoing systems. They have a strong inclination towards E. 20° N., while further eastward they dip W. 20° N., or also E. 20° N. Upon them, in fact, rests conformably clay-slate with Trilobites and other fossils of the Lower Silurian formation.
5. Quartzite, greywacke, clay-slate, and metamorphic rocks; they are all destitute of fossils, and extend from the left bank of the Ribeiro da Murta over the Serra de Vallongo as far as the granite of Baltár (which strikes from N. 20° W. to S. 20° E.), thus taking in a breadth of from 9 to 10 kilomètres.

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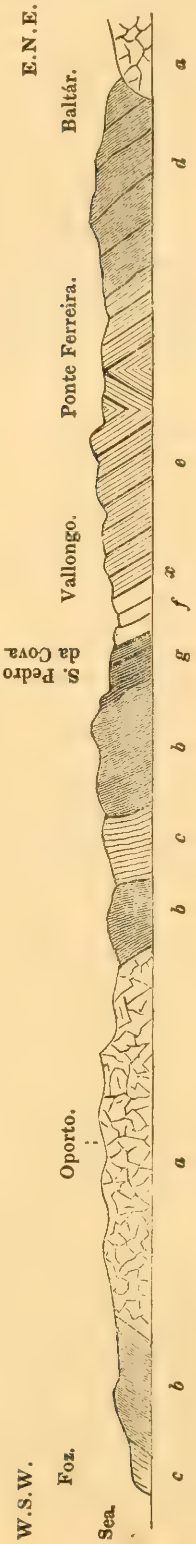
* On November 29, 1848, the late Mr. D. Sharpe read before the Society a paper "On the Geology of the Neighbourhood of Oporto, including the Silurian Coal and Slates of Vallongo" (Quart. Journ. Geol. Soc. vol. v. pp. 142, &c.); and on April 6, 1853, he read a paper "On the Carboniferous and Silurian Formations of the Neighbourhood of Bussaco, in Portugal" (Quart. Journ. Geol. Soc. vol. ix. pp. 135, &c.), compiled from letters received from Senhor C. Ribeiro in November 1850 and during some months afterwards; and in this latter paper he stated (at p. 142) that Senhor C. Ribeiro's views of the geological relations of the Coal of Vallongo then coincided with his own. The memoir of which an abridgement is now given appeared in the 'Neues Jahrbuch,' as a German translation of the first part of one published in Portugal by Senhor C. Ribeiro, on the Coal-bearing beds of Oporto, in 1853, and again republished, with other essays, under a general title, "Memorias sobre as minas de carvao dos districtos do Porto e Coimbra e de carvao e ferro do districto de Leiria, por Carlos Ribeiro" (Mem. Acad. Real das Sciencias de Lisboa, vol. i. part 2, 1858), in 1858, from which it appears that, in 1853, Senhor Ribeiro no longer agreed with Mr. Sharpe's views with respect to the age of the Coal in question.

The following section shows the order of succession and the stratigraphical relations of these several systems:—

Section from the Mouth of the Douro to Baltár. (15 miles.)



SHARPE.—*a.* Granite and Syenite. *b.* Micaceous schist. *c.* Gneiss. *d.* Sandstone. *e.* Clay-slate. *f, g.* Carbonaceous shales and sandstones, containing Coal, and with Trilobites in the upper part (*x*).

RIBEIRO.—*a.* Granite. *b, c, d.* Crystalline schists. *e.* Silurian. *f.* Devonian. *g.* Carboniferous (*Hulla*). (*b, c, b.* 1st and 2nd Systems. *g, f.* 3rd System. *e.* 4th System. *d.* 5th System.)

This section has been already given by Mr. D. Sharpe in his paper "On the Geology of the Neighbourhood of Oporto"*; it represents the relations which apparently exist between the foregoing systems of rocks and the coal-beds, the latter appearing to dip beneath the former.

Even if the manner in which the coal-beds here crop out intimated their true geological situation in reference to the rocks of the fourth system, which appear to cover them, it would still remain to be explained why the mining-works that have been carried out in the neighbourhood of S. Pedro da Cova, Covelo, and Povoa have always been in that zone in which the valuable beds are exposed, and why the attempt has never been made further east, in which direction the coal dips at an angle of about 35° under the coal-shale. If it had been discovered, through the first workings, that the coal-beds continued further beneath and dipped under the Silurian beds, it would have been attempted to win the coal again by shafts sunk to the east of the intermediate zone. As this, however, has not taken place, there is every reason for doubting this con-

* Quart. Journ. Geol. Soc. vol. v. 1849, p. 145.

tinuation of the coal-beds in depth, and, therefore, also the geological position which they here appear to possess.

And, in truth, these coal-beds, so far from belonging to the Lower Silurian formation, as their stratification might appear to prove, and as Daniel Sharpe * has assigned them, are much younger, and must be considered of Devonian or Carboniferous age, as will be shown hereafter.

The mica-slate and the gneiss composing the first system are well displayed beyond the beds of Oporto and S. Pedro da Cova, without, however, showing a regular connexion or covering a great area. Excepting the Serra da Freita for the mica-slate, and the Valley of Cambra, with the banks of the Caima and the Vouga, for the gneiss, these crystalline rocks everywhere appear more as the results of local metamorphism—produced through the alteration of the clay-slate and talc-slate where those formations were exposed to the influence of the intrusive granite—than as a definite, uniform, metamorphic formation covering a large superficial area.

But the azoic talc-slate and clay-slate, besides the extreme uniformity of connexion and development which they exhibit in the before-mentioned zone, cover large spaces in Portugal, and contribute largely to the peculiar features of many districts in that country. We must, therefore, consider that stripe which appears between Oporto and Baltár as isolated, through its being cut off by a mass of granite. This is by no means the case with the fossiliferous beds of the zone in question. Although the fossiliferous beds may be shown to be clearly independent of the azoic group, both in regard to their geographical position as well as their distribution and stratigraphical relations, this cannot yet be done in regard to the relations which the coal-beds show to that fossiliferous group.

On the contrary, a geographical dependence of the one system upon the other can be recognized, as has been observed in the neighbourhood of Oporto, Bussaco, and at some places in Beira-Baixa.

The author then gives some details respecting the lithology, dip, and direction of the foregoing beds of the first and second systems, and of the members of the third system. The latter series he divides into two groups, distinguished by peculiar mineralogical characters and fossil Plants, as well as by the different dips of their individual beds.

A section from west to east, about the neighbourhood of the Igreja velha de S. Pedro da Cova, through those beds, will show the following series, in ascending order:—

First group.

1. Greenish and grey, lustrous slate, dipping from 70° to 80° towards E. 20° N. Upon this slate rest the coal-bearing beds.
2. Breccia, formed out of the angular fragments of the argillaceous slate which forms the basement-bed of this group (1).
3. Blackish and very micaceous clay-slate, alternating with thin beds of micaceous sandstone, in which appear also small pieces of felspar.

* Quart. Journ. Geol. Soc. vol. v. 1849, pp. 145–148.

4. Coal, having a medium thickness of about 1 mètre, and called a *Devesa.*

5. Beds of micaceous sandstone, interstratified with clay and grey psammite, all being carbonaceous. A great number of fossil Plants and a few veins of carbonate of iron are found in these beds.

6. Coal, about one mètre in thickness, and called *Camada do Poso Alto.*

7. Beds of pudding-stone and coarse-grained micaceous sandstone of a bright-yellow colour, in which occur broken pieces of rock identical in character with the quartzite and slate of the fifth system. These beds are called "the roof" (*telhado*) by the miners of the district.

These rocks compose the first group of the coal-bearing series of beds, and are all inclined about 30° to 35° towards E. 20° N.

The second group, immediately superimposed upon the first, comprises the following beds:—

1. Clay-slate, partly blackish grey and partly of a bright ash-grey passing to a reddish colour, containing some fossil Plants; and beds of coarse-grained, micaceous sandstone passing into conglomerate; they dip from 40° to 50° towards E. 20° N.

2. Black psammite, with large leaves of mica, passing into a fine-grained, micaceous, and hard schistose sandstone, and containing many fossil Plants whose forms appear to have been slightly altered through the contortions of the beds. These strata alternate with beds of black, bituminous, and very hard pudding-stone; and they all dip approximately 54° towards E. 20° N. In them occur here and there thin bands or veins of anthracite, which expand, in places, almost suddenly, to form nests of as much as 6 mètres in diameter, the anthracite being sometimes soft and dull, and sometimes hard, with a beautifully lustrous fracture. With these anthracite masses, and in contact with them, occurs a very black graphitic slate.

3. Pudding-stone, sandstone, and shale, alternating variously with one another, all very hard and slightly micaceous. This subdivision consists mostly of thick beds of conglomerate, in which can be discerned fragments of the quartzite, greywacke, and clay-slate of the second, fourth, and fifth systems. The beds dip from 60° to 65° towards E. 20° N.

Then follow the Silurian slate and quartzite of the fourth system, which dip from 60° to 80° towards E. 20° N.

After giving some further details of the third system, the author proceeds to describe the various rocks in regard to their geographical distribution and mutual relations, more particularly in regard to the two groups of the coal-bearing beds; and he gives the following lists of Plants found in each:—

Fossil Plants of the First Group.

Pecopteris oreopteridis.	Pecopteris lepidorhachis.
—— gigantea.	—— murieta.
—— arborescens.	—— Serlei.
—— alata.	—— cristata.
—— Pluckeneti.	—— chœrophylloides.
—— aquilina.	—— Bucklandi.
—— cyathea.	Neuropteris heterophylla.
—— unita.	—— flexuosa.
—— leptophylla.	—— elegans?

Fossil Plants of the First Group (continued).

Neuropteris Villiersi.	Asterophyllites foliosa.
—— auriculata.	Annularia longifolia.
Sphenophyllum Schlotheimi.	—— brevifolia.
Walchia.	Calamites approximatus.
Asterophyllites equisetiformis.	—— cannæformis.
—— tuberculata.	Equisetum columnare.
—— comosa.	Lepidodendron Harcourti.

With many other, as yet undetermined, genera and species.

Fossil Plants of the Second Group.

Pecopteris oreopteridis.	Sphenophyllum Schlotheimi.
—— gigantea.	Cyclopteris orbicularis.
—— longifolia.	Lonchopteris Bricei.
—— affinis.	Calamites pachyderma.
—— polymorpha.	Poacites.
—— Grandini.	Knorria.
—— arguta.	Lepidodendron.
—— abbreviata.	Asterophyllites ?
Sphenophyllum erosum.	

With many other undetermined species.

The Trilobite-slates of the Lower Silurian formation do not everywhere border the eastern side of the coal-bearing beds. From Monte Alto to beyond Cancella velha, east of Paçal, they are displaced several hundred mètres towards the east, and the rocks of the coal-group rest upon those unfossiliferous slates and quartzites which the author is inclined to consider as the lowest member of the Lower Silurian Formation, or rather as the newest member of the Cambrian. The Trilobite-slates, however, by no means underlie the newer formation, for they are clearly seen at their eastern boundary reposing upon the azoic slates and quartzites. This formation is therefore represented, on the right bank of the Douro as well as on the left, as a narrow band, which runs parallel to the coal-bearing beds. It has an independent strike from N.N.W. to S.S.E., and it was deposited in a basin of unfossiliferous slates and quartzites.

The rocks of the fifth system, as exhibited in the Serra de Santa Justa and near Vallongo, are next described; and the author remarks that from the structure of that "Serra" it may be easily perceived that the elevation of the beds is not the result of forces which have affected this mountain-range only, but has been produced by an immense lateral pressure, which caused the slates to be folded over one another in undulations, through which the fifth system lost much of its original extension at the surface, and was compressed into a narrower space. The strike of the granite of Oporto and Baltár being parallel to that of these rocks, that is E. and W., Senhor Ribeiro considers the unheaval of that igneous mass to have produced the upheaval and compression already alluded to, which also affected similarly the Trilobite-slates containing *Calymene Tristani*, *C. Arago*, *Ogygia Guettardi*, *O. Edwardsi*, *Illænus Lusitanicus*, *I. giganteus*, and many other fossils, which are often distorted in consequence of the disturbance which the beds have sustained. It is, however, remarked, that the contortions of the Trilobite-beds are slighter than those in the fifth system and the remaining parts of the fourth.

After enumerating the places where the coal-bearing beds may be seen to dip under the slate and quartzite of the fourth system, and describing the appearance of the rocks at each place, he states that near the summit of Monte Alto the contorted shale of the second coal-group may be seen reposing unconformably upon the beds of the fourth system, and notices similar appearances of unconformity in other localities between the coal-beds and the Trilobite-slates.

Although he considers these and other similar facts sufficient to correct the erroneous idea of the age of the coal-beds which their position would at first cause to be entertained, he again calls attention to the fact mentioned at p. 13, that, while in some places the Trilobite-beds border the Coal-series, as at Cancella velha, at others they occur at some distance apart; and he also states that on the banks of the Rio Ferreira, near the brook of Boloi, the beds of the second system are immediately succeeded by those of the fourth, without the occurrence of any of the members of the Coal-series, while this does not occur in passing from the strata of the fourth system towards the Trilobite-beds.

And if to all these facts we add the one already referred to at pp. 9 & 12, that the conglomerate of the Coal-series is mostly formed of pebbles of slate and quartzite identical in character with those rocks of the fourth system; and also bear in mind that, while the Silurian fossils are generally distorted, in consequence of the contortion and compression of the beds, the fossil plants of the Coal-series, and especially those of the first group, are beautifully preserved; as well as the fact of the beds of the last-named group not being at all disturbed, though those of the second group are slightly so, but in a much less degree than the Silurian quartzite,—the following conclusions may be drawn:—

1. The Silurian slate existed prior to the formation of the coal-beds, and formed the sides of the basin in which they were deposited.

2. The second group of these beds appears overlying the first, through the inversion of the former. Consequently the overlying second group is the older of the two, and they are both covered by the still older Silurian rocks.

It is therefore seen, from the visible line of strike of the several systems, and from the undulations of the strata into anticlinals and synclinals whose axes are in the same direction (namely N. 20° E.), that a parallel overthrow has taken place, through which the beds now lie in an inverted order to that in which they were originally deposited. We also see that the heaving operation of the granite, while it exercised an immense lateral pressure upon the rocks, pushed together the beds into a smaller space than they originally occupied.

The investigation of the stratigraphical relations of those rocks shows us that the principal contortions took place before and during the deposition of the Trilobite-beds; and the complete absence of the Upper Silurian strata, which are represented in the neighbourhood of Coimbra by the blackish and grey slate with *Cardiola interrupta*, intimates that the disturbance of the rocks continued in the Lower Silurian period, when that area was already elevated above the sea. The stratigraphical relations of the coal-beds described above also show that during their deposition the disturbance of the strata ceased, and that the most westerly portion of the fourth system must at that time have been a valley in connexion with the sea, forming a narrow strait or an estuary, into which the fresh-water drainage of the country was discharged. In this estuary the beds of the second group of the Coal-series were deposited, certainly before the formation of the conglomerate seen near Varziela, on the east of the Valle de Deão and near Sete Cazaes. This conglomerate leans against the steeply inclined beds of the fourth system, which formed the eastern side of this basin. This and other facts, especially the unconformity of the stratification, lead the author to the opinion —already expressed by Herr E. Schmitz—that the second group of the Coal-series must be considered of Devonian age.

The author then describes what he conceives to have been the prevailing physical conditions of the period immediately succeeding the formation of these Devonian strata, during which the first Coal-group was deposited. He considers this group to represent the Carboniferous formation (Hulla) for the following reasons:—The thick mass of breccia separating it from the Devonian strata; its occurrence in small basins; the difference in the fossil Plants of the two groups, and the difference in mineralogical characters.

The manner in which the present relations of the several series have been produced is then treated of, including the effect of denudation in exposing the strata; and the author concludes by stating his belief that the coal-beds of Vallongo and those of S. Pedro da Cova are of the same age. [H. M. J.]

On the Neogene Plastic Clay (*Tegel*) *of* Olmütz, Moravia. By Franz von Hauer.

[Proceed. Imp. Geol. Instit. Vienna, Dec. 16, 1862.]

Mr. Waldrich found in this clay specimens of *Phasianella Eichwaldi*, Hörnes, *Bulla Utricula*, Brocchi, *Ervilia pusilla*, Phil., *Venus multilamella*, Lam., and *Lucina exigua*, Eichwald. All these species are also met with in the Tertiary basin of Vienna, the first three near Steinabrunn and Baden, the fourth at Gainfahrn, and the fifth at Steinabrunn. The sands intercalated with this clay yielded, upon washing, some few traces of *Bryozoa*, spines of *Cidaridæ*, some *Nulliporæ*, and, more abundantly, some fine species of *Cypridinæ*. Foraminifera are rather scarce, and only represented by some few forms. Among these are predominant:—

Asterigerina planorbis, *D'Orb.*, in the Vienna basin, occurring near Nussdorf.
Polystomella crispa, *D'Orb.*, near Nussdorf and Baden.
Rosalina Viennensis, *D'Orb.*

The following species are of very rare occurrence in the Olmütz sands:—

Polystomella Fichteliana, *D'Orb.*
Nonionina communis, *D'Orb.*
Amphistegina Haueriana, *D'Orb.* } from Nussdorf.
Bulimina elongata, *D'Orb.*
Triloculina inflata, *D'Orb.*

The strata from which these sands were produced belong evidently to the Upper Marine Neogene beds of the Vienna Basin, and certainly stand next to the Amphistegina-zone of the Vienna Tertiaries.

[Count M.]

On the Fossil Fishes *of* Austria. By Professor Kner.

[Proceed. Imp. Acad. Vienna, May 8, 1862.]

Professor Kner has described three species of Acanthopterygian fishes from the Calcaire grossier of the Leitha Hills, between Lower Austria and Hungary. One of these fishes is a Labroid—*Julis Sigismundi*; another, *Palimphanus anceps*, is a representative of a new generic type. The third, known only by a single specimen (wanting the head and the whole fore part of the body), is undoubtedly a Sparoid, and probably belonged to a species of *Pagrus*, for which the appellation *P. priscus* is proposed. The late distinguished ichthyologist Heckel published two species, as Labroids, from the same locality; one of them (*Labrus Agassizi*) is probably a species of *Julis*, while the other (*Labrus parvulus*) is certainly not a Labroid.

[Count M.]

On the Lias *of* Fünfkirchen, Hungary. By Professor Peters.

[Proceed. Imp. Acad. Vienna, July 24, 1862.]

Each of the three Liassic subdivisions, with its subpelagic fauna (comparable to the Lias of Swabia), is represented in the Fünfkirchen district. The lowest subdivision (of great practical importance on account of its rich coal-seams) rests on beds poorer in coal (probably analogous to the Bone-bed series); and these last cover a sandstone destitute of coal, which, lying upon the Muschelkalk, is analogous with the Keuper. The limestones of the Upper Alpine Trias and of the Rhætic subdivision (Dachstein-limestone) are consequently wanting.

The pelagic subdivisions of the Alpine formations appear again in the Jurassic series, in the form of Ammonite-limestones, analogous to the marbles of Trient, Campo Rotondo, and other localities of the Southern Alps. The Stramberg strata are represented by some isolated organic forms.

The whole series under notice comprehends the formations from the Upper Triassic beds (and a red sandstone of problematic age) to the Jurassic, both inclusive. [Count M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

Upon the Material Indications *of the* Coexistence *of* Man *with* Elephas meridionalis *in Beds, near* Chartres, *more ancient than the* Quaternary Gravels *of the* Valleys *of the* Somme *and the* Seine. By M. J. Desnoyers.

[Note sur des Indices matériels de la Coexistence de l'Homme avec l'*Elephas meridionalis* dans un terrain des environs de Chartres, plus ancien que les terrains de transport quaternaires des vallées de la Somme et de la Seine; par M. J. Desnoyers. Comptes Rendus des séances de l'Académie des Sciences, vol. lvi., No. 23, pp. 1073–1083. June 8, 1863.]

The researches of Dr. Falconer and M. Lartet have made known that amongst the fossil *Proboscidea* there are at least three perfectly distinct species of *Elephas,* each characterizing a distinct portion of the later tertiary period. A *résumé* of the well-known fauna of each of these stages is first given by M. Desnoyers, and he then enunciates the several kinds of evidence from a consideration of which the coexistence of man with extinct animals may be inferred, namely:—

1. The association of human bones with the bones of extinct *Mammalia.*

2. The occurrence of objects of human industry, principally instruments of stone (*pierre**), in the same beds which contain bones of the large *Mammalia.*

3. The traces of the hand of man upon those bones.

The last kind of evidence the author considers to have a value perhaps superior to that of the other two, because it unites in one specimen the evidence of the action of man with the indication of the coexistent species. Many observers, and especially M. Lartet, have called attention to the occurrence, in caverns, of bones marked in this manner.

In the middle of last April M. Desnoyers examined the sand-beds of Saint-Prest, near Chartres, well known as a remarkable deposit, containing bones of *Elephas meridionalis, Rhinoceros leptorhinus, Hippopotamus major,* several species of Deer, a large Ox, a Horse similar to that of the Val d'Arno, and of other extinct *Mammalia* considered to belong exclusively to the Pliocene period.

After giving a description of the beds of Saint-Prest, and noticing the various memoirs that have been written upon them, as well as the principal collections of the bones obtained therefrom, which he had examined, M. Desnoyers remarks that, in partly disengaging the

* This expression is intended by the author to include only flint implements, and evidently does not refer to implements of *stone* as technically understood.—Ed.

tibia of a *Rhinoceros* from the sand investing it, he was struck with the appearance of striæ, varying in form, depth, and length, which could not have resulted from fracture or from desiccation (the evidences of which were also apparent), because they had evidently been formed prior to that operation, and traversed the bone in the direction of its breadth, passing also over its ridges, and otherwise following its contours. These striæ, or traces of incisions—very sharp, some very fine and very smooth, the others larger and more obtuse, and as if they had been produced by sharp flakes or denticulated pieces of flint—were accompanied by small incisions or elliptical notches, which were clearly defined, as if they had been produced by the blow of a sharp instrument. A great many of these striæ and cavities were covered by ferruginous dendrites and sand, and were also nearly all a little worn, in consequence of the friction and rolling to which the greater number of the bones and teeth had undoubtedly been subjected, before and during their deposition. They immediately recalled to his mind analogous incisions upon the bones of *Mammalia* from the caverns, the gravels, and the peat-bogs, and also from the infinitely more recent deposits in tombs of various ages.

Although perfectly convinced in his own mind of the human origin of these marks, yet, for fear of bringing forward an incomplete statement, he examined all the collections of bones from Saint-Prest, that he could get access to, in company with M. Lartet, by whom the species were determined.

M. Desnoyers then states that the examination of more than one hundred bones, of which several are a metre in length, has convinced him that the notches (the traces of incisions, of excoriation, and of blows), the striæ, whether transverse, rectilinear, sinuous, or elliptical (these being sharper at one end than the other), sometimes polished, sometimes subdivided into several striæ occupying the cavity of the larger indentation,—in a word, that marks altogether analogous to those which are produced by cutting-instruments of flint, with more or less sharp points and more or less jagged edges, are seen on the greater number of these bones. Upon some of them, and particularly upon a portion of the skull of an Elephant belonging to the Muséum d'Histoire Naturelle de Paris, may be perceived traces of arrows, which appear to have glanced upon the osseous material after having traversed the hide and the flesh. A sharp triangular cavity caused by the point, and some lateral notches produced by the denticulations of an arrow of flint or of bone, may also be distinguished. The *Mammalia* the bones of which present these different appearances are—*Elephas meridionalis*, *Rhinoceros leptorhinus*, *Hippopotamus major*, several species of Deer, of which two are of very great size (*Megaceros Carnutorum*, Laugel), a large Ox, and a much smaller species.

All the skulls of Deer which M. Desnoyers has seen appear to have been fractured near the insertion of the two horns, by a violent blow given upon the frontal bone, towards their origin.

After enumerating the various kinds of bones which present the most distinct traces of incisions, and noticing the occasional occurrence of bones which appear to have been split open for the purpose of extracting the marrow, the author remarks that several bones of *Hippopotamus*, especially a metatarsus, are finely furrowed in every direction by very distinct striæ, which he is disposed to refer less to the action of man than to another cause; he then gives his reason for believing them to have been produced by the action of blocks of ice transporting grains of sand. He sums up the result of his observations as follows:—

1. Some fossil bones of several animals (see p. 18), considered as characteristic of the Upper Tertiary rocks or Pliocene, and discovered in an undisturbed deposit of that geological period, bear numerous and incontestable traces of striæ and of gashes.

2. These notches and these striæ are perfectly analogous to those which have been observed upon fossil bones of newer species of *Mammalia*; namely, the extinct species accompanying the *Elephas primigenius*, *Rhinoceros tichorhinus*, *Hyæna spelæa*, &c., and those that are now living, such as the Reindeer, several Deer, and the Aurochs, found in the ossiferous caverns and in the Drift. Similar appearances have also been recognized upon numerous bones of living species collected in Gallic, Gallo-Roman, Breton, and Germanic tombs.

3. The marks upon the most ancient bones appear to have, in great part, the same origin as those of the more modern, and cannot, therefore, be attributed to any other cause than the hand of man.

4. Some other striæ—finer, rectilinear, and crossing one another—are also seen in great number upon the bones from the Pliocene beds of the environs of Chartres, and other localities, and appear to be analogous to those which have been observed upon the pebbles and blocks which have been striated, scratched, and polished by glaciers. The motion due to torrential waters would with difficulty produce a similar result.

5. The beds of Saint-Prest, unanimously recognized as Upper Tertiary, or Pliocene, and certainly as anterior to all the Quaternary deposits which contain *Elephas primigenius*, include numerous bones of *Elephas meridionalis*, and of the greater number of the large *Mammalia* characteristic of the Upper Tertiaries; upon these bones both kinds of notches and striæ may be observed.

6. From these facts it seems possible to conclude, with a very great appearance of probability, until some other more satisfactory explanation better elucidates this double phenomenon, that man lived upon the soil of France before the great and first Glacial period —at the same time as the *Elephas meridionalis* and the other Pliocene species of the Val d'Arno, in Tuscany; and that he was contemporary with these large animals, anterior to the epoch of the *Elephas primigenius* and the other Mammals whose bones have been found mixed with the remains of man in the gravels, or Quaternary beds of the great valleys, and in the caverns.

7. Finally, the beds of Saint-Prest furnish, as yet, the most ancient example in Europe of the coexistence of man with extinct animals.

[H. M. J.]

On the PALÆONTOLOGY *of* NEW ZEALAND. By Dr. ZITTEL.

[Proceed. Imp. Geol. Instit. Vienna, January 20, 1863.]

THE collection of organic remains brought to Vienna by Prof. Hochstetter is the most considerable that has ever been brought to Europe from this remote part of the globe. It is at present under examination by the Vienna palæontologists, who are preparing the results of their investigations for publication in the scientific section of the work on the Voyage of the 'Novara.' Prof. Unger has undertaken the descriptions of the Plants; Chev. F. de Hauer will describe the Jurassic Ammonites and Belemnites; M. Karrer and Dr. Stache have undertaken the *Foraminifera*; Dr. Zittel is preparing descriptions of the *Mollusca* and *Echinodermata* (about fifty to sixty species, among which six still exist); and Prof. Suess will describe the *Brachiopoda*.

The most ancient fossiliferous deposit of New Zealand is a greywacke-like rock, characterized by the extraordinary abundance of two species of *Monotis*. One of these—*Monotis Richmondiana*, Zittel—sometimes constitutes whole strata, and, although greatly resembling the *Monotis salinaria* of our European Trias, differs essentially from it by its more vaulted shape and by its stronger, less numerous, and more distinct ribs. The second species, *Monotis decipiens*, Zittel, is rather similar to *Halobia Lommeli*. Together with these Triassic forms, a species of *Spirigera*, and other fossils, declared by Prof. M'Coy to be Palæozoic, occur in this greywacke. The stratum next in ascending order contains a deeply grooved Belemnite (*Belemnites Aucklandicus*, Hauer) and a new species of Ammonite (*Ammonites Novo-Zelandicus*, Hauer), together with a very characteristic *Aucella* (*Aucella plicata*, Zittel), a *Placunopsis*, and several other bivalves of Jurassic type.

The succeeding deposits, far more abundant in organic remains, and evidently of Tertiary age, may be brought under two palæontologically distinct groups. The first of these groups offers no traces of any living species, although the genera of *Mollusca* and *Echinodermata* met with in it are such as have arrived at their full development in the present period, or did so in the Tertiary epoch. Among these, *Pecten*, *Ostrea*, *Hemipatagus*, *Schizaster*, *Brissus*, and *Nucleolites* are remarkable for their abundance. Taking into consideration the absence of any living forms whatever, we may be justified in correlating this group with the most ancient of our European Tertiaries. The second group, which occurs in a great number of localities on the Southern Island, has a fauna closely allied to that now existing round New Zealand and Australia; some species (a few of which were determined by Mantell and Forbes) are identical with recent ones, and the rest belong to genera peculiar to the present period. This fossil fauna is strongly marked with the characteristic features of the present marine fauna of New Zealand, and even genera of most limited range (as *Struthiolaria*) are represented in it by extinct species. This second group may safely be considered as an equivalent of our European younger Tertiaries.

[COUNT M.]

On the Geology *of* Cyprus. By Prof. Unger.

[Proceed. Imp. Acad. Vienna, February 5, 1863.]

This island exhibits, on a surface of only 173 square miles, two distinct mountain-systems,—the larger occupying the south and south-west portion, and partly rising to a height of 6000 feet above the level of the sea; the other running parallel with the north coast in a lengthened range of steep cliffs. The fundamental rock of both is greenstone, with its varieties, as diorite, gabbro, aphanite, &c., extending into a continuous mass in the south and west of the island, while in the northern chain it occurs only in small subordinate domes. This igneous rock, associated with a small portion of trachyte, is everywhere overlain by sedimentary deposits. In the north chain these are red cliff-limestone and white compact limestone, the latter containing Corals of an Upper Jurassic appearance. The Jurassic strata are overlain by non-fossiliferous, fine-grained sandstone, which may be identified with the Vienna Sandstone (Cretaceous and partly Eocene); it crops out only along the north chain, and disappears in other parts of the island beneath a deposit of Tertiary marls and marly limestones. These Tertiaries sometimes include large layers of gypsum, and are prevalent in the eastern and southern slopes of the main mountain-mass. The most recent deposits are conglomerates and sandstones, filling up the depression between the two mountain-systems and bordering the whole island. Their numerous and well-preserved organic remains denote their Quaternary age, belonging to a time when the geological constitution of the Mediterranean basin was nearly the same as at present. The upheaval by which this marine sediment was raised above the level of the sea and the present physical features were given to the island must have established a land-communication with Syria. This supposition alone may account for the concordance of the Cyprian fauna and flora with those of the neighbouring continent. The communication may have been taken away by the sinking of the isthmus shortly before the beginning of the historical period, in consequence of one of those commotions which in later times, and even in our own days, have converted several places on the island into heaps of ruins.

[Count M.]

Intimate Structure *of* Rocks *and* Minerals. By Dr. Zirkel.

[Proceed. Imp. Acad. Vienna, March 12, 1863.]

The author has submitted to microscopical examination extremely thin laminæ of rocks and minerals. All the varieties of quartz entering into the composition of granites, porphyries, and trachytes show innumerable cavities containing liquids; some of them are so small that, even under a magnifying power of 2000*, they appear only as minute points. These varieties of quartz, and the felspar associated with them, include particles of matter, fused by igneous action, which

* This measurement is probably superficial, in which case it would be equal to about 45 diameters.

have been incorporated during the gradual increase of the crystals, and which have become solidified into vitreous or lithoid cavities or pores*. During refrigeration small acicular crystals of a black substance have been deposited within the vitreous cavities, which, like the water-cavities, generally include a vesicle. Transitions between vitreous and lithoid cavities occur frequently, and in great variety, together with empty cavities resulting from the development of gaseous substances. The whole of these structures, only visible by the aid of the microscope, may throw some light on the origin of the rocks in question, being indicative of the simultaneous action of water and vapours and of the igneous fusion of solid substances. In nearly all varieties of granite the quartz includes myriads of crystals of vitreous felspar, irregularly spread in every direction. A polarizing apparatus connected with the microscope proves the small quartz-granules of the granites to be a combination of minute crystals. The fundamental mass of the euritic porphyries, showing three distinct types, has proved to be really (as it has been generally supposed to be) an intimate mixture of quartz and felspar; the quartz in many of them, however, is more prevalent than geologists generally are ready to admit. The basalts, appearing to the naked eye merely as a homogeneous mass, exhibit, under the microscope, their various constituents, and, by examining a great number of varieties, the progress of decomposition, so interesting in these rocks, may be followed through all its stages. The pitchstones, generally admitted to be composed of an amorphous vitreous substance, have proved to consist of a confused aggregate of innumerable acicular crystals, imbedded in a comparatively small proportion of vitreous matrix, the nature of which is still doubtful. Obsidians, cautiously heated with hydrofluoric acid, exhibit microscopical acicular crystals, which may be also seen, as shown by the late Prof. Leydolt, in artificial glass when acted upon by the same acid. [Count M.]

On the Cretaceous Strata *of the* Circles *of* Königgratz *and* Chrudim (S.E. Bohemia). By C. H. M. Paul.

[Proceed. Imp. Geol. Instit. Vienna, January 20, 1863.]

These strata have been shown by Professor Reuss to rest on the Gault, and consequently they represent M. d'Orbigny's "Cenomanien" and "Turonien."

Their subdivisions are, in descending order:—1. Pläner; 2. Quader Marl; 3. Quader Sandstone; 4. Quader Conglomerate.

The Pläner (1) consists of thinly laminated, argillaceous (locally calcareous) marls, with *Inoceramus Cuvieri* and *I. planus* (both abundant); also *Micraster cor-anguinum*, *Pecten membranaceous*, *Nucula pectinata*, *Terebratulina chrysalis*, and *Tellina tenuissima*. The Quader Marl (2) may be further subdivided into (*a*) an inferior,

* Synonymous with the "stone-cavities" of Sorby; see Quart. Journ. Geol. Soc. vol. xiv. p. 466.—Edit.

argillaceous, thinly laminated portion, much resembling Pläner, with but few fossils, locally containing the chelæ of *Callianassa Faujasi* in abundance; (*b*) calcareous fossiliferous strata (Beyrich's Planer-sandstone); and (*c*) an upper portion, thicker, highly arenaceous, and fossiliferous. *Inoceramus Cuvieri, I. mytiloides*, and *Lima multicostata* occur abundantly; next to them come *Inoceramus Brongniarti, Leguminaria trunculata, Ostrea vesicularis, Janira quinquecostata, Pecten lævis, Arca glabra, Hippurites ellipticus, Hamites rotundus, H. plicatilis, Hemiaster bufo*, and *Micraster coranguinum*. The Quader Sandstone (3) may be subdivided, upon the same principle as the Marl, into an upper, highly glauconitic portion (Green-sandstone), and an inferior white portion without any trace of carbonate of lime, with intercalations of shales from five to ten feet thick, and containing a thin seam of coal. The Conglomerate (4), which is entirely composed of rolled fragments of quartz, without any trace of organic remains, is here, as everywhere within the Cretaceous districts of Bohemia, the lowermost deposit of this formation.

[Count M.]

A Comparison *of the* Strata *of the* Italian *and* French Slopes *of the* Alps. By M. Gabriel de Mortillet.

[Terrains du versant italien des Alps comparés à ceux du versant français; par M. Gabriel de Mortillet. Bulletin de la Société Géologique de France, vol. xix. 1862, pp. 849–907.]

The central axis of the Alps consists of a series of channels which have been formed by crystalline rocks. The fossiliferous rocks, to adopt the expression of M. Elie de Beaumont, lie around them like the edges of vast button-holes. It may, therefore, be presumed that the sedimentary rocks are the same on both sides, though hitherto this has been denied.

It would follow from this that the upheaval of the Alps is more ancient than is generally admitted; that it was effected during successive epochs, and was accompanied by oscillations of level. The sediments on the two slopes have thus been deposited independently of each other; nevertheless they have a general correspondence.

Although, as a whole, the crystalline rocks form the axis of the chain, yet, on the Italian side, they are prolonged to its extreme boundary; and in Piedmont they rise immediately from the plain, constituting the advanced guards of the mountains.

Silurian and Devonian rocks have as yet been recognized only towards the extreme north-east of the Austrian Alps. M. de Mortillet notices, in connexion with them, Sir R. Murchison's views respecting the probable metamorphism of strata of this age, and concludes that, at this epoch, the axis of the Alps consisted of a protuberance almost wholly above the waters.

Carboniferous rocks have been detected in the eastern portions of the district; they are of marine origin, and contain traces of fossil Plants. The anthracite-deposits thin off towards the Alps of Savoy and Dauphiny.

The Trias is well developed on both sides of the chain, as at Hallstatt on the north and St. Cassian on the south. M. Mortillet gives for this, as for each formation, lists of the fossils from various localities, and institutes a comparison of them. During this epoch the land continued raised above the sea, but volcanic eruptions occurred on a large scale.

Lower Lias has been shown to exist in Lombardy on one side and in Dauphiny on the other. The Middle and Upper Lias are largely developed on the French side, and are found on the Italian slope also. During the deposition, the eastern portion of the chain was raised and the western depressed. The succession of the Jurassic rocks shows that the upheaval of the Alps was a slow, continuous movement, with local oscillations. Sections of the Cretaceous rocks are given, from which it is deduced that in Italy there is an unbroken succession from the Oxfordian into the Neocomian; whence the writer concludes, that whilst in some parts of the earth there existed modifying causes producing intermediate deposits, in other parts free from disturbing causes the same fauna may have continued to exist. The Eocene deposits south of the Alps are eminently littoral; and they are found northwards in the High Alps in a continuous line; here, also, they contain evidence of littoral conditions, and are analogous to similar beds on the south side.

Miocene beds are extensively developed in Venetia, but not in the French or Swiss Alps, save in the Molasse of the plains, of which the upper beds are Pliocene.

The Quaternary deposits are divisible into ancient alluvium, glacial deposits, and modern alluvium. Under the first division may be placed the frequently occurring débris of ancient lakes; upon this rest the striated boulders of the second period, as M. de Mortillet has shown in his map of the old Italian glaciers: under the head of "recent alluvium" are placed all the deposits formed subsequently to the retreat of the glaciers, some of which contain the remains of extinct Mammals. The author maintains that there has been but one Glacial period, in opposition to the views of M. Scipio Gras and M. Morlot, who have propounded the theory of the existence of two.

The conclusions to which the author has arrived are expressed in a table of correlations, which shows that the upheaval of the Alps, effected during the Palæozoic period, was succeeded by a submergence during the Liassic; and since that time the central portion has been raised by a series of oscillatory movements extending through all subsequent periods to the close of the Miocene, when the chain attained its maximum height. There has been an intermixture of the faunas on the Italian side, not only of formations immediately succeeding one another, as of the Cretaceous and Eocene strata, but also of others, such as the Oxfordian and the Neocomian.

[S. R. P.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Coal-formation *between* Prague *and* Pilsen.
By Herr R. Ludwig.

[Die Steinkohlenformation zwischen Prag und Pilsen: von Herrn R. Ludwig. Notizblatt des Vereins für Erdkunde, &c., zu Darmstadt. Folge iii. Heft 1. Nos. 7, 9, 11, 12. 1862.]

The productive Coal-formation of Bohemia is underlain either by Silurian and metamorphosed slates or by granite and crystalline quartzose rocks; but other marine deposits are altogether wanting, whether of Devonian, Carboniferous, Permian, Triassic, or Liassic age. In fact, from the Silurian Period to the Cretaceous, the district was a continent free from the presence of the sea.

In consequence of the productive coal-beds between Prague and Pilsen reposing neither upon Devonian rocks nor upon marine beds of the Carboniferous formation, but upon much more ancient rocks, and because they are not covered by well-marked Rothliegende, neither by Zechstein, Trias, nor Jurassic rocks, it is impossible to determine their age with the same certainty as that of other Coal-formations, such as those of Zwickau and Westphalia. It only remains, therefore, to endeavour to determine the age of the coal-beds from a comparison of their fossils with those of other localities. Fortunately the Bohemian beds are extremely rich in Plant-remains in a good state of preservation.

The Coal-formation occupies a broad band extending from Staab, across Pilsen, to Kralup beyond Prague, 14 German miles in length, from 1 to 2 in breadth, and which may be divided into three large basins: namely, that extending from Staab to Plass, and which the author terms the Basin of Pilsen; that extending from Kralowiz to Lana, or the Basin of Rakonitz; and that commencing at Schlan and extending beyond Kladno, to Kralup, which Herr Ludwig calls the Basin of Buschtiehrad.

Each of these basins is composed of a greater or smaller number of unconnected troughs, and the whole band is bounded on the north and south by several outlying basins. The author then gives a general sketch of their physical features, and he afterwards remarks that in some of the larger basins there is an upper or younger coal-formation, separated from the lower one by very thick beds of conglomerate and sandstone, and which Reuss, in his Memoir on the geological relations of the Basin of Rakonitz, referred to the Rothliegende.

The individual troughs of one and the same basin possess, as Herr von Ettingshausen has proved in his Memoir upon the Basin of Radnitz*, different floras—a circumstance which enables one to conclude either that they were formed in succession or that the coal-beds were produced under varying conditions (as high-level or as low-level bog-formations), and that the greater or less humidity has exercised an influence upon the flora.

The basins and troughs lie upon very various kinds of rock: the basin of Harr is in gneiss, that of Merklin lies upon granite and crystalline schist, and that of Pilsen rests upon the same descriptions of rock in the south-west portion, and upon Silurian rocks in the north-east; upon the last-named formation repose also the other basins. The author believes that from the absence of all contemporaneous marine formations, and even from the facts already mentioned, it may be concluded that the Bohemian coal-deposits have been formed in bogs and lakes in the midst of a somewhat extended continent (or an island), which met the sea in the region of the county of Glatz (Silesia), where the Carboniferous Limestone now occurs, containing *Productus latissimus*, &c. This long series of bogs was perhaps in connexion with those of Trautenau, Waldenburg, and other places in the district of Glatz; but the Upper Silesian and the Moravian basins lay upon the other side of the sea-gulf. The variation in the flora of the individual basins may perhaps be explained by the difference in situation: the Sigillaria- and Stigmaria-bogs were perhaps on a high level, while those rich in Ferns but poor in coal were on a low level, and those which contain *Stigmaria* in the lower beds and many Ferns and *Calamites* in the upper were probably high-level bogs which became changed to low-level bogs through oscillations of level.

Herr Ludwig then describes the basins and troughs in the following order:—

1. Basin of Pilsen.
   a. Trough of Wilkischen.
   b. Trough of Nürschan.
2. Basin of Radnitz.
3. Basin of Horschowitz.
4. Basin of Miröschau.
5. Basin of Merklin.
6. Basin of Wranowa, near Mies.
7. Basin of Steindörfel, near Manetin.
8. Basin of Rakonitz.
   a. Coal-beds in the lower portion of the Carboniferous formation.
   b. Coal-beds in the upper portion of the Carboniferous formation.
   c. Coal-beds in the Rothliegende.
9. Basin of Klein-Prschilep.
10. Basin of Stradonitz.
11. Basin of Buschtiehrad.

In the beds below the coal-seams in the Wilkischen and Nürschan districts (Basin of Pilsen) occur the *Stigmaria ficoides*, and thick, long roots, which perhaps belong to *Calamites*, both very abundant. In the beds above the coal-seams occur:—

Sigillaria elegans, *Brongn.*
—— ornata, *Brongn.*
—— alveolaris, *Brongn.*
Lepidodendron dichotomum, *Sternb.*
Lepidodendron rimosum, *Sternb.*
—— undulatum, *Sternb.*
Calamites equisetiformis, *Sternb.*
—— communis, *Ettingsh.*

No Ferns have yet been found in these districts.

To the north of Pilsen the flora consists of *Sigillariæ*, *Lepidodendra*, and *Calamites*, and some species of *Neuropteris* are said to be abundant here. From the trough of Plass (Babina), Herr von Ettings-

* Abhandl. der k. k. geol. Reichsanstalt. vol. ii. 1855.

hausen mentions, in his work already quoted, *Neuropteris obovata*, Sternb., and *N. rubescens*, Sternb.

Herr Corda, Graf Sternberg, and Herr von Ettingshausen have investigated the flora of the Radnitz Basin, from which about 138 species have been determined by them; of these, 82, or 60 per cent., are peculiar, while the remaining 56, or 40 per cent., occur also in other districts. Four species are found also in Devonian rocks, and two in the Rothliegende.

In the Miröschau Basin Herr von Ettingshausen has found *Neuropteris acutifolia*, Brongn., and *N. obovata*, Sternb.; and in the Basin of Merklin *Alethopteris Sternbergi*, Brongn.

Northward from Senetz, near Lubna, in the Rakonitz Basin, and probably in the lower portion of the Carboniferous formation, Herr Stur has found *Calamites communis*, Ettingsh., *Sphenopteris rutæfolia*, Gutb., *Stigmaria ficoides*, Brongn., *Flabellaria Sternbergi*, Ettingsh., and *Nœggerathia foliosa*, Sternb.; but the author remarks that these few remains are scarcely sufficient to determine the age of the beds from which they were obtained.

The upper part of the Coal-formation in the Rakonitz Basin is seldom coal-bearing; but at the Belschanka, near the Rischlaw mill, there is a bed of coal 3 feet thick, the roof of which is composed of white and yellow shale containing many Fern-remains, as *Neuropteris acutifolia*, Brongn., *Cyclopteris rhomboidea*, Ettingsh., *Sphenopteris Haidingeri*, Ettingsh., *Asplenites elegans*, Ettingsh., *Asplenites Reussi*, Ettingsh. *Lepidodendra* and *Calamites* are comparatively rare; but *Nœggerathia foliosa*, Sternb., is somewhat abundant.

Nearer Rakonitz are two coal-beds, the beds above which are rich in *Lepidodendron obovatum*, Sternb., *L. dichotomum*, Sternb., and *Sigillaria elongata*, Brongn. The shale above the upper coal-seam contains likewise *Nœggerathia foliosa*, *Asplenites elegans*, *A. Reussi*, and *Cyclopteris rhomboidea*.

The beds in the Rothliegende contain no Plants; sometimes, however, pyritized Wood is found, or brandschiefer with Fish-remains, —namely, teeth of *Diplodus*, sp., *Xenacanthus Decheni*, Beyr., and *Pygopteris*, sp.; scales and fins of *Acanthodes gracilis*, F. Römer; and head-bones and other remains of *Palæoniscus*. All the coal-beds have brandschiefer above them.

The author gives the following summary of the characters of the Basin of Rakonitz:—

1. This basin is similar to those of Pilsen and Radnitz in being divided into several coal-bearing troughs, separated by barren ridges.

2. These small troughs are richest in coal in the southern and south-western portions of the basin, while those in the eastern can scarcely be described as coal-bearing.

3. The lower portion of the Coal-formation contains the thicker beds; in them *Sigillaria*, *Lepidodendron*, and *Calamites* predominate.

4. The upper portion of the formation includes coal-beds in which are *Nœggerathia* and Ferns similar to those from Stradonitz, and equally abundant.

5. In the Carboniferous formation in the northern portion of the

basin there are only a few, thin coal-seams; but, on the other hand, the thickly developed Rothliegende here contains some productive coal-beds. It is to be hoped that the Rothliegende in this portion of the basin, where it dips beneath the Cretaceous beds, will be still further worked for coal.

The Basin of Stradonitz, which is situated about two German miles south of the south-eastern border of the Rakonitz Basin, in the neighbourhood of Beraun, contains, so far as is known at present, no coal-beds. The fossil Plants occurring in the sandstone and shale have been described by Herr von Ettingshausen; they are the following:—

Chondrites Gœppertianus, *Ettingsh.* (perhaps the root of a land-plant).
Calamites Volkmanni, *Ettingsh.*
Sphenophyllum Schlotheimi, *Brongn.*
Annularia longifolia, *Brongn.*
Neuropteris gigantea, *Sternb.*
—— Loshii, *Brongn.*
—— coriacea, *Ettingsh.*
—— squarrosa, *Ettingsh.* (=Dictyopteris Brongniarti, *Gutb.*).
Cyclopteris tenera, *Ettingsh.*
—— rhomboidea, *Ettingsh.*
Sphenopteris Haidingeri, *Ettingsh.*
—— intermedia, *Ettingsh.*
—— trifoliata, *Brongn.*
Asplenites elegans, *Ettingsh.*
—— Reussi, *Ettingsh.*
Cardiocarpum orbiculare, *Ettingsh.*
Cordaites borassifolia, *Unger.*
Palmacites caryotoides, *Sternb.*

It is remarkable that this basin contains especially the remains of Ferns, some of which correspond with those found in the upper beds of Rakonitz. It is certain that those fossils are not found at any other locality in Bohemia, and are unknown from other coal-fields.

From Kladno, in the Basin of Buschtiehrad, the author obtained the following plants:—

Calamites communis, *Ettingsh.*
—— tenuifolius, *Ettingsh.*
Sphenophyllum Schlotheimi, *Brongn.*
Neuropteris acutifolia, *Brongn.*
—— rubescens, *Sternb.*
—— obovata, *Sternb.*
Sphenopteris meifolia, *Sternb.*
—— acutifolia, *Brongn.*
—— tenuissima, *Sternb.*
—— obtusiloba, *Brongn.*
—— elegans, *Brongn.*
—— rutæfolia, *Gutb.*
Cordaites borassifolia, *Unger.*
Asplenites Sternbergi, *Ettingsh.*
—— lindsæoides, *Ettingsh.*
Cyatheites oreopteroides, *Goepp.*
Cyatheites undulatus, *Goepp.*
—— setosus, *Ettingsh.*
Pecopteris pennæformis, *Brongn.*
—— Glockerana, *Goepp.*
Lepidodendron dichotomum, *Sternb.*
—— aculeatum, *Sternb.*
—— Sternbergi, *Lindl.*
—— brevifolium, *Ettingsh.*
—— plumarium, *Lindl.*
—— Haidingeri, *Ettingsh.*
—— crassifolium, *Ettingsh.*
Sigillaria elongata, *Brongn.*
—— rhomboidea, *Gein.*
—— mammillaris, *Brongn.*
Stigmaria ficoides, *Brongn.*
Araucaria Cordai, *Sternb.*

According to Herr Stur, the following species also occur:—

Cyatheites arborescens, *Goepp.*
—— Miltoni, *Goepp.*
Pecopteris Silesiaca, *Goepp.*

The flora of this basin corresponds in general with that of the Basin of Radnitz. Some short lists of Plants found at other localities in the Basin of Buschtiehrad are then given; the most important of these lists are the following, of Plants occurring in the roofs of two coal-beds worked in the Rappiz (Hrapic) district, and near Buschtiehrad, as well as near Wotowitz and Koletz.

From above the lower coal-bed (10 feet* thick), according to Stur, were obtained:—

Calamites communis, *Ettingsh.*
Annularia fertilis, *Sternb.*
Asterophyllites charæformis, *Sternb.* (=Calamites tenuifolius, *Ettingsh.*).
Schizopteris Gutbierana, *Presl.*
Dictyopteris Brongniarti, *Gutb.* (=Neuropteris squarrosa, *Ett.*).
Asplenites Sternbergi, *Ettingsh.*
—— cristatus, *Gutb.*
Cyatheites oreopteroides, *Goepp.*
Cyatheites Miltoni, *Goepp.*
—— arborescens, *Goepp.*
Pecopteris Silesiaca, *Goepp.*
Lepidodendron Haidingeri, *Ettingsh.*
—— plumarium, *Lindl.*
Cardiocarpon emarginatum, *Goepp.*
Stigmaria ficoides, *Brongn.*
Cordaites borassifolia, *Unger.*
Flabellaria Sternbergi, *Ettingsh.*
Sigillaria mammillaris, *Brongn.*

From above the upper coal-bed (20 feet* thick) Herr Stur obtained:—

Calamites communis, *Ettingsh.*
Sphenophyllum emarginatum.
Alethopteris pteroides, *Brongn.*
Sphenopteris tenuissima, *Sternb.*
Cyatheites orepteroides, *Goepp.*
—— Miltoni, *Goepp.*
Cordaites borassifolia, *Unger.*

Herr Ludwig concludes with the following summary of results:—

1. The Bohemian coal-beds have not been formed of drifted Wood or floated Plants, but of Plants which grew in the localities where the coal is now found, partly in high-level and partly in low-level bogs.

2. The formation of coal was faster and more continuous in the southern portion of the coal-field than in the northern,—probably because the former afforded more favourable situations for the growth of *Sigillaria, Stigmaria*, and *Calamites*, while the northern district was a more suitable locality for the growth of Ferns.

3. In all the basins the coal occurs in shallow unconnected troughs.

4. The coal-formation consists of two divisions. The greater number of troughs belong to the lower, which is also the richest in coal. To the upper division belong the beds of Stradonitz and some seams near Rakonitz.

5. Above the Carboniferous formation are beds belonging to the Rothliegende, and which contain coal in the Basin of Rakonitz. In the Basin of Pilsen the red clay [Letten] and sandstone occurring between Pilsen and Nürschan belong to this formation, as also in all probability do the greater part of the sandstones and conglomerates of the Basin of Buschtiehrad.

6. Like the Rothliegende, the coal-beds of Bohemia are terrestrial [Festland] and freshwater formations.

7. The flora of the Bohemian coal-beds proves that they were formed almost contemporaneously with those of the remaining German coal-fields. The Bohemian beds have, it is true, only about 40 per cent. of Plants in common with other German coal-fields, the remaining 60 per cent. being peculiar to them; and it should also be mentioned that, as Herr Stur observes, the occurrence of *Knorria imbricata*, Sternb., and *Sagenaria Veltheimiana*, Sternb., renders it probable that the formation of the coal-beds in Bohemia began earlier, and, as it extended into the Rothliegende, ended later than in most other German coal-fields. [H. M. J.]

* German feet.

On some Fossils *from* Guadaloupe. By M. Payen.

[Sur divers fossiles trouvés aux Environs de la Basse-Terre (Guadeloupe). Par M. Payen. Bulletin de la Société Géologique de France. Deuxième Série, Juillet 1863, vol. xx. p. 475.]

The fossils which are described in this paper were obtained from two localities in the neighbourhood of the Basse-Terre, close to the Old Fort, Guadaloupe. They belong to the genera *Pecten*, *Terebratula*, *Cypræa*, *Spatangus*, and *Echinus*, and were imbedded in a white or greyish-white limestone, having the appearance of chalk. One locality is about 50 yards from the shore, and about 40 yards above the level of the sea. The bed which contains the fossils appears to have been deposited against the flank of a mountain, which is composed of volcanic tufa. The other locality, which is about 100 yards from the former, is 200 yards from the sea, and has an altitude of about 100 yards above high water. It forms the summit of a conical hill; and the stone, which is burned for its lime, lies in horizontal beds on the volcanic formation.

M. Deshayes considers the fossils to have belonged to the Quaternary period, and the two fossiliferous beds to have been elevated contemporaneously with the formation of the existing contours of the Island of Guadaloupe. The *Terebratula*, however, is considered to belong to a new species. No recent *Terebratulæ* have yet been found on the shores of Guadaloupe, and M. Schram, who is well acquainted with the Natural History of the region, denies their existence in the West Indian seas. He notices, however, the *Orbicula Antillarum*, D'Orbigny, as having been found living on the reefs. M. Charles Sainte-Claire Deville had previously noted the existence of the calcareous stratum in 1842. [P. M. D.]

On the Geology *of* Dalmatia. By Fr. Ritter von Hauer, Dr. Stache, and Dr. Zittel.

[Proceed. Imp. Geol. Instit. Vienna, March 3, 1863.]

Barren and denuded ranges of limestone of Cretaceous or Eocene origin, running parallel to the coast, with abrupt slopes towards longitudinal or transverse valleys, or towards the coast of the Adriatic, impress this country with a peculiar feature. Some strata of Eocene Carpathian sandstones, intercalated between the undulating beds of more ancient limestones, and some freshwater basins (as those of Siverich and of Sign, with Lignite-beds and abundant Mollusca), are met with in some localities. The Eocene series (in descending order) consists of (1) sandstones and conglomerates, (2) Nummulitic Limestone, (3) Borelis limestone, and (4) freshwater (Casina) strata. They form a broad continuous band in the interior of the country, between the River Kerka and the Mane de Novigrad, giving off some branches southward, and gradually thinning towards the Cretaceous deposits. Three Eocene ranges may be traced through Southern Dalmatia,—one running from Spalato along the coast, over the mouths of the Narenta, Ragusa, and Bocca di Cattano (with increasing breadth) to Budua; another from Xernovizza (E. of Spalato), over Vergoraz, to the banks of the Narenta; and a third through the Isle of Lerina and on the south side of the Peninsula of Sabioncello. The Cretaceous rocks, here and there interrupted by Eocene, and *vice versâ*, prevail along the coast; and on the islands their upper strata are characterized by *Caprotinæ*, and their lower beds by *Radiolites* and *Hippurites*. Old Carpathian or Vienna Sandstones (probably equivalent to the Upper and Middle fossiliferous Cretaceous strata) are totally wanting in Dalmatia. Jurassic, Triassic, and eruptive rocks are confined to some few isolated and very restricted localities. [COUNT M.]

On EOCENE FOSSILS *from* ISTRIA. By DR. STACHE.

[Proceed. Imp. Geol. Instit. Vienna, March 3, 1863.]

THESE organic remains were found in a Nummulitic Limestone of Middle Eocene age, equivalent to the "Calcaire grossier" of the Paris tertiaries. Their special locality is the Colle Canis, near Pisino, where they occur in a marly conglomerate, immediately above a very thin seam of inferior Nummulitic Limestone resting on Cretaceous limestone. Among them are *Cancer punctulatus*, Desm., *Nautilus lingulatus* (not known before from the Istrian Eocenes), *Nautilus umbilicaris*, Desh., *Pleurotomaria Deshaysii*, Lam., *Voluta crenulata*, Lam., *Cassidaria carinata*, Lam., *Scalaria crispa*, Lam., *Corbula exarata*, Lam., *Neæra Pisinensis* (a new species of a genus but scarcely represented in the Paris Eocenes), *Nummulites distans*, Desh., and *Nummulites Dufrenoyi*, D'Arch. & Haime, with undetermined species of the genera *Carcharias*, *Oxyrhina*, *Voluta*, *Xenophora*, *Teredo*, *Cardium*, *Trochocyathus*, and *Micraster*.

[COUNT M.]

On some recently discovered MAMMALIAN REMAINS. By PROF. SUESS.

[Proceed. Imp. Geol. Instit. Vienna, March 2, 1863.]

A WELL-PRESERVED, although strongly compressed, skull of *Hyotherium Meissneri*, a Porcine Pachyderm, has lately been found at 90 fathoms' depth, in the brown coal of Hart, near Gloggritz (south of Vienna). The incisor, canine, and molar teeth of both jaws are distinctly perceivable. These remains prove the brown coal of Hart to be coeval (as are also the brown coals of Tauling and Schauerleithen) with the Marine Neogene deposits of the Vienna Basin. A fine and uncommonly large canine tooth of *Anthracotherium magnum* has been found in the coal of Lukawitz (N.W. Bohemia). This fossil, together with the vegetable remains found there by the late Mr. Jokely, prove this coal to belong to the Oligocene period, and consequently to be coeval with those of Solzka in Carniola, Zovencedo in Venetia, and Monte Promina in Dalmatia.

[COUNT M.]

On the Occurrence *of the* Nummulitic Formation *in* Japan *and the* Philippines. By Ferdinand von Richthofen.

[Ueber das Vorkommen von Nummulitenformation auf Japan und den Philippinen; von Ferdinand Freiherr von Richthofen. Zeitschrift der Deutschen geologischen Gesellschaft. Band xiv. Heft 2. Februar—April 1862, p. 357.]

The Nummulitic formation has hitherto been known to extend eastwards only so far as British India, and southwards scarcely so far as the Tropic of Cancer. In Java it has not been found; for it appears that in this island the *Orbitolites*, which occur very abundantly in Trachyte-tuff, have been mistaken for *Nummulites*. The mining engineers of the Dutch East Indies mention the presence of Nummulitic rocks in the southern part of Borneo, where they are said to contain coal. It is possible, however, that these beds are a repetition of the Orbitolite-containing strata of Java. The author was therefore all the more interested in finding, in September 1860, evidence of the Nummulitic formation in Eastern Japan, and consequently about fifty degrees further eastward than it was known before to occur. In May 1861 he also discovered the formation in Luzon, near the fourteenth degree of north latitude.

In the stone-polishing establishments at Yokohama, near Yeddo, the author purchased small boxes and pebbles, consisting of a blackish marly limestone, containing abundance of *Nummulites*; he was informed that the stone was obtained from a mountain lying eastward from Yeddo,—probably in the Principalities of Simosa and Kadsusa, and that it occurred in very large masses. These few pieces are sufficient to prove the occurrence in Japan of the Nummulitic formation; and of it they are at present the only evidence.

In Luzon, on the contrary, the Nummulitic formation appears to be very widely distributed, and is an important element in the constitution of the island. The author then describes the distribution of the limestone in the neighbourhood of the well-known limestone-quarry near Manila, called the Caeva de San Matteo; he remarks that fossils have often been searched for in this limestone, but that, as none had been found, it was supposed to be at least of Jurassic age; he was so fortunate, however, as to search in a quarry where *Nummulites* occurred in it in abundance, together with a few obscure Oysters. The *Nummulites* are of various sizes, and belong to several species.

Herr von Richthofen also found the same Eocene formation on the south coast of the Island of Mindarao, where it possesses, however a more varied lithological character—consisting of limestone, sandstone with Plant-remains, shale, and marl. He concludes by remarking on the improbability of the Nummulitic Limestone of Nippon and Luzon being isolated patches, and infers that the limits of the old Nummulitic sea must be extended from the Himalaya Mountains through China to Japan, and also so as to include the remaining Philippine Islands. [H. M. J.]

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TO THE

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