THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

VOLUME THE FOURTH.

1848.

PART THE FIRST.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:

LONGMAN, BROWN, GREEN, AND LONGMANS.

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NEW YORK:—WILEY AND PUTNAM, 161 BROADWAY.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCXLVIII.

List

OF THE

OFFICERS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

ELECTED FEBRUARY 1848.

President.

Sir Henry T. De la Beche, F.R.S. & L.S.

Vice-Presidents.

G. B. Greenough, Esq. F.R.S. & L.S.
Leonard Horner, Esq. F.R.S. L. & E.
Sir Charles Lyell, F.R.S. & L.S.
G. A. Mantell, LL.D. F.R.S. & L.S.

Secretaries.

William John Hamilton, Esq. Pres. Geog. Soc.
John Carrick Moore, Esq. M.A.

Foreign Secretary.

C. J. F. Bunbury, Esq. F.L.S.

Treasurer.

John Lewis Prevost, Esq.

COUNCIL.

R. A. C. Austen, Esq. B.A.
J. S. Bowerbank, Esq. F.R.S.
E. H. Bunbury, Esq. M.A. M.P.
Charles Darwin, Esq. M.A. F.R.S.
Prof. Daubeny, M.D. F.R.S. & L.S.
Sir P. Grey Egerton, Bart. M.P. F.R.S.
Prof. E. Forbes, F.R.S. & L.S.
Robert Hutton, Esq. M.R.I.A.
John Morris, Esq.
Sir R. I. Murchison, G.C.St.S. F.R.S.& L.S.
Samuel Peace Pratt, Esq. F.R.S. & L.S.
Prof. A. C. Ramsay.
D. Sharpe, Esq. F.L.S.
S. V. Wood, Esq.

Assistant-Secretary.

James Nicol, Esq. F.R.S.E.

TABLE OF CONTENTS.

LIST OF THE FOSSILS FIGURED AND DESCRIBED IN THIS VOLUME.

[In this list those fossils, the names of which are printed in Roman type, have been previously described.]

EXPLANATION OF THE PLATES.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 18, 1848.

REPORT OF THE COUNCIL.

The Council of the Geological Society of London have once more the satisfaction of commencing their Annual Report with the statement that there has been an increase in the number of its Members during the past year.

The number of new Fellows elected during the year 1847, who have paid their admission-fees, has been 17, besides 3 elected in former years, whose admission-fees had not been previously paid, making, with the addition of two Foreign Members, an increase of 22 new Members; one non-resident Member, whose name was erroneously erased as deceased in 1838, being restored, will raise the increase to 23. On the other hand, there have been during the same period 9 deaths, including 2 foreigners, 8 resignations and 3 removals, making a decrease of 20 to be deducted from 23, leaving a total increase of 3 in the number of the Society during the past year, and raising it from 894 to 897.

The excess of expenditure over income during the past year has been £41 19*s*. 2*d*. This deficiency has been occasioned by the necessity of throwing off the remaining lithographic illustrations of the Transactions, an expense amounting to £55 17*s*., not calculated on in preparing the estimates, and which will not recur.

The number of living compounders at the close of 1846 was 128; it has been increased during the past year to 130, one compounder having died and three Fellows having compounded during that period. Two of these compositions, with one received in 1846 too late to be invested during that year, have been funded during the past year. The total amount received from these 130 compounders is £4095. The estimated value of the funded property at the close of 1846 was £3150 5*s*. 6*d*. At the close of 1847, in consequence of the fall of Consols from 94 to 86, it was, notwithstanding the investment of compositions, reduced to £2970 4*s*.; the amount of Consols held by the Society being £3453 14*s*. 7*d*.

The Council have the satisfaction of announcing to the Society that the appointment of Mr. James Nicol as Assistant Secretary and Librarian has been confirmed by a General Meeting of the Society; and they cannot but congratulate the Society on having secured the services of a gentleman under whose auspices the editing of the Journal has been so prosperous and satisfactory.

They have also to announce that they have resolved that, in the present state of the Finances of the Society, the expense incurred in the care of the Museum shall not exceed the sum of £50 for the present year. They regret that in consequence of the adoption of this arrangement, it is no longer possible to retain the services of Mr. J. de Carle Sowerby; and they are unwilling to take leave of that gentleman without availing themselves of this opportunity of expressing their high sense of his merits, and of the attention and assiduity with which he has performed the duties assigned to him by the Council.

The Council have to announce the completion of the third volume of the Quarterly Journal of the Geological Society, and the publication of the first part of Vol. IV., the Council having resolved that the publication of the Journal shall be continued on the same plan and conditions as heretofore; and they consider it their duty to point out the advantages which will accrue to the funds of the Society, and to the diffusion of geological information, by an increased number of subscribers.

In conclusion, they have to announce that they have awarded the Wollaston Palladium Medal for the present year to William Buckland, D.D., the Very Reverend the Dean of Westminster, for the valuable services rendered by him to Geology by his researches in the field, communicated to the world in many important papers and treatises, and in his public lectures in the University of Oxford, and also for the energy and zeal he displayed as one of the earliest Members of this Society, thereby contributing largely to increase its usefulness in the cause we are united to promote; and that they have resolved that the balance of the proceeds of the Donation Fund for the present year be appropriated to making available to science the fossils which were received from the Cape of Good Hope in 1844 from Mr. Geddes Bain, and which are now in the vaults of the Society's house, amongst which the interesting remains of the Dicynodon were discovered, and have been since described by Prof. Owen; and that a Committee, consisting of Prof. Owen, Dr. Mantell and Mr. Bowerbank, be appointed to carry out the above-mentioned objects.

The Report of the Museum and Library Committee will be given in No. 15 *of the Journal of the Society.*

Comparative Statement of the Number of the Society at the close of the years 1846 *and* 1847.

		Dec. 31, 1846.		Dec. 31, 1847.
Compounders		128		130
Residents		253		248
Non-residents		439		445
		820		823
Honorary Members	20		20	
Foreign Members	50		50	
Personages of Royal Blood	4—74		4—74	
		894		897

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1846 *and* 1847.

Number of Compounders, Residents and Non-residents, December 31, 1846			820
Add, Fellows elected during former years, and paid in 1847 — Residents		3	
Fellows elected, and paid, during 1847 — Residents	9		
Non-residents	8		
	—17		
Fellow erased in error as deceased in 1838, Non-resident		1	
		—	21
			841
Deduct, Compounder deceased		1	
Resident ,,		1	
Non-residents ,,		5	
Resigned		8	
Removed		3	
		—	18
Total number of Fellows, 31st Dec. 1847, as above			823
Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1846			74
Add, Foreign Members elected in 1847			2
			76
Deduct, Foreign Members deceased			2
As above			74

Number of Fellows liable to Annual Contribution at the close of 1847, *with the Alterations during the year.*

Number at the close of 1846			253
Add,	Elected in former years, and paid in 1847		3
	Elected and paid in 1847		9
	Non-residents who became Resident		4
			269
Deduct,	Deceased	1	
	Resigned	8	
	Removed	3	
	Compounded	3	
	Became Non-resident	6	
		—	21
		As above	248

DECEASED FELLOWS.

Compounder (1).

Samuel Duckworth, Esq.

Resident (1).

Duke of Northumberland.

Non-residents (5).

James John Adams, Esq.
Major Henry Bullock.
Benjamin W. Johnson, Esq.
J. Chaning Pearce, Esq.
J. Butler Williams, Esq.

Foreign Members (2).

Prof. Alexander Brongniart.
Herr Geo. Gottlieb Pusch

The following Persons were elected Fellows during the year 1847.

January 6th.—Charles Fraser, Esq., Conduit Street.

——— 20th.—William Thomas Collings, Esq., Trinity College, Cambridge.

February 24th.—John Craig, Esq., Glasgow.

April 14th.—Henry F. Hallam, Esq., Wilton Crescent; and Thomas Ottrey Rayner, M.D., Cambridge Heath, Hackney.

May 12th.—R. E. A. Townsend, Esq., Doctors' Commons; James Nicol, Esq., Grafton Street; and William Alexander Provis, Esq., Ellesmere, Salop.

May 26th.—Neill Arnott, M.D., Bedford Square.

June 9th.—John William Kirshaw, Esq., Bennett's Hill, Birmingham.

——16th.—Charles Walker, Esq., Cramfordton, near Dumfries; Sir James Ramsay, Bart., Banff, Forfar; J. Howard Norton, M.D., Shirley, near Southampton; and William Benjamin Carpenter, M.D., Clarence Terrace, Stoke Newington.

November 17th.—Amos Beardsley, Esq., Langley, Heanor, Derbyshire.

December 1st.—George H. Saunders, Esq., Cowley Street, Westminster; J. R. Lingard, Esq., Stockport; Samuel Hughes, Esq., Duke Street, Westminster; Albert Robinson, Esq., Blackheath Park; John F. Bateman, Esq., Manchester; and Richard Meeson, Esq., Grays, Essex.

December 15th.—Thomas Field Gibson, Esq., Walthamstow; and John North, Esq., Gloucester Place.

The following Persons were elected Foreign Members.

May 12th.—M. C. H. Pander, St. Petersburg; and M. le Vicomte D'Archiac, Paris.

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

British Specimens.

Several large Ammonites and other Fossils from Trowbridge; presented by R. M. Mantell, Esq.

Impressions in Sandstone of the Coal formation, from Hemsworth near Sheffield; presented by James Yates, Esq., F.G.S.

Vertebræ of *Otodus appendiculatus* in Chalk, from Dorking; presented by James Hastie, Esq., F.G.S.

Specimens of Teeth from Kent's Cavern; presented by William Long, Esq., F.G.S.

Shells, Bones and Teeth, from alluvial beds and raised beach near Hythe; presented by H. B. Mackeson, Esq., F.G.S.

Specimens of *Spirifer gigantea* and other Shells in Slate, from Tregatta Quarries near Tintagell; presented by H. Mac Lauchlan, Esq., F.G.S.

Series of Fossils from the Oxford Clay in the Ridgway Cutting; presented by C. W. Weston, Esq.

Foreign Specimens.

Collection of Fossil Teeth and Bones from Moreton Bay, Australia; presented by D. Taylor, Esq.

Specimens of Wood from a Submerged Forest, coast of Jersey; presented by James Smith, Esq., F.G.S.

Iron and Copper Ores from the Island of Maseera; presented by the Honourable the East India Company.

Specimens of Recent *Ostrea Virginica*, and of Fossil *Ostrea longirostris*, from the Tagus; presented by W. C. Trevelyan, Esq., F.G.S.

Collection of Rock Specimens from America; presented by Charles Lyell, Esq., F.G.S.

Ferruginous Concretions in Sandstone from Central India; presented by A. H. Cheek, Esq.

Collection of Coal Fossils from Newcastle, New South Wales; presented by the Right Hon. Earl Grey.

Collection of Rock Specimens from Western Australia; presented by Messrs. Gregory.

Coal from Vancouver's Island; presented by Rear-Admiral Beaufort, Hon. Mem. G.S.

Charts and Maps.

The Charts, &c. published by the Admiralty during the years 1846 and 1847; presented by Rear-Admiral Beaufort, by direction of the Lords Commissioners of the Admiralty.

Section XIV. of the Geological Map of Saxony; General Map and Index of Colours.

Geognostische Specialkarte Königreichs Sachsen und der angrenzenden Länder, with Sections and Index, mounted; presented by the Council of Mines of Freyberg.

Topographical Map of Massachusetts, with Geological Map of Massachusetts, by Edward Hitchcock, made by order of the Legislature, mounted on roller; presented by the Government of the State of Massachusetts.

Geological Map of Russia in Europe and the Ural Mountains, by Sir R. I. Murchison, M. E. de Verneuil and Count A. von Keyserling; presented by Sir R. I. Murchison, F.G.S.

Index to the Ordnance Survey of England and Wales, in frame; presented by Mr. James Gardner.

Map of Western India, exhibiting Lines surveyed by the Great Indian Peninsula Railway Company; presented by W. J. Hamilton, Esq., F.G.S.

Carte du Golfe Arabique des petits Géographes Grecs, et Carte Générale de la Mer Égée, par M. A. Rabusson; presented by the Author.

Map and Seven Sections of the Leinster Coal District, by R. Griffith, Jun., 1814; presented by L. Horner, Esq., F.G.S.

Geognostisch-Geographische Karte der Umgebung des Laacher Sees entworfen von C. von Oeynhausen, Berlin, 1847, in 8 sheets; presented by the Author.

Lithographic Print of Dr. Ami Boué, in frame; presented by L. Horner, Esq., F.G.S.

Stratigraphical Section from Atherfield Point to Black-Gang Chine, and Table of the Distribution of the Fossils of the Lower Greensand, by W. H. Fitton, M.D., F.G.S. (2 copies); presented by the Author.

Proof Engraving of Sir H. T. De la Beche, Pres. G.S., by W. Walker, framed and glazed; presented by Mr. Walker.

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

Academy of Sciences of Paris.
Admiralty, The Right Hon. the Lords Commissioners of the.
Agricultural Magazine, The Editor of the.
American Academy of Arts and Sciences.
American Journal, Editors of the.
American Philosophical Society.
Ansted, Prof. D. T., F.G.S.
Athenæum, Editor of the.
Auerbach, M. J.
Austin, Messrs. Thomas.

Babbage, Charles, Esq.
Bain, Geddes, Esq.
Beaufort, Rear-Admiral, Hon. Mem. G.S.
Bellardi, Sig. L.
Berwickshire Naturalists' Club.
Bianconi, Sig. J. Jos.
Binney, E. W., Esq.
Bohn, Mr. H. G.
Boston Society of Natural History.
Botfield, B., Esq.
Boué, A., M.D., For. Mem. G.S.
British Association for the Advancement of Science.
British Government.
British Museum, Trustees of.
Brongniart, Prof. A., For. Mem. G.S.

Catullo, Prof. T. A.
Charlesworth, E., Esq., F.G.S.
Cheek, A. H., Esq.
Chemical Society of London.
Colquhoun, E. Pye, Esq.
Corbaux, Miss F.
Coxworthy, F., Esq.

Da Hemso, Sig. J. G.
Dana, J. D., Esq.
D'Archiac, M. le Vicomte.
Darwin, Charles, Esq., F.G.S.
Daubeny, Prof., M.D., F.G.S.
De Koninck, M. L., M.D.
De la Beche, Sir H. T., Pres. G.S.
Delesse, M. A.
Des Moulins, M. C.
D'Hombres-Firmas, Baron.
Dumont, Prof. A. H., For. M.G.S.

East India Company, Hon.
Élie de Beaumont, M. L., For. Mem. G.S.
Emmons, E., M.D.
Everest, Lieut.-Col., F.G.S.
Ez-querra, Don J.

Falconer, Hugh, M.D., F.G.S.
Fischer de Waldheim, G., M.D., For. Mem. G.S.
Fitton, H., M.D.
Frears, M. H.
Freyberg, School of Mines of.

Gardner, Mr. James.
Geological Society of Dublin.
Geological Society of France.
Gesner, A., M.D.
Gibbes, R. W., M.D.
Göppert, Prof.
Grateloup, Dr.
Gregory, Messrs.
Grey, Right Hon. Earl.

Haidinger, Herr W.
Hamilton, W. J., Esq., Sec. G.S.
Hartmann, Herr C.
Hastie, James, Esq., F.G.S.
Hausmann, Prof. J. F. L., For. Mem. G.S.
Hawkins, T., Esq., F.G.S.
Hopkins, Prof. W., F.G.S.
Horner, L., Esq., F.G.S.
Hume, Rev. A., LL.D.

Imperial Society of Moscow.

Indian Archipelago Journal, Editor of.
Johnston, Prof. J. F. W., F.G.S.
Jukes, J. B., Esq., F.G.S.

Kerigan, T., Esq., R.N.

Leymerie, M. A.
L'École des Mines.
Linnæan Society.
Logan, W. E., Esq., F.G.S.
London Library, Committee of.
Long, Wm., Esq., F.G.S.
Lyell, Charles, Esq., F.G.S.

Mackeson, H. B., Esq., F.G.S.
Mac Lauchlan, H., Esq., F.G.S.
Mantell, G. A., LL.D., F.G.S.
Mantell, R. M., Esq.
Massachusetts, Government of the State of.
Maury, Lieut.
M'Coy, F., Esq.
Metternich, Prince.
Müller, Prof. John.
Murchison, Sir R. I., F.G.S.

Nattali, M. A.
New York, Government of the State of.
New York Lyceum of Natural History.
Northumberland, His Grace the late Duke of.

Ordnance, Hon. Board of.

Philadelphia Academy of Natural Sciences.
Pictet, M. F. G.
Pilla, M. L.
Pomel, M. A.

Quetelet, M. A.

Rabusson, M. A.
Ray Society.
Redfield, W. C., Esq.
Royal Academy of Belgium.
Royal Academy of Berlin.
Royal Academy of Munich.
Royal Academy of Turin.
Royal Agricultural Society of England.
Royal Asiatic Society.
Royal Astronomical Society.
Royal Geographical Society.
Royal Geological Society of Cornwall.
Royal Irish Academy.
Royal Polytechnic Society of Cornwall.
Royal Society of Copenhagen.
Royal Society of Edinburgh.
Royal Society of London.

Sabine, Lieut.-Col., F.G.S.
Savi, Prof. Paolo.
Saunders, Mr.
Scarborough Philosophical Society.
Schimper, M. W. P.
Sheepshanks, Rev. R., F.G.S.
Silliman, Prof., M.D., For. Mem. G.S.
Smith, James, Esq., F.G.S.

Taylor, D., Esq.
Taylor, R., Esq., F.G.S.
Tennant, Mr. James, F.G.S.
Trevelyan, W. C., Esq., F.G.S.

Vandermaelen, M. Ph., F.G.S.
Vaudoise Society.
Vienna, Society of the Friends of Natural History of.
Von Buch, Herr L.
Von Hagenow, F., M.D.
Von Keyserling, Count A.
Von Oeynhausen, Herr.
Voorst, Mr. J. Van.

Walker, Mr. W.
Weston, C. W., Esq.
Wilson, Rev. J., D.D.
Wymann, J., M.D.

Yates, James, Esq., F.G.S.

List of PAPERS *read since the last Anniversary Meeting, February 19th,* 1847.

1847.

Feb. 24th.—On recent Depressions of Land, by James Smith, Esq., of Jordan Hill, F.G.S.

——— On the East of New South Wales and Van Diemen's Land, by J. B. Jukes, Esq., F.G.S.

March 10th.—On the Gypsiferous Strata of Nova Scotia, by Richard Brown, Esq.; communicated by Charles Lyell, Esq., F.G.S.

——— On the Soft Parts of Orthoceras, by — Anthony, Esq.; communicated by Charles Lyell, Esq., F.G.S.

——— On the Structure of Trinucleus, by J. W. Salter, Esq., F.G.S.

April 14th.—On the Oolitic Coal-field of Richmond, Virginia, by Charles Lyell, Esq., F.G.S.

——— On the Fossil Plants from the Oolite of Richmond, Virginia, by C. J. F. Bunbury, Esq., For. Sec. G.S.

April 28th.—On the Geology of Scinde, by Capt. N. Vicary; with an Introduction by Sir R. I. Murchison, F.G.S.

May 12th.—On Fossil Chimæroid Fishes, by Sir P. G. Egerton, Bart., M.P., F.G.S.

——— On Kent's Cavern, Torquay, by E. Vivian, Esq.; communicated by R. A. C. Austen, Esq., F.G.S.

May 26th.—On the Discovery of Coal in one of the Islands on the Coast of the Malay Peninsula, by J. R. Logan, Esq.; communicated by Prof. Ansted, F.G.S.

——— On the Structure and probable Age of the Bagshot Sands, by Joseph Prestwich, Jun., Esq., F.G.S.

June 9th.—Letter from Grant Dalton, Esq. to the President, On a Fossil Tooth of a Mammoth fished up off the Island of Texel.

——— On the Microscopic Structure of Bone, by J. S. Bowerbank, Esq., F.G.S.

——— On the Geology of South-western Europe, by Ami Boué, M.D., For. Mem. G.S.

——— On the Eocene Formation of Alabama, by Charles Lyell, Esq., F.G.S.

June 16th.—Descriptions of new genera and species of Pachyderms, from Eocene Cliffs of Hordwell, Hants, by Richard Owen, Esq., F.G.S., Hunterian Professor of Anatomy in the Royal College of Surgeons.

——— Letter from Leonard Horner, Esq., F.G.S., to the President, On the Discovery of Saurians in the Coal Formation of Saarbück.

1847.

June 16th.—On an Upright Lepidodendron with Stigmaria Roots, in the Coal of Cape Breton, by Richard Brown, Esq.; communicated by C. J. F. Bunbury, Esq., For. Sec. G.S.

———— On the New Red Sandstone of Nova Scotia, by J. W. Dawson, Esq.; communicated by Charles Lyell, Esq., F.G.S.

———— Letter addressed to the Secretary, On the Discovery of Coal on the Coast of Borneo, by Thomas Bellott, Esq.

———— On the Carboniferous Plants of New South Wales, by the Rev. W. B. Clarke, F.G.S.

———— On Trilobites from New South Wales, by the Rev. W. B. Clarke, F.G.S.

———— On Trematis, a new genus of Brachiopodous Mollusca, by Daniel Sharpe, Esq., F.G.S.

Nov. 3rd.—Description of Teeth and Portions of Jaws of Anthracotherioid Quadrupeds, discovered by the Marchioness of Hastings in the Eocene Deposits of the North-west Coast of the Isle of Wight, by Richard Owen, Esq., F.G.S., Hunterian Professor of Anatomy in the Royal College of Surgeons.

Nov. 17th.—On the Geology of the Coasts of Australia, by J. B. Jukes, Esq., F.G.S.

———— Remarks to accompany a Geological Map of Western Australia, by Messrs. J. W. and F. T. Gregory; communicated by the President.

December 1st.—Report on the Fossil Remains of Mollusca from the Palæozoic Formations of the United States, contained in the Collection of Charles Lyell, Esq., by Daniel Sharpe, Esq., F.G.S.

December 15th.—On the Oolite of Minchinhampton, by John Lycett, Esq.; communicated by John Morris, Esq., F.G.S.

———— On the *Nautilus Saxbii*, by John Morris, Esq., F.G.S.

———— Letter from Col. A. F. Macintosh, F.G.S., to J. C. Moore, Esq., Sec. G.S., On the Temple of Serapis.

December 15th.—On the Land-slip at the Lizard, by C. A. Johns, Esq.; communicated by the President.

1848.

Jan. 5th.—On the Silurian Rocks in the Valley of the Tweed, by James Nicol, Esq., F.G.S.

Jan. 19th.—On the Agates of Oberstein, by W. J. Hamilton, Esq., Sec. G.S.

Feb. 2nd.—On the Fossil Remains of Birds from New Zealand, by G. A. Mantell, LL.D., F.G.S.

———— On Organic Remains in the Skiddaw Slate, by the Rev. Adam Sedgwick, F.G.S., Woodwardian Professor in the University of Cambridge.

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

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

It was afterwards resolved:—

1. That the thanks of the Society be given to Sir P. G. Egerton, Bart., Professor Owen, and the Rev. Professor Sedgwick, retiring from the office of Vice-President.

2. That the thanks of the Society be given to Hugh Falconer, M.D., William Hopkins, Esq., Professor Owen, Rev. Professor Sedgwick, and H. E. Strickland, 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 the Officers and Council for the ensuing year:—

OFFICERS.

PRESIDENT.

Sir H. T. De la Beche, F.R.S. and L.S.

VICE-PRESIDENTS.

G. B. Greenough, Esq., F.R.S. and L.S.
Leonard Horner, Esq., F.R.S. L. and E.
Charles Lyell, Jun., Esq., F.R.S. and L.S.
G. A. Mantell, LL.D., F.R.S. and L.S.

SECRETARIES.

William John Hamilton, Esq., P. R. Geog. S.
John Carrick Moore, Esq., M.A.

FOREIGN SECRETARY.

C. J. F. Bunbury, Esq., F.L.S.

TREASURER.

John Lewis Prevost, Esq.

COUNCIL.

R. A. C. Austen, Esq., B.A.
J. S. Bowerbank, Esq., F.R.S.
C. J. F. Bunbury, Esq., F.L.S.
E. H. Bunbury, Esq., M.A., M.P.
Charles Darwin, Esq., F.R.S.
Prof. Daubeny, M.D., F.R.S. and L.S.
Sir H. T. De la Beche, F.R.S. and L.S.
Sir P. Grey Egerton, Bart., M.P. F.R.S.
Prof. E. Forbes, F.R.S. and L.S.
G. B. Greenough, Esq., F.R.S. and L.S.
William John Hamilton, Esq.
Leonard Horner, Esq., F.R.S. L. and E.
Robert Hutton, Esq., M.R.I.A.
Charles Lyell, Jun., Esq., F.R.S. and L.S.
G. A. Mantell, LL.D., F.R.S. and L.L.
John C. Moore, Esq.
John Morris, Esq.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.
Samuel Peace Pratt, Esq., F.R.S. and L.S.
John Lewis Prevost, Esq.
Prof. A. C. Ramsay.
D. Sharpe, Esq., F.L.S.
S. V. Wood, Esq.

Trust Accounts.

Receipts.

	£	s.	d.	£	s.	d.
Balance at Banker's, 1st January, 1847, on the Wollaston Donation Fund				31	11	6
Balance at Banker's, Geological Map Fund				47	10	0
Received on account of the Geological Map (sold)	11	10	0			
Dividends on the Donation Fund of 1084*l*. 1*s*. 1*d*. Red. 3 per Cents.	31	11	6	—43	1	6
				£122	3	0

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

Jan. 27, 1848. R. HUTTON, A. TYLOR, } *Auditors*.

Payments.

	£	s.	d.	£	s.	d.
Cost of Striking Four Palladium Medals, one of which awarded to M. Ami Boué	3	0	0			
Balance of Proceeds awarded to M. Alcide D'Orbigny	30	0	0			
				33	0	0
Paid on account of Geological Map:— Mr. Greenough, balance of 1846				47	10	0
Balance at Banker's, Trust Account				41	13	0
				£122	3	0

Valuation *of the Society's Property; 31st December*, 1847.

Property.

	£	s.	d.	£	s.	d.
Due from Messrs. Longman and Co., on Journal, Vol. III.				64	7	4
Due for Authors' Corrections in Journal, Vol. III.				10	5	0
Balance in Banker's hands				270	2	7
Balance in Clerk's hands				22	19	3
Funded Property, 3453*l*. 14*s*. 7*d*. Consols				2970	4	0
Arrears of Admission Fees	39	18	0			
Arrears of Contributions prior to 1847, considered good	9	9	0			
Arrears of Contributions of 1847	18	18	0			
				68	5	0
				£3406	3	2

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

Jan. 26, 1848. J. L. PREVOST, *Treasurer*.

Debts.

	£	s.	d.
Due to Messrs. R. and J. E. Taylor, on Journal, Vol. III.	59	18	6
Due to Patent Fuel Company	6	15	0
Due to G. Laing, for House Repairs	8	1	9
Balance in favour of the Society	3331	7	11
	£3406	3	2

INCOME.

	£	s.	d.	£	s.	d.
Outstanding :						
Quarterly Journal, Vol. II. (Messrs. Longman & Co.)				65	7	7
Balance at Banker's, January 1, 1847	286	4	1			
Balance in hands of Clerk..............	8	19	11			
				295	4	0
Compositions received	63	0	0			
Ditto at Banker's, Dec. 31, 1846.........	31	10	0			
				94	10	0
Ditto received in Dec. 1847, after Consols closed				31	10	0
Arrears of Admission Fees	18	18	0			
Arrears of Annual Contributions	34	13	0			
				53	11	0
Admission Fees of 1847				140	14	0
Annual Contributions of 1847				748	2	6
Dividends on 3 per cent. Consols..................				99	0	11
Sale of Transactions				93	0	0
Sale of Transactions in separate Memoirs				10	16	3
Sale of Proceedings				8	2	6
Journal, Vol. I., Publishers' allowance on sale				2	5	0
Sale of Journal, Vol. II.				32	15	6
Sale of Journal, Vol. III.				214	14	2
Sale of Library Catalogue				6	0	0
				£1895	13	5

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

R. HUTTON,
A. TYLOR, } *Auditors.*

Jan. 27th, 1848.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Outstanding:						
Quarterly Journal, Vol. II. (Messrs. R. and J. E. Taylor)..				57	3	6
Compositions invested				94	10	0
General Expenditure:						
Taxes and Rates	35	11	4			
Fire Insurance	9	0	0			
House Repairs	1	5	0			
Furniture Repairs	24	1	5			
New Furniture	3	12	4			
Fuel	22	9	0			
Light	30	6	8			
Miscellaneous House expenses, including Postages	43	17	6			
Stationery	19	6	0			
Miscellaneous Printing	21	13	0			
Tea for Meetings	25	7	0			
				236	9	3
Salaries and Wages:						
Assistant Secretary (3 qrs. of a year) £97 10; ... ... (travelling expenses) 10 0	107	10	0			
Curator	130	0	0			
Clerk £100 0; ... (Gratuity) 20 0	120	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	9	0	0			
Collector	26	2	6			
				505	16	6
Library				31	5	4
Museum, including Assistant				24	17	10
Diagrams at Meetings				16	1	0
Miscellaneous Scientific Expenses				2	10	1
Arrears of Contributions repaid				6	6	0
Contributions of 1847 repaid				6	6	0
Publications:						
Transactions	116	9	4			
Transactions, separate Memoirs	6	12	6			
Journal, Vol. I., Presentation Copy	0	13	6			
Journal, Vol. II.	10	6	6			
Journal, Nos. 9, 10, 11 and 12	468	9	3			
Proceedings, Index to Vol. IV. &c.	18	15	0			
				621	6	1
				1602	11	7
Balance at Banker's:						
Composition received in December, after Consols shut, to be invested				31	10	0
				1634	1	7
Balance at Banker's, Dec. 31, 1847	238	12	7			
Balance in Clerk's hands	22	19	3			
				261	11	10
				£1895	13	5

Estimates *for the Year* 1848.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Account due by Messrs. Longman and Co. in June, on Quarterly Journal				64	7	4
Account due by Author, for Corrections in Journal, Vol. III.				10	5	0
Arrears (See Valuation-sheet)				68	5	0
Ordinary Income for 1848 estimated :						
Annual Contributions (228 Fellows)				718	4	0
Admission Fees :						
Residents (9)	56	14	0			
Non-residents (8)	84	0	0			
				140	14	0
Dividends on 3 per Cent. Consols				101	12	0
Sale of Transactions, &c.				50	0	0
Sale of Quarterly Journal				230	0	0
				£1383	7	4

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
Bill due to Messrs. R. and J. E. Taylor on Quarterly Journal				59	18	6
Bill due to Patent Fuel Company				6	15	0
Bill due to G. Laing, for House Repairs				8	1	9
General Expenditure :						
Taxes and Rates	35	11	4			
Fire Insurance	9	0	0			
House Repairs	35	0	0			
Furniture Repairs	24	0	0			
New Furniture	15	0	0			
Fuel	22	10	0			
Light	30	10	0			
Miscellaneous House Expenses	45	0	0			
Stationery	20	0	0			
Miscellaneous Printing	22	0	0			
Tea for Meetings	26	0	0			
				284	11	4
Salaries and Wages :						
Assistant Secretary	130	0	0			
Curator	32	10	0			
Clerk	100	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	12	0	0			
Collector	26	0	0	413	14	0
Library, Binding and Additions				50	0	0
Museum				50	0	0
Diagrams at Meetings				20	0	0
Miscellaneous Scientific Expenditure				10	0	0
Quarterly Journal				460	0	0
				1363	0	7
Balance in favour of the Society				20	6	9
				£1383	7	4

J. L. PREVOST, Treasurer.

Jan. 26, 1848.

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

18TH FEBRUARY, 1848.

AWARD OF THE WOLLASTON MEDAL AND DONATION FUND.

AFTER the Reports of the Council and Committees had been read, the President delivered the Wollaston Palladium Medal to Dr. Buckland, Dean of Westminster, addressing him as follows:—

DR. BUCKLAND,—The Geological Society has awarded you its Wollaston Palladium Medal for the important services you have rendered to Geology during a long series of years, by your labours in the field, and by your numerous and valuable writings; for your exertions to promote the study of geology in the University of Oxford; and especially for the zeal and energy with which, in its earlier day, you laboured to advance the objects of this Society, a zeal and energy which has remained unabated to the present time.

To attempt an enumeration of your many geological works before the geologists I now see assembled in this room, would be a poor compliment to those to whom they are so familiar, and who have employed them so frequently to aid them in their labours. Your works will remain lasting memorials of your power to observe, and your ability to describe and render clear to others those discoveries and researches, which have so materially advanced that science for which we are here associated.

It may not be generally known, especially to the younger members of our Society, that, while yet a child, at your native town, Axminster in Devonshire, ammonites, obtained by your father from the lias-quarries in the neighbourhood, were presented to your attention. As a scholar at Winchester, the chalk, with its flints, were brought under your observation, and there it was that your collections in natural history first began. Removed to Oxford as a scholar of Corpus Christi College, the future teacher of geology in that university was fortunate in meeting with congenial tastes in our colleague, Mr. W. J. Broderip, then a student at Oriel College. It was during your walks together to Shotover Hill, when his knowledge of conchology was so valuable to you, enabling you to distinguish the shells of the Oxford oolite, that you laid the foundation for those field-lectures, forming part of your course of geology at Oxford, which no one is likely to forget who has been so fortunate as at any time to have attended them. The fruits of your walks with Mr. Broderip formed the nucleus of that great collection, more especially remarkable for the organic remains it contains, which, after the labours of forty years, you have presented to the Geological Museum at Oxford, in grateful recollection of the aid which the endowments of that university, and the leisure of its vacations, had afforded you for extensive travelling during a residence at Oxford of nearly forty-five years.

When you contemplate our present knowledge of the geological structure of the British Islands, it cannot be without gratification that you can look back to your early labours in promoting it. It was so long since as 1808 that alone you crossed the chalk-downs of Berkshire, Wiltshire and Dorsetshire to Corfe Castle, there recognising chalk in the vertical position of the hard white limestones on which the latter stands. Alone also in 1809 you explored a large part of South Devon; in 1810 you examined the centre and north of England, colouring the results of your researches upon Cary's great map of England; and in 1811 you extended your investigations to part of Scotland, crossed over to Ireland, and returned home by North Wales. About this time we find you associated with Mr. Greenough, collecting materials for his geological map of England, and it must be no small gratification for you to see, as witnesses of this presentation of the Wollaston Medal, your early fellow-labourer in the geology of England, and our first president, Mr. Greenough, and my immediate predecessor in this chair, Mr. Horner, as active and zealous now, when forty years have elapsed since the foundation of this Society, as when, still in its infancy, it required all the fostering care which they and you then afforded it.

Let me express my personal gratification that I should be the official channel through which you receive this mark of the high value which the Geological Society attaches to your services. We have been fellow-labourers together in the same field, and let me gratefully remind you of the kind encouragement you afforded me in the pursuit of our common science, when a youth then residing at Lyme Regis, I endeavoured to avail myself of your advanced and superior knowledge of the remarkable fossils discovered in that neighbourhood, and of the geological structure of the surrounding country. Receive this medal, Dr. Buckland, as the highest distinction our Society can award, and may its presentation to you prove a stimulus to the exertions of our younger geologists, some of whom, now active, date their birth after you had entered upon your geological career, and may their labours in the great cause of truth be found worthy of honours similar to that which in the name of this Society I now place in your hands.

On receiving the Medal, Dr. Buckland replied as follows:—

Sir Henry De la Beche,—I am indeed highly gratified to receive at the hands of a fellow-labourer with whom I have been associated in promoting the science of Geology for so many years, this testimony of the approbation of the Council of the Geological Society, which the discretion of that acute and minute philosopher, Dr. Wollaston, has committed to their disposal; unfettered by the restrictions which founders too often impose on their benefactions, and free to be awarded to whatever works, by individuals of any nation upon earth, they may judge to have been most efficient in promoting the progress of Geology. In the impress on this Medal I behold the image of that great man with whose friendship I was honoured, the memoirs of whose useful life we are impatiently expecting from the pen of one of your predecessors in that Chair, Mr. Warburton. By this medal of palladium, the metal discovered by Wollaston, I am reminded also of the cognate honour that five-and-twenty years ago was conferred on me by the Royal Society of London, in the presentation of the Copley Gold Medal, at the hands of Sir Humphry Davy, for my geological discoveries in the Cave of Kirkdale.

Sir H. Davy and Dr. Wollaston, both supremely pre-eminent as discoverers in chemistry, concurred in duly appreciating the importance of geology; nor is this our science at the present time less highly appreciated, nor uncultivated in some of its transcendental branches by a Herschel, a Whewell, and a Babbage. I am further gratified to receive this honour simultaneously with the announcement in foreign scientific journals, of another honour proposed to be conferred on me in Bohemia, conjointly with Mr. Robert Brown and Professor Faraday, and with nineteen of the most distinguished cultivators of science and literature on the Continent, viz. the degree of a Doctor of Philosophy in the University of Prague, at the approaching celebration of the five-hundredth year of the foundation of that university. This foreign recognition of my labours concurring with the reward conferred on me this day by the Council of a Society most competent to appreciate the value of researches in geology is indeed most gratifying; *laudari a laudatis viris*, is the highest praise attainable in human pursuits. The science which forms the subject of our especial investigation is, indeed, as a master science, most expansive, most comprehensive: its requirements embrace the sciences of mineralogy and chemistry, the history also of the entirety of the animal and vegetable kingdoms, both incomplete without the addition of that large amount of extinct genera and species of animals and plants that occur only in a fossil state; it comprehends also conchology, comparative anatomy, physical geography, agriculture, and natural theology.

How vast are the requirements of this our master science, Geology, with such manifold subordinates! what a mighty miracle is the earth, which it is our province and privilege to be permitted to investigate! how highly calculated, in the study of its structure and contents, to awaken many of the most exalted feelings of our spiritual nature—feelings kindred to those of which original first discoverers of the laws and principles that govern the material world must occasionally be conscious—feelings of grateful and humble admiration of the great Author of all created things,—which exalt us in the scale of beings, and which I once experienced, when, standing on the highest summit of the Mendip Hills, at the close of an elaborate investigation of the structure of the surrounding country, I recollected that I was the first individual of the human race to whom it had been permitted to unravel the structure and record the history of that subterraneous portion of the works of God that lay within the horizon then around me.

Sir, it has been the high privilege of our time, which our successors cannot enjoy, to be the pioneers of a great and comprehensive master science; and wherever we have pushed forward our original discoveries, these discoveries will have indelibly inscribed our names on the annals of the physical history of the globe. We have established landmarks and fixed physical and chronological horizons which must endure so long as men regard the structure and contents and physical history of the earth which God has given the children of men.

Many individuals of that Council who have concurred in awarding to me this Medal, have acquired to themselves, not only an European, but a Mundane reputation, not only as citizens, but as instructors and benefactors of the world. Many of their names are as familiar on the banks of the Ganges and of the Ohio as on those of our own Thames. The scientific discoverers of the world are now closely united as one brotherhood in one great family of the human race, and the literature of science which records the physical discoveries of our time will continue indestructible by the burning of another Alexandrine library, and so long as science shall be regarded by any nation upon earth. Were all Europe and Africa again submerged beneath the oceans from which they have been elevated by the force of subterranean fires, our literature would survive in the libraries of Asia and America.

It is highly gratifying to feel that whatever real additions we may have made to man's positive knowledge of the works of God, will be indelibly preserved and imparted to all our successors of the human family in all countries and in all generations yet to come, and we trust, for their moral as well as intellectual and social and physical advantage.

Geological knowledge, *i. e.* the knowledge of the rich ingredients with which God has stored the earth beforehand, when He created it for the then future uses and comfort of man, must fill the mind of every one who acquires this knowledge with feelings of the highest admiration, the deepest gratitude, and the most profound humility. The more our knowledge increases of the infinity of the wisdom and goodness of the Creator, greater and greater becomes the consciousness of our own comparative ignorance and insignificance. The sciolist alone is proud; the philosopher is humble, and duly conscious of the comparative littleness of his most extended knowledge. We may be gratified by our discoveries and by the recognition of the value of our labours by our fellow-men. We may and ought to be gratified, but we are not made proud; we feel that pride was not made for man; we learn the lesson of humility, increasing more and more continually as our knowledge of the works of God becomes more and more expanded; and to those who have laboured diligently and successfully in their calling, as investigators of the wonders of creation, it is permitted to hope that they may have done good in their generation, and that their labour has not been in vain.

After the other proceedings had been completed, and the Officers and Council had been elected, the President proceeded to address the Meeting.

ANNIVERSARY ADDRESS OF THE PRESIDENT,

SIR HENRY T. DE LA BECHE, V.P.R.S. & L.S.

Gentlemen,—In accordance with the practice established for twenty years by my predecessors in this Chair, I have now to address you on the progress of our Society and of our science. This is our fortieth anniversary, and the Report of your Council will have shown you that our numbers were never greater than at the present time. It has been stated to you that there has been a small excess of expenditure over income, but this has been shown to have arisen from an unforeseen circumstance, and the cause cannot again occur. Without it we should have been within our income, and even with it we still had a considerable balance in our bankers' hands, independently of our funded property. The communications to our Society have not deteriorated, and the discussions which have followed the reading of them have continued to preserve that character for good feeling, and desire to arrive at truth, for which they have long been known. Finally, the publication of your Quarterly Journal has been regular, and few months can now elapse between the reading of a memoir in this room and its appearance before the public, an advantage of no slight kind, and which cannot but be fully appreciated by the Fellows of this Society.

Among the seven deaths which have deprived the Society of its ordinary fellows since the last Anniversary, we have to lament that of Mr. Chaning Pearce. He was born at Bradford, Wiltshire, on the 18th of July, 1811. His desire to collect organic remains commenced with his infancy, and it was with difficulty that his nurse could withdraw him from the heaps of stone or clay near Bradford, whence he obtained and brought to his father various fossils. He probably acquired this desire from his parent, who, before him, was accustomed to search for specimens of the Apiocrinites, commonly known as the Bradford encrinite. This disposition to obtain organic remains grew with his growth, and by the time his apprenticeship to his father, as a surgeon, expired, he had formed a large collection of them. He subsequently went to London, and was entered at Guy's Hospital, where he distinguished himself, and obtained a prize for anatomy. After passing his examinations, which he did with great credit, he proceeded to Paris and Switzerland for a short time, and upon his return joined his father in his medical practice in and around Bradford. Still continuing a zealous and active collector of organic remains, he availed himself of every opportunity which his residence in a district rich in those remains afforded. From the members of the oolitic series, particularly the great oolite, Bradford clay and Forest marble, in the immediate vicinity of Bradford, he obtained an abundant harvest of ancient organic forms, and his opportunities for procuring specimens of that beautiful fossil, the *Apiocrinites Parkinsonii*, were so good and frequent, detecting them upon the very layers of rock on which they lived, that he was enabled to effect important exchanges with collectors in other parts of the British Islands and in foreign countries, thereby greatly enriching his museum, so that at length it might be considered one of the finest private collections of organic remains in this country.

Besides a communication to the London Geological Journal on the *Belemnoteuthis*, Mr. Chaning Pearce contributed three short papers to this Society, one in 1842, on the Mouths of the Ammonites, &c., from the Oxford clay, Wilts, and two in 1843, the first on the Locomotive powers of the Family *Crinoidea*, and the second on a new Encrinite from the Dudley limestone.

Finding it necessary to abandon the medical profession, Mr. Pearce, in 1845, took Montague House, Lambridge, near Bath, built a convenient museum for his extensive collections, and in this placed saurian remains only a fortnight before his death. He suffered severely from calculi, composed of the phosphate and carbonate of lime, which he occasionally expectorated. He expired, with perfect calmness, on the 11th of May 1847.

We have here to deplore the loss, from among our Foreign Members, of one who, during a life extended beyond the ordinary number of years, occupied himself with our science and its applications, and who for a long period has been ranked among the most distinguished geologists. ALEXANDRE BRONGNIART, the son of the well-known architect of the Invalides, Alexandre-Théodore Brongniart, was born in Paris in 1770. In his early years he was fortunately associated with men who could appreciate his talents, and at that important period of his life was so situated as to benefit by the conversations of Franklin, and obtain his first ideas of chemistry from those of Lavoisier, and so well did he learn from the latter, and so clear was his mode of expressing himself, that it is recorded that when only fifteen years of age, Lavoisier himself was the gratified attendant at a chemical lecture by the young Brongniart. To chemistry and mineralogy he was always attached, giving courses upon them from the age of seventeen years until three years before his death. Few have exceeded him in the length of time devoted to instruction. He taught for sixty years, and during fifty years was a public professor.

Alexandre Brongniart early completed his studies at the École des Mines at Paris, and in 1788, then only eighteen years of age, was one of the founders of the Société Philomathique established in that city. In 1790 he visited England, where the mines and picturesque beauties of Derbyshire made a strong impression upon his mind. It was during this visit that he acquired data for a memoir on enamelling, his first appearance in a career connected with the manufacture of porcelain, and other fictile substances: for which he was afterwards so much distinguished. He became the assistant of his uncle, who was demonstrator of chemistry at the Jardin des Plantes, and also studied at the École de Médecine, where he took honours. He subsequently was attached to the army of the Pyrenees as pharmacien. The opportunity afforded by fifteen months' residence among the Pyrenees was not neglected by the young Brongniart, and he there not only studied the botany and zoology of those mountains, but their geological structure also. So ardent was his pursuit of science, that he fell into dangers which his youth prevented him from seeing, and he was thrown into prison, suspected of having favoured the escape of the naturalist Broussonnet, who fled through the Brèche de Rolland from a death with which he was threatened. Liberated on the 9th Thermidor, he returned to Paris, and, at the recommendation of Fourcroy and Coquebert de Montbret, was attached to the mining department, as an Ingénieur des Mines. Soon afterwards he became Professor of Natural History at the École Centrale des Quatre-Nations, and a contributor to the best scientific journals of the time.

In 1800 M. Brongniart was named director of the porcelain manufacture at Sèvres, at the recommendation of Bertholet, and continued in this appointment until his death, thus devoting his energies to, and promoting the welfare of that establishment for forty-seven years. His well-known 'Traité élémentaire de Minéralogie,' appeared in 1807, he being charged with composing this treatise at the time that the Imperial University was organised. This work became the text-book for the lectures which M. Brongniart, as coadjutor with Hauy, delivered at the Faculté des Sciences, and which he continued at the Muséum d'Histoire Naturelle, when he was called upon to succeed his distinguished predecessor, Hauy.

M. Brongniart did not confine himself to the study of mineral substances. He long continued to occupy himself with zoology, and to him is due the division of Reptiles into four orders, the *Saurians*, the *Batrachians*, the *Chelonians* and the *Ophidians*. All palæontologists are acquainted with his treatise on the *Trilobites*, a work which was received with so much favour at the time (1822), and which paved the way for so many other labours upon these remarkable crustaceans, which in the earlier geological periods swarmed by myriads, ceasing, however, to form part of the marine fauna of our globe even at a very remote epoch.

When Cuvier was called to Paris, M. Brongniart was among the first to appreciate his talents, and to his union with that great man geologists owe that important work, — important under so many aspects,—the 'Essai sur la Géographie Minéralogique des Environs de Paris,' presented to the Institute in April, 1810. The advance in geology made by the appearance of these labours is too well known to those whom I now address to render any account of them needful. They form one of those great resting-places in the progress of knowledge, whence the cultivators of science start with renewed vigour.

In 1815 M. Brongniart was admitted into the Academy of Sciences, succeeding Desmarest. In 1817 he travelled in Switzerland, the Alps and Italy, accompanied by his son, Adolphe Brongniart, at the time of his father's death, the President of the Academy of Sciences, and so well known to us all for the aid he has afforded to our science by his works on fossil botany. One of his distinguished pupils, M. Bertrand Geslin, was also of this party. The result of these travels was, among other things, the then startling announcement that the dark limestones of the Montagne des Fis, in Savoy, could only be regarded as an equivalent of the cretaceous rocks of Northern France and England. We are accustomed to such comparisons now, but thirty-one years since geologists were not prepared so readily to receive announcements of this kind.

It was in 1824 that M. Brongniart visited Norway and Sweden, where his attention was alike directed to the more ancient and more modern rocks and accumulations.

The works of M. Brongniart corresponded with the range of his mind, and we find him alike advancing our knowledge of mineralogy, geology, zoology, palæontology, and of the employment of mineral substances for the use of man and the ornament of his works.

The last work of M. Brongniart, commenced in 1830 and completed in 1844, entitled 'Traité des Arts Céramiques,' presents us with the most valuable information on this head ever accumulated, treated in the manner which might be expected from one so perfectly conversant with his subject, studied during so many years, and so well illustrated by the splendid museum of fictile and vitreous manufactures which he founded at Sèvres.

The kindness of M. Brongniart to all in any manner connected with him, is proved by the affectionate regard entertained so generally for him. While so well-informed, and occupying deservedly so high a place among men of science, he was always modest. Those who knew him well describe him as most frank, and so desirous of being scrupulously just, that the fear of partiality was often too strong upon him. His mind was at all times ready to receive truth, and he was anxious to regard subjects from different points of view. He considered minerals both as regards their chemical composition and crystalline structure, and in geology, though as one of the authors of the mineral geography of the environs of Paris, it might be expected that he would hold the value of organic remains as not slight, he carefully avoided giving them exclusive importance.

I cannot close this notice of our losses by death without adverting to that of one, who though not placed among even the easier classes of society, but who had to earn her daily bread by her labour, yet contributed by her talents and untiring researches in no small degree to our knowledge of the great Enalio-saurians, and other forms of organic life entombed in the vicinity of Lyme Regis. Mary Anning was the daughter of Richard Anning, a cabinet-maker of that town, and was born in May, 1799. While yet a child in arms (19th August, 1800), she narrowly escaped death, when with her nurse taking shelter beneath a tree during a thunderstorm, which had scattered a crowd collected in a field to witness some feats of horsemanship to be performed by a party travelling through the country. Two women, with the nurse, were killed by the lightning, which struck the tree beneath which they considered themselves safe; but the child, Mary Anning, was by careful treatment revived, and found not to have sustained bodily injury. From her father, who appears to have been the first to collect and sell fossils in that neighbourhood, she learnt to search for and obtain them. Her future life was dedicated to this pursuit, by which she gained her livelihood; and there are those among us in this room who know well how to appreciate the skill she employed, (from her knowledge of the various works as they appeared on the subject,) in developing the remains of the many fine skeletons of Ichthyosauri and Plesiosauri, which without her care would never have been presented to comparative anatomists in the uninjured form so desirable for their examination. The talents and good conduct of Mary Anning made her many friends; she received a small sum of money for her services, at the intercession of a member of this Society with Lord Melbourne, when that nobleman was premier. This, with some additional aid, was expended upon an annuity, and with it, the kind assistance of friends at Lyme Regis, and some little aid derived from the sale of fossils, when her health permitted her to obtain them, she bore with fortitude the progress of a cancer on her breast, until she finally sunk beneath its ravages on the 9th of March, 1847.

Geological Society of London.

With respect to the progress of Geology during the past year, and more especially in this country, it may be desirable in the first instance to take a survey of the manner in which our Society may have contributed towards it. For this purpose we may conveniently divide the general subject into—

1. Investigations respecting the accumulation of mineral matter now taking place on the surface of the earth, mechanically and chemically, by aqueous and igneous means.
2. Researches connected with the mode in which mineral matter has been accumulated in previous geological times.
3. The manner in which the remains of animal life at present existing may be entombed amid the accumulations of mineral substances now in progress.
4. Ancient life, or Palæontology.
5. Observations respecting the mode in which the remains of ancient life may have been mingled with the mineral deposits of former geological periods.
6. Descriptions of the superposition of rocks, their supposed equivalents in different regions, and general classifications of them.
7. The movements which the mineral masses may have sustained subsequently to their accumulation.
8. The various mineral changes and modifications these mineral masses may have suffered since their accumulation, either before or after any movements they may have sustained.

Under the first head there has been nothing communicated to the Society during the past year, except an incidental notice by Captain Vicary in his paper on the geology of parts of Sinde, wherein, describing the deposits at the harbour of Kurrachee, he mentions the gain of the sea on the land. The prevalent in-shore wind, while blowing at times with considerable force, constantly drives dry sand into the harbour, tending to fill it up, the outflow of the tide only carrying back to the sea a part of the sand thus blown in; on the land side also every fall of rain, forming a temporary flood, leaves detritus. As no river now flows out of the harbour, tidal action alone (except during the temporary effects of rains) has to contend with the causes filling up the space inside the sands, and thus the continuation of the mud-flats occurring within the present harbour becomes exposed outside to the action of the sea; the sands which formerly protected the mud-flats, while river-action afforded a sufficient supply of detritus to be piled up in banks, being driven over the flats inwards.

Respecting the manner in which mineral matter may have been accumulated in former geological times, Mr. Lycett, describing the great oolite as it occurs in the neighbourhood of Minchinhampton, observes that even a cursory glance at the sections of that vicinity show the beds to have been accumulated in a shallow sea, where strong currents prevailed, the surface and mineral character of the deposit continually changing. "Heaps of broken shells," he adds, "piled in uncertain laminated beds, are intermixed with occasional rounded fragments of rock, (foreign to the neighbourhood,) of abraded madrepores, dicotyledonous wood, crabs'-claws, &c." He further remarks upon the apparent denudation of some shelly beds, the cavities left by the removed portion being filled with clay, on the common false bedding, on the non-conformity of certain beds in juxtaposition, and upon the barren or less fossiliferous character of other beds.

He gives a very detailed account of the beds he describes under the head of the compound great oolite, included in a thickness of about 130 feet, not neglecting their very changeful character. This description constitutes a valuable addition to our information respecting the local mineral structure of a part of the oolitic series, which, taken as a whole, in its range from the coast of Yorkshire to that of Dorsetshire, affords a most excellent opportunity for the study, over a limited area, of modifications and changes in physical conditions during the lapse of a certain portion of geological time. No doubt parts of these deposits have been so removed by denudation that we lose their contact with the older accumulations which bounded them in one direction; and, on the other hand, they are so covered up by more modern deposits, that a stripe only remains of the old oolitic area. Enough, however, is still exposed to reward examination; and a careful comparison of its mineral character, with the mode in which mineral matter is accumulated at the present day, will be found highly instructive, more particularly if we extend our view to those other parts of Europe where deposits of equal date may be exposed. We have elsewhere endeavoured to point out the modifications observable in the lower part of the oolitic series, when the Mendip Hills in Somersetshire, and other places extending into South Wales, in all probability, after forming islands and shores, were so depressed beneath the sea-level as to be covered up by the oolitic accumulations; and we may now add, that the Geological Survey has not lost sight of the physical history of these deposits during its examination of them, while at the same time every attention is given to their zoological modifications and changes. We may here call attention to a more careful study of the oolitic grains than is sometimes given. Whole masses of them are no doubt concentric concretions round a minute nucleus, sometimes even appearing to surround a small crystal of carbonate of lime; but others, though of the same general shape externally, are merely rolled pieces of corals and of shells, much resembling the coarser coral sands familiar to those who have examined coral reefs, or shores adjacent to coral accumulations. Often both kinds are mingled together in a common drift, diagonally laminated, with larger portions of corals and broken shells, the flat parts of the corals and shells commonly parallel to the false bedding, thus pointing to the pushing action of moving water along a sea-bottom, the careful study of which readily shows the direction whence and to which the water moved. Indeed the mechanical aggregation of a large proportion of the calcareous beds is very striking, while the chemical production of others is equally apparent. By the careful consideration of these differences in the limestones, of the sandstones and of the clays, not forgetting the friction marks from moving water, and the trails and other traces of the various molluscs and other animals which have moved on surfaces, for the time, exposed, the geologist will find his labours well rewarded by an insight into the manner in which mineral matter has been deposited over a few thousand square miles at this geological period.

Mr. Nicol, in his communication to the Society on the Silurian rocks in the south of Scotland, where they occupy an area estimated at 4000 square miles, examined into the manner in which the various beds composing it may have been accumulated. Though igneous rocks, such as felspar porphyries and the ordinary hornblendic varieties, commonly termed trappean rocks, are present in the conglomerates, sandstones and slates, noticed under the head of greywacke or Silurian Rocks, they would, by the descriptions of Mr. Nicol, rather appear to have been intruded among the beds formed in water, after the deposit of such beds, than thrown among them while accumulating. It is shown, that in tracing the general mass from its northern border in Peeblesshire and the Lothians, south through Selkirkshire and Roxburghshire to the confines of England, and across the strike of the beds, that the coarser varieties of rock prevail on the north in large irregular masses, while on the south the finer varieties predominate in thinner, more regular, and more distinctly stratified beds, whence Mr. Nicol concludes that the deposits generally have been derived from the north. Examining the beds themselves he finds a mixture of clay-slates, and sandstones and conglomerates, the former rarely exhibiting any of the cleavage so common in parts of Wales and the older Cumbrian districts. The grains of quartz in the sandstones are rarely larger than a pea, while the flat fragments of a clay-slate attain several inches in length. He discovered no traces of granitic rocks, gneiss, or mica-slate rocks in these beds.

Mr. Nicol then proceeds to show that this accumulation of beds was consolidated, squeezed and upraised anterior to the formation of the old red sandstone, and infers that the older deposits were formed into hill and valley, and probably, in part at least, rose above the sea into the atmosphere, when the conglomerates of the old red sandstone were collecting round them, tongues of old red sandstone now entering valleys of the older series. He also points out that the old red sandstone once covered the latter more extensively than we now find it, denudation having removed the greater part which once existed.

These researches of Mr. Nicol are highly valuable in enabling us to trace into Scotland evidences of the general disturbance of so much of the older palæozoic rocks prior to the date of the upper parts, at least, of the old red sandstone. Those familiar with the geology of Southern Ireland are aware, that there the conglomerates of the old red sandstone repose upon the upturned and frequently contorted beds of the older palæozoic rocks, and it is not difficult to see that the overlap of the higher over the lower parts of the old red sandstone, which commences in Herefordshire and runs through South Wales, is prolonged into Southern Ireland, the movements in the latter having been more decided and greater than in South Wales. If the higher portions of the old red sandstone overlapped the lower in Herefordshire and Shropshire, such extensions by overlap have been removed by denudation; but again, in North Wales, we find the old red sandstone, as a conglomerate, here and there appearing from beneath its covering of carboniferous limestone, the latter in its turn extending over and beyond the former, and both together covering the upturned and frequently-contorted beds of the older palæozoic rocks. Anglesea shows us the old red sandstone covered by mountain limestone, and even by coal-measures, thus overlapping older rocks further in that direction. In Cumberland and Westmoreland we have the well-known examples detailed to us by Dr. Buckland, and published many years since (1816) in our Transactions, and now we have the addition to our knowledge made by Mr. Nicol. Local circumstances, therefore, in Herefordshire and Shropshire would appear to have interfered with, or so modified the great contortion and upraising of the older palæozoic rocks, observable over an area comprising probably the greater part of Ireland, Northern Wales, Westmoreland, Cumberland and Scotland, that the old red sandstone, or its upper portions, did not there accumulate, as a conglomerate, over portions of them. In the direction of Devonshire there was apparently a comparative absence of crumpling and bending of beds at this time, and there deeper waters may have occurred, while littoral and river action were forming conglomerates in other parts of the area now occupied by the British Islands.

When we see conglomerates, in which the water-worn pieces of subjacent and adjacent rocks are often large, we necessarily look to an adequate cause for their production, and find little else than the grinding together of such pieces of rock on sea-beaches, or the throwing or thrusting forward of shingle and gravel by rivers, capable of producing them, as we now find them. These conditions suppose dry land and seas of various depths, as at present, and therefore the view of Mr. Nicol, that in the district he describes the older palæozoic rocks may have formed such a portion of dry land, clothed with an appropriate vegetation and inhabited by fitting animals, while the old red sandstone was accumulating around it, may be considered as a fair inference from facts. Indeed it seems needful to extend this view to other parts of the British Islands at the same period, and even to suppose the sea to increase in depth in the direction of Devonshire and Cornwall, so that while shingles were accumulating round the dry lands, sands and mud were there drifted. The researches, begun by Mr. Griffiths, which have shown that the probable equivalents of certain North Devonian beds are found in Southern Ireland above the old red conglomerate, bear out this view. Mr. Nicol, while pointing out the absence of fragments of the so-called primary rocks in the older palæozoic rocks of the valley of the Tweed, infers that the igneous agencies which metamorphosed the rocks of the Scottish Highlands into gneiss and mica-slate also crushed and folded the older palæozoic rocks of the Tweed; and as fragments of the gneiss and mica-slates are included in the old red sandstone series of Central Scotland, that this happened at the time before-mentioned, namely anterior to the formation of the old red sandstone. When we regard the evidence respecting the intrusion of the granite of South-Eastern Ireland, connect it with the alteration of the rocks in contact with the granite, and look to the probable date of such intrusion, as far at least as known researches would seem to give it, other portions of the area now occupied by the British Islands would appear to have been exposed to similar geological action at the same period. We must not hence infer that all the British granitic intrusions were of the same date, for there is good evidence to show that the protrusion of the Devonian and Cornish granites was effected at a subsequent period, one posterior to the formation of at least a part of the palæozoic coal-measures, and probably to all those in our islands.

We cannot avoid calling attention to the striking general resemblance between the conglomerate accumulations of the old red sandstone around and over the upheaved and contorted beds of the older palæozoic rocks, and that of the new red sandstone series of England around and over the upturned and often bent and contorted beds of the newer palæozoic rocks, and indeed upon the upturned edges of the old red sandstones themselves. In like manner we have to infer dry land, with its coasts broken into bays and headlands, seas of different depths, the deposits in which were charged with peroxide of iron, and conditions unfavourable for the entombment and probably the existence of animal life in such seas. For both we have to suppose submergence of the land, and an accumulation of shingles over shingles upon coasts, as also occasionally conditions permitting the protrusion of shingle-banks far outwards. The extent to which all parts of the land may have descended is not clear; portions may here and there have remained from that time to the present in the atmosphere, but we do know that the deposits of the time covered ground now high elevated above the sea. Patches of these now alone remain scattered at various distances from each other, and attest the denudation which the whole deposit has suffered in such situations from the combined action of atmospheric influences and of breakers wasting away the lands as they gradually rose above the sea, and indeed, in some cases, during many a rise and depression producing changes in the relative level of sea and land.

Regarding palæontology we have received several communications. The first paper read was from Mr. Salter on the structure of Trinucleus, with remarks on the species, in which the author, after adverting to the name as that of Llwyd, given so far back as 1698, and revived by Sir Roderick Murchison, describes this genus, the individuals composing the species of which are so abundant in the Silurian rocks, especially in the lower division of them. Mr. Salter more particularly points out the peculiar perforate border as a highly interesting part of these animals. It would be difficult to explain the author's description without the aid of his figures, but he endeavours to show that the punctate or plicated fringes are only modifications of each other, adding that these perforate or spinous fringes are not essential, but only supplementary parts of the head; the width of the head, without the fringe, being exactly that of the body; so that when the animal is doubled up, the fringe projects freely on all sides. Mr. Salter then proceeds to consider a subject of much importance, especially when the Trilobites of different and distant localities are under consideration, namely the identity or distinctness of Trinuclei referred, or to be referred to the species *T. Caractaci* (Murchison). From the examination of specimens, he considers that *Trinucleus ornatus* of Sternberg, *T. tessellatus* and *T. Bigsbii* of Green, *T. Caractaci* of Murchison, *T. elongatus* and *T. latus* of Portlock, and *T. Goldfussii* of Barrande, are all the same species, for which he would preserve the name of *Trinucleus ornatus*, that having been first given by Sternberg. Of this species four distinct varieties are admitted:—1. *Sternbergii* (Salter); 2. *Caractaci* (Murchison); 3. *elongatus* (Portlock); 4. *favus* (Salter). Five species of the genus Trinucleus are known to Mr. Salter, namely *T. ornatus*, Sternberg, *T. seticornis*, Hisinger, *T. granulatus*, Wahlenberg, *T. fimbriatus*, Murchison, and *T. radiatus*, Murchison.

Mr. Lyell in his paper on the coal-field of Eastern Virginia has figured certain bivalves found in the carbonaceous shales associated with the main coal seam. They are discovered in multitudes, dividing the shale into thin laminæ like plates of mica, and resemble Posidonomya, and more than any other *P. minuta*. He also figures and describes, chiefly from notes supplied by Prof. Agassiz and Sir Philip Egerton, ichthyolites obtained from the same coal-field. These consist of *Dictyopyge macrura* (*Catopterus macrurus* of Redfield), the most abundant species; a second species of *Dictyopyge*, and a *Tetragonolepis*.

Our Foreign Secretary, Mr. C. Bunbury, has given us detailed descriptions of fossil plants from the same coal-field, and brought to this country by Mr. Lyell. He enumerates—1. *Tæniopteris magnifolia* (a fern first noticed by Prof. Rogers); 2. *Neuropteris linnææfolia* (n. sp.); 3. *Pecopteris Whitbiensis*; 4. *Pecopteris* (Aspidites) *bullata* (n. sp.); 5. a questionable *Pecopteris*; 6. *Filicitus fimbriatus*; 7. *Equisetum columnare*; 8. *Calamites arenaceus* (Rogers); 9. another *Calamite*, probably the young plant of the above; 10. *Zamites obtusifolius* (Rogers); 11. *Zamites gramineus* (n. sp.?); 12. a questionable *Sigillaria* or *Lepidodendron*; 13. casts of small portions of a decorticated stem a little like those of some Lepidodendra; 14. a doubtful *Knorria*; and 15. indeterminable fragments of a plant apparently with verticillated grass-like leaves. Figures accompany the descriptions Nos. 2, 4 and 6 of the above-mentioned fossil plants.

To Sir Philip Egerton, who has so successfully studied fossil fish, the Society is indebted for a communication on the Nomenclature of the Fossil Chimæroid fishes, in which he rectifies errors previously committed, and proposes to divide these fossil fishes into four genera, namely *Ganodus* (Egerton), *Ischyodus* (Egerton), *Edaphodon* (Buckland), and *Elasmodus* (Egerton). The first genus contains ten species, all from the Stonesfield oolite; the second nine species, from the chalk marl and greensand, the gault, the Portland beds, the Kimmeridge clay, the Caen oolite, and the lias; the third genus contains seven species, from the Bagshot sands and Bracklesham beds, the *molasse* of Switzerland, the chalk, and greensand; the fourth, two determinable and one unnamed species, from the Sheppey and Bracklesham beds, and from one unknown locality. Thus, these remarkable fishes have existed from the time of the lias to the present day, and the researches of Sir Philip Egerton have shown their range through geological time, established three new genera, and added no less than thirteen new species to the same number of species previously figured or described by Dr. Buckland, Prof. Agassiz, and Prof. Owen.

In his microscopical observations on the structure of the bones of *Pterodactylus giganteus* and other fossil animals, Mr. Bowerbank gives a detailed account of his researches into the forms of the bone-cells of man, and of recent or fossil birds, reptiles and fishes, and considers that these forms furnish characters sufficiently distinct to permit their classification; thus while the proportion of the length to breadth in the bone-cells of man are represented to be as 1 to 4, that of the albatros is as 1 to $6\frac{1}{4}$, of a fossil bone of a bird from the Wealden 1 to $5\frac{1}{4}$, of the *Thylacotherium Prevostii* 1 to $4\frac{1}{8}$, of the common frog 1 to $11\frac{3}{4}$, of the *Boa constrictor* 1 to 11, and of a Pterodactyle jaw 1 to 11: other examples are given, as also considerable detail, requiring the plates for their proper appreciation. Mr. Bowerbank considers that the aid of the microscope may thus be most advantageously employed to determine the class of animals to which doubtful fossil bones may belong. From his researches he refers certain bones from the chalk, considered to be those of birds, to the Pterodactyle, and states that they confirm the views taken by Professor Owen respecting the mammalian character of the disputed remains discovered in the Stonesfield slate.

In his paper on the so-called nummulite limestone of Alabama, Mr. Lyell cites the opinion of Professor E. Forbes and Mr. Lonsdale that the supposed nummulites were in reality zoophytes, referable to the genus *Orbitolites*. Professor Forbes observes that the *Orbitolites complanata* of the Paris tertiary series is very nearly allied to the American fossil (*Nummulites Mantelli*), and that the *Orbitolites elliptica* of Michelin (from Nice) and that author's *Orbitolites Prattii* are nearly-allied species. He refers also to disciform bodies discovered by Mr. Beete Jukes in Australia, in great numbers upon marine plants resembling *Zostera*, and when dead in great abundance in mud from various depths under seventeen fathoms, considering them as belonging to the same generic group with the tertiary *Orbitolites*. Mr. Lyell also quotes the opinion of M. d'Orbigny that the American specimens sent to him are referable to his genus *Orbitoides*, one nearly allied to *Orbitolina*. In consequence of these determinations Mr. Lyell concludes that the fossil in question will henceforth be known as *Orbitoides Mantelli*, retaining the specific name first given to it by Dr. Morton. As *Orbitolites* have been frequently taken for *nummulites*, the strict determination of them is important geologically.

Our colleague Professor Owen has presented us with an account of the fossil remains of mammalia referable to the genus *Palæotherium*, and to two genera, Paloplotherium and Dichodon, hitherto undefined, from the Eocene sand of Hordle, Hampshire. He is led to suspect that the species of Palæothere represented by a lower jaw and teeth may be distinct from the Palæotherium medium of Cuvier, while the distinctive position of another lower jaw is more doubtful, and he consequently registers the Hordle fossils provisionally under the name of *Palæotherium medium*. After describing in great detail the specimens which have afforded him the data for the genus *Paloplotherium*, carefully comparing them with all that is known respecting allied forms, Professor Owen notices a subject of much interest with respect to the entombment of some of these mammalian remains. He states, after mentioning the effects of force on a head of Palæotherium due to pressure before the rock in which it was inclosed had hardened, that there are other marks of violence, as if a crocodile had seized the animal, a young one, for his prey, the skull exhibiting marks as if produced by two distinct bites, the head having been turned half round between them. "At all events," he observes, "it is plain that the violence inflicted upon the head of this young pachyderm has been received before the skull became imbedded in the eocene mud, and that the matrix hardening around it has preserved the evidence of the nature of the injuries received to this day. The points of the great canine teeth of old crocodiles," he adds, "not unfrequently become so blunted as would produce such crushed and depressed fractures without penetrating more deeply."

To the extinct crocodile the remains of which are common in the same beds in which the Palæotherium was found, Professor Owen assigns the name of *Crocodilus Hastingsiæ*. He afterwards presents us with a detailed account of the teeth and lower jaw of an extinct species of mammal belonging to the section of hoofed quadrupeds, and forming the type of a new genus to which he gives the name of *Dichodon*.

In another communication Professor Owen notices the occurrence of the fossil remains of the *Megaceros hibernicus* (commonly known as the 'Irish elk') and of the *Castor europæus* in the pleistocene deposits forming the brick-fields at Ilford and Grays-Thurrock, Essex, thus confirming his statements as to the occurrence of the remains of the so-called Irish elk in England. He also remarks that the remains of the Megaceros, found in England, have been mistaken for those of *Bos*, and points out the difference between the teeth of the great Bovines and Megaceros. The teeth of the *Bos longifrons* being smaller than those of Megaceros are readily distinguished by their size.

Professor Owen observes that the *Bos longifrons* coexisted with *Megaceros* in Ireland, and with *Megaceros, Rhinoceros, Elephas, Hyæna*, &c. in England, and that the remains of *Bos longifrons* have been found in ancient places of sepulture, and are so associated with British and Roman works "as to leave little doubt of its having survived, as a species, many of the mammals with which it was associated during the pleistocene period." The Professor conceives that as yet no good evidence has been adduced to show the coexistence of man and the Megaceros.

We have also to record the reading of another communication to the Society by our colleague, Professor Owen, one entitled "A description of teeth and portions of jaws of two extinct Anthracotherioid quadrupeds, *Hyopotamus vectianus* and *H. bovinus*, discovered by the Marchioness of Hastings in the eocene deposits of the N.W. coast of the Isle of Wight, with an attempt to develope an idea of Cuvier's on the classification of pachyderms by the number of their toes." After a careful detail and comparison of teeth, the Professor points to a general type of configuration ("a quadrate crown with four principal pyramidal and more or less triedral lobes divided by deep valleys, not filled up by cement, but in some genera interrupted with minor tubercles and ridges,") which "characterises a great natural group of *Ungulata*, most of the members of which are extinct, but which tend to fill up, in the zoological series, the wide interval that now divides the Peccari or the Hippopotamus from the Ruminants." "The generic or subgeneric modifications of structure," adds Professor Owen, "at present recognised in this great natural group, are signified by names given to the partially restored genera :—

"*Anthracotherium.*
"*Hyopotamus.*
"*Merycopotamus.*
"*Hippohyus.*
"*Chæropotamus.*
"*Adapes.*
"*Dichodon.*
"*Hyracotherium.*

Calicotherium.
" *Dichobunes.*
" *Anoplotherium.*
" *Hippohyus* and *Chæropotamus* seem to have stood nearest to the existing Peccari and the Hog tribe: *Anthracotherium* or *Merycopotamus* were perhaps more nearly allied to Hippopotamus. Cuvier thought the *Anoplotherium* to bear a close affinity to the Camelidæ, and *Dichobunes* seems to have approached the Musk-deer (Moschidæ)."

In this communication Professor Owen shows that to his catalogue of extinct British mammals we have now to add two quadrupeds, one as large at least as the tapir, the other as the boar, with the full complement and kinds of teeth characteristic of the typical *Ungulata*, viz.:—$in\ \frac{3-3}{3-3};\ c\ \frac{1-1}{1-1};\ p\ \frac{4-4}{4-4};\ m\ \frac{3-3}{3-3} = 44.$

In the second part of this memoir, Professor Owen enters upon large and general views, combined with the needful comparisons, respecting the *Ungulata*, the characters of which are given as follows:—

I. *Artiodactyla.* Hoofed quadrupeds with toes in even number, as two or four, and which have a subdivided or complex stomach, and a moderate-sized simple cæcum. Ex. *Ox, Hog, Peccari, Hippopotamus.*

II. *Perissodactyla.* Hoofed quadrupeds with functional toes on the hind foot in uneven number, as one or three, and which have a simple stomach, and an enormous or complex cæcum. Ex. *Horse, Tapir, Rhinoceros, Hyrax.*

III. *Proboscidia.* Resembling the preceding in having toes in uneven number (5), a comparatively simple stomach, and an enormous cæcum, but combining, with a long proboscis, so many peculiarities of structure as to merit the rank of a distinct group of *Ungulata.*

Professor Owen, endeavouring to see, as he says, whither and how far the thread of comparative anatomy may guide us in the maze of the affinities of the recent and extinct animals with hoofed extremities, observes, " It is evident at the first glance that the known genera cannot be ranged in a single linear series in the order of their natural affinities: it will be equally evident," he continues, " by the digital, the osteological, dental, and visceral characters adduced, that the horse is not the next of kin to the camel or ox, even among existing genera, but that the proboscideans apart, all the other ungulate quadrupeds are divisible into natural, and, upon the whole, parallel series, having respectively the *Anoplotherium* and *Palæotherium* as their types, which genera, so far as our actual knowledge extends into the dark vistas of the past, were their first, or amongst their earliest representatives on this earth. The known families or genera of the odd-toed and even-toed hoofed quadrupeds respectively headed by these two extinct genera, may be ranged as follows: but much additional special knowledge must be obtained before their order of juxtaposition can be precisely determined."

UNGULATA.

	Artiodactyla.	*Perissodactyla.*
Ruminantia.	Anoplotherium.	Palæotherium.
	Chalicotherium.	Paloplotherium.
	Dichobune.	Lophiodon.
	Cainotherium.	Coryphodon.
	Xiphodon.	Tapirus.
	Moschus.	Macrauchenia.
	Antilope.	Nesodon.
	Ovis.	Hippotherium.
	Bos.	Equus.
	Cervus.	Elasmotherium.
	Camelopardelis.	Hyrax.
	Camelus.	Rhinoceros.
	Merycotherium.	Acerotherium.
Non-Ruminantia.	Merycopotamus.	
	Hippopotamus.	
	Dichodon.	
	Hyracotherium.	
	Hyopotamus.	
	Anthracotherium.	
	Hippohyus.	
	Chæropotamus.	
	Adapis (?).	
	Dicotyles.	
	Phacochærus.	
	Sus.	

It is difficult to contemplate a catalogue of this kind without being impressed with the important aid which Geology and Comparative Anatomy have afforded to each other. To those who in years past were struck with the discoveries of the great author of the 'Ossemens Fossiles,' and have traced the addition after addition since made to our knowledge of the forms of vertebrate animals which have existed prior to our day; delighting alike in contemplating the linking together of these forms by fresh researches, and the history they afford us of the additions to, and changes in terrestrial animal life effected upon the earth's surface in such comparatively recent geological times, these labours of our colleague cannot but afford the highest interest. Let us hope that the researches of geologists may present him with an abundance of materials for thought and description, and that the meetings of this Society may continue to be enriched by his communications.

We have next in the order of papers to refer to a communication from Mr. Richard Brown, in which he considers that he has discovered evidence, in the palæozoic coal-field of the island of Cape Breton, of the connection of Stigmaria-form roots with a stem of *Lepidodendron*. An interesting figure accompanies his description of a fossil plant, supposed to belong to the *Lepidodendra*, found above the Sydney main coal. This is a subject well-deserving of attention. That the plant named *Stigmaria fucoides* is a root, may now be considered as an opinion somewhat commonly adopted. The geological inferences thence arising are highly important, more especially when we refer to the conditions under which our palæozoic coal has been usually formed.

Mr. Sharpe, in his paper on the fossil remains of Mollusca from the Palæozoic Formations of the United States contained in the collection of Mr. Lyell, besides a comparison between the older fossiliferous accumulations of North America and of Europe, and a list of the published species of Mollusca recognised in that collection, enters into a more detailed examination of some of the species contained in that list. He thus passes under review *Avicula Boydii, A. quadrula, A. naviformis, Leptæna demissa, L. depressa, Orthis carinata, O. parva, Pentamerus galeatus, Spirifer biforatus, Sp. macronotus, Sp. plicatus,* the genus *Strophomena, Terebratula aspera, T. unguiformis,* and *Porcellia ornata.*

The same collection afforded Mr. Sharpe the data for a new genus, belonging to the Brachiopodous Mollusca and named by him *Trematis,* an account of which formed another communication to the Society. In general appearance this shell is similar to *Orbicula,* in which genus it has hitherto been placed. It "differs from *Orbicula* in the punctated structure of its shell, and in having the valves united by a hinge, while it is distinguished from *Terebratula* and the other hinged forms of Brachiopods by the ligament passing through the ventral valve. It thus forms a connecting link of great interest between several genera." The species of *Trematis,* described as *Orbiculæ,* are considered Lower Silurian fossils. Three American and one English species are described by Mr. Sharpe.

Appended to the communication of Prof. Sedgwick on the Fossils of the Skiddaw Slates, is an account by Mr. M'Coy of those fossils, in which, after noticing the occurrence of *Graptolites sagittarius,* he describes a graptolite as new under the name of *G. latus,* and also as hitherto unnoticed, two species of fucoids, *Chondritis informis* and *Ch. acutangulus.* He also considers that there are sufficient data on which to found a new genus, under the name of *Palæochorda,* describing two species, *P. minor* and *P. major.*

Those present at our last ordinary meeting in this room must have been gratified by the exhibition of the mass of bones of the Dinornis and other fossil birds of New Zealand, collected there by Mr. Walter Mantell, son of our colleague, Dr. Mantell, who at the same meeting communicated a paper to us on these bones, chiefly however with a view of illustrating their mode of occurrence in the deposits of New Zealand. The collection of bones was the finest hitherto made and transmitted to this country. "It consists of between 700 and 800 specimens, the bones belonging to birds of various size, and periods of growth," some, Dr. Mantell observes, "of aged individuals and others of very young animals, in which the epiphyses of the long bones are still distinct from the shaft."

As Prof. Owen was the first to make us acquainted with the gigantic birds known to the natives of New Zealand as the Moa, and to which he assigned the name of Dinornis, the views of this comparative anatomist, since so well borne out by abundant proof, being founded on a mere shaft of a thigh-bone a few inches long, with both extremities deficient,—a beautiful illustration of the chain of inferences so strikingly pointed out as available by the great Cuvier,—Dr. Mantell, in the true spirit of science, at once placed the collection at the disposal of the Professor for examination.

As far as the researches of Prof. Owen have as yet extended, the bones sent home by Mr. Walter Mantell are referable to five genera, the crania and mandibles of four of which were previously unknown. The first genus is the Dinornis, "now restricted by Prof. Owen to the birds which possessed a skull and beaks essentially different from any form either recent or fossil." The form of the cranium, especially of the temporal and occipital regions, is wholly unlike any hitherto observed in the class of birds, and approaches that of reptiles. Of this genus seven species have been determined, namely, *Dinornis giganteus, D. robustus, D. ingens, D. casuarinus, D. geranoides, D. curtus, D. didiformis*. Some of the bones of this genus, even those of young birds, were of colossal proportions.

The second genus is *Palapteryx*; the third, *Aptornis*; the fourth, *Notornis*; and the fifth, *Nestor*, a genus of nocturnal owl-like parrots, of which only two living species are known, one (*N. hypopolius*) restricted to New Zealand, the other (*N. productus*) to Phillip Island, one not more than five miles in extent. What further researches may find in this collection, which also contains fragments of egg-shells, remains to be ascertained: enough, however, has already been accomplished to afford most important additions to our knowledge of those remarkable birds, the Moas, some of which, at least, may have lived to a period comparatively as recent as the first entrance of man upon the New Zealand islands; thus occupying a place of somewhat the same kind with the Dodo in geological history.

To the mode of occurrence of these bones we shall have to refer hereafter in its place, but we must not here omit the remarks of Dr. Mantell, accompanying this communication, respecting the present grouping of peculiar forms of animals and plants upon different areas of dry land, constituting centres or foci of creation of certain organic types; nor those bearing upon peculiar faunæ and floræ, the remains of which are found entombed in various fossiliferous deposits. He calls attention to the fauna of New Zealand, in which the class of birds so prevails, to the almost entire exclusion of mammals and reptiles; and associating this fauna with the flora of the same country, wherein ferns, club mosses, &c. predominate to the almost entire exclusion of the graminaceæ, compares the whole with the fossils discovered in the carboniferous and triassic rocks. Dr. Mantell then adverts to the peculiar fauna and flora of Australia and Tasmania, to which allusion is elsewhere made, and their bearing upon the European deposits of the oolitic time, remarking also upon the reptilian character of the fauna of the Gallapagos Islands, distant from other lands. Quoting Mr. Darwin as stating these islands to form a little world within themselves, most of the aboriginal creations being found nowhere else, and the land itself upon which they exist being the result of igneous action at a comparatively recent geological period, he refers us to the time of the Wealden, when we must have had lands in the area of the British islands replete with reptilian forms.

Dr. Mantell concludes that "throughout all geological time the changes on the earth's surface, and the appearance and extinction of peculiar types of animals and plants, have been governed by the same physical and organic laws; that the paroxysmal terrestrial disturbances, though apparently in the earlier ages involving larger areas, and operating with greater energy than the volcanic and the subterranean action of modern times, did not affect the established order of organic life upon the surface of the globe, and that, throughout the innumerable ages indicated by the sedimentary formations, there was at no period a greater anomaly in the assemblage of certain types of the animal and vegetable kingdoms than exists at the present time."

With respect to the manner in which organic remains have been mingled with mineral accumulations in former geological times, the memoirs presented to the Society accord with the increased attention of late years paid to this subject. Mr. Beete Jukes, in his notes on the palæozoic formations of New South Wales and Van Diemen's Land, when describing the sandstones (named Wollagong) associated with shales and a few beds of coal in the vicinity of Sydney, remarks, that as the higher beds and coal-seams are approached, the sandstones become charged with great quantities of fossil wood, the fragments with their edges rounded and worn, having evidently been pieces of drift-wood before they were enveloped by the sand of the sandstone rock. Mr. Beete Jukes was particularly struck with the resemblance of these fragments to common drift-wood on a beach, and could scarcely avoid considering them as such, until undeceived by finding them included in the solid beds. Assuming that in this case we have evidence of a littoral deposit, it would follow, that to account for a continued succession of beds so characterized,—and the sandstones with their associated shales and coal are estimated at 300 to 400 feet in thickness,—a continued and slow depression of the land, as regards the level of the sea, would be needed. The evidence, if any, in favour of the growth of the plants forming the associated coal is not given, but the shallow water or littoral character of the wood-bearing arenaceous deposit accords well with that of the coal accumulations of different geological ages known elsewhere.

In the same communication Mr. Beete Jukes states, that the igneous rocks of the Macquarrie Plains, above New Norfolk, in Tasmania, appear to him to have flowed in the open air, and while in a fluid molten state to have caught up, while living, the trees now so well known as found fossil in that district. It may be here observed, that while this might happen, the showering forth of lapilli and ashes from a volcanic vent would afford conditions very favourable for the entombment of trees in the position in which they grew, and we know that by the binding together of the volcanic ashes of former geological times, chiefly by silica, rocks have been formed as solid as greenstone.

The communication of Mr. Anthony on the impression of the soft parts of an Orthoceras in a shale, frequently termed *marlite*, occurring interstratified with limestone in the group of the palæozoic rocks of North America, to which the name Hudson's River group has been given, affords us an additional example of the excellent preservation of organic remains, where a fine argillaceous sediment has accumulated upon them. The shale or *marlite* in question is described as occurring of unusual thickness where the Cincinnati Astronomical Observatory has been erected, and in it numerous fossils were discovered beautifully preserved; among others Orthocerata, frequently measuring more than three feet in length. The smaller specimens were found encased in a sac, this sac of an oval form, about twice the diameter of the enclosed Orthoceratite, enveloping its whole length, like it flattened, and with a longitudinal impression throughout. Mr. Anthony supposes that the Orthoceras was furnished with a fleshy body, like the Sepia and its kindred cephalopods, or perhaps like the Belemnite with its accompanying ink-bag. It will be in the recollection of the Society that Colonel Portlock figured similar appearances in 1843, the Silurian slates of Tyrone having furnished several examples; indeed he founded his genus of Koleoceras upon them, so that be the impressions surrounding the Orthoceratites what they may, when these remains have been covered over by fine sedimentary matter, similar appearances are observable both in America and in Europe.

Mr. Lyell, in his paper on the structure and probable age of the coal-field of Eastern Virginia, describes Calamites and Equiseta, especially the former, as found standing erect, and as not confined to one geological level, but as occurring at various heights in the series, and at points widely different. He considers that they were not drifted, but grew on the area where we now find them, and infers the constant proximity of land, the drainage of which may have supplied a body of fresh water. Mr. Lyell sees no character in any of the fossils of this coal-field inconsistent with the hypothesis that all the beds may have been accumulated in a lake, estuary or delta. The fossil plants are inferred to have been all terrestrial, while too little is known of the genus Posidonomya to permit us to reason on its habits; and as to the fish, Sir Philip Egerton informed Mr. Lyell that the Tetragonolepis of the British lias is accompanied by Lepidotus, a genus common in the freshwater strata of the Wealden rocks of England. The coal itself occurs in three or more distinct beds, the chief of which appears to be thirty to forty feet in depth, a thickness requiring the accumulation of a vast amount of vegetable matter to produce it. The mass of sandstones, shales, and remains of vegetation of which this coal-field is composed, reposes in a kind of basin-formed cavity on granite, hornblendic and other rocks of older date, the beds dipping inwards. The view taken by Mr. Lyell, that the plants grew where now found, having been covered up by mud and sand during a gradual subsidence of the whole region, is one in harmony with that which, from an increased knowledge of facts, has now become so common with respect to the palæozoic coal deposits of Europe and North America; the view in this case, as we shall hereafter see, having reference to a coal accumulation formed at a less ancient geological date.

Mr. Prestwich, in his communication on the London clay, incidentally mentions that at Clarendon Hill and at the Cuffell cutting the shells of *Panopæa* are abundantly found in a vertical position, similar to that which the recent species assume in their living habitats at the present day, proving the quiescent deposition of these portions of the strata. He also states that Dr. Fitton had called his attention to the occurrence of *Panopæa* and *Pinna* in the same position in the lowest beds of the lower greensand. In the same clays with the *Panopæa*, Mr. Prestwich observed *Pholadomya* and *Pinna*, the latter attaining a large size at Cuffell, also in a vertical position.

It may be scarcely necessary to advert to the advantage, indeed necessity, of strictly observing the position in which organic remains are found in the rocks containing them, as also their distribution, the association of the different species, and the proportion of the individuals of different kinds, if we are to have sufficient data on which to reason correctly on their mode of occurrence, and upon the conditions under which ancient life may have existed during the lapse of geological time. The ordinary catalogues of organic remains seldom furnish us with any information of the kind, some rare species of mollusc occupying a place as important as those, the mode of occurrence, distribution and abundance of which really afford us the information required, and on which we should reason. While on this subject, it may be desirable to call attention to a table by Dr. Fitton, in the last volume of our Journal, and dated October 1847, wherein symbols are employed to show when certain species first appear, when repeated, when disappearing, or when only discovered in one bed, in a series of deposits of the Lower Greensand, exhibited in a coast-section from Atherfield Point to Black-Gang Chine in the Isle of Wight. This table not only contains a list of all the organic remains known in the Atherfield section up to the date of publication, but also presents us with a lithological detail of the various groups, amounting to sixteen, into which Dr. Fitton has considered it desirable to divide the succession of beds. An easy system of reference having been adopted, and the table being surmounted by two sections of the coast, a valuable mass of information is at once presented to our attention respecting a succession of sedimentary accumulations and the distribution of organic remains in them for a thickness of 808 feet.

Reasoning upon the equivalents of the tertiary deposits in the London and Hampshire districts, Mr. Prestwich observes, that he would not restrict the synchronism of the Bognor beds of Hampshire to the lower part only of the London clay of the London district, considering that the conditions which in the Isle of Wight area were favourable to the prolonged existence of the animals, the remains of which are characteristic of the beds of the London clay, were modified as we approach the site of London by a greater depth of sea, whereby the shallow-water and littoral fauna of the Bognor deposits had its character altered by new forms, such as the Nautilus, Pentacrinites and other deeper sea animals, the remains of which abound in the London clay near London.

When we regard the mode in which organic remains may become mingled with the mineral matter in which they may be found, it is very important to consider the character of the latter immediately in contact with the former. Physical conditions can so readily have changed during the accumulation of a series of beds, that greater or less portions of subaqueous areas upon which certain kinds of animals may exist under the circumstances best fitted for them, may become so modified or even wholly changed as respects such conditions, that the animals become scarce or disappear; and yet a return of the needful conditions may enable germs borne from some locality where the physical circumstances have remained suitable to the existence of their parents, to establish themselves, and the mineral accumulations of the locality be again charged with the harder remains of this species as heretofore. Mud, under the needful conditions, can be accumulated in waters of very varied depths, and gravels which could, under ordinary circumstances, be only formed or accumulated in shallow situations or beaches, might be depressed, and not be covered by any other deposits, until the remains of animals, which could then be entombed, no longer belonged to the class of those which lived in shallow water. Indeed it might so happen that some of the animals inhabiting the bottom, after the depression of the gravel, might penetrate among the pebbles, particularly if large, so that in after geological times the upper portions of such a gravel may contain the remains of animals which did not live in the situations where the gravel was either formed or accumulated. Touching the chances of such changes of conditions, it may be observed, that there is no want among the coasts of the world of irregular fringes of gravel and shingle along lines of deep sea-coasts, where, if depressions of the land, relatively to the sea, did take place, such shingle accumulations might descend into seas to which little sand, and even little mud, could be for a long period borne, though no doubt from changes of physical conditions, such as the study of geology teaches us have often taken place, any such mass of shingles may finally become well covered by arenaceous and argillaceous accumulations.

That the mass of coal-bearing beds of the palæozoic period were accumulated in shallow water, a gradual subsidence of the land taking place, the coal-beds themselves being the remains of plants which have grown in the atmosphere and upon the subjacent deposits on which they repose, when the accumulations became such as to reach to the surface, has now become a common opinion. Still every additional good evidence on this point is not without its value. Mr. Richard Brown, in his description of an upright stem above the Sydney main coal, in the island of Cape Breton, wherein he concludes that *Stigmaria* roots are attached to a stem of *Lepidodendron*, shows that this plant grew where it is now found, its roots spreading out above the coal-bed, its stem rising vertically above the roots. From the arrangement of shale in nearly horizontal layers in the roots, fern-leaves being interposed between the layers of shale, Mr. Richard Brown infers that the roots were hollow before the mud, which now forms the shale, was accumulated round this plant. It may not be out of place here to remark on the frequent evidence we have in the palæozoic coal-measures of upright stems, some certainly those of large *Sigillariæ*, which were hollow before they were completely entombed in the mud, silt, or sand now consolidated around and in their remains. These plants seem often to have continued standing while several feet of detritus were accumulated around them, the upper parts finally becoming too much decomposed to resist pressure upon them. The accumulations of mud, silt, or sand, as the case might be, with any plants drifted with them, then fell over into the hollow, and there often settled in layers, separated from the main accumulations outside by the bark, now found so commonly converted into coal.

Concluding that the evidence is good respecting the connection of Lepidodendron stems with Stigmaria roots, Mr. Richard Brown infers that all the large trees which flourished at this period were furnished with roots of a similar character, especially adapted to the soft muddy ground in which they grew.

In his memoir on the mineral character and fossil conchology of the Great Oolite near Minchinhampton, Mr. Lycett presents us with a list of 104 Conchifera, 44 Monomyaria, 7 Brachiopoda, 135 Gasteropoda, and 8 Cephalopoda, with 9 Radiaria, making a total of 317 species, discovered in the 130 feet of that member of the oolitic series as developed in that vicinity. It should however be observed, that about 128 of these species are considered to be undescribed, and that figures and descriptions of them are not given in the memoir. Mr. Lycett directs attention to the excellent preservation of the fossils in the locality he notices, one comprised within a radius of three miles, the external ligaments of the bivalves and coloured markings of the univalves being not unfrequently preserved. Though the area is so limited it is rich in organic remains, and Mr. Lycett remarks, that when collating the fossil forms in it with those from foreign countries, it is remarkable how few are found to be identical, though there is a strong family resemblance, and observes that the small size of the area described is advantageous so far as it exhibits the grouping or assemblage of contemporaneous species, free from the doubt which sometimes exists with respect to fossils collected over a more extended district. He then states that out of 127 species of univalves found, and exclusive of *Cephalopoda* and *Radiaria*, no less than forty-one are carnivorous, six others belonging to a genus (*Phasianella*) the recent species of which are both phytophagous and carnivorous, "thus presenting a proportion of species in the zoophagous tribes not very different from that which obtains in warm seas of the recent period." Our author then adverts to the scarcity of Cephalopods. Of Belemnites there is only one small species, and the individuals few; only two species of Nautilus; and Ammonites are so rare, that of five species Mr. Lycett has seen only forty individuals. Referring to the abundance of Cephalopods before and after the accumulation of the great oolite, he asks, if the distribution of families at this period was general or local, in the latter case dependent on conditions obtaining only within certain limited areas, so that, these ceasing, changes in the kind of animal life of the locality were effected also. After noticing the mineral character of the great oolite of Minchinhampton, he concludes that a littoral deposit, such as he considers this to have been, will account for the paucity of Cephalopods and the absence of species found over large areas where deeper and more tranquil water prevailed.

Detailing the mineral and zoological characters of the various beds observable in a large quarry on Minchinhampton Common, Mr. Lycett mentions a soft shelly sandstone, six feet thick, resting on another shelly sandstone abounding in carbonate of lime, both of which exhibit numerous holes made by lithodomous molluscs, some of the holes still containing their shells. This shows pauses in the accumulations sufficient for the consolidation of beds, thus enabling these molluscs to bore fitting habitations for themselves. It is another instance, in a higher part of the oolitic series, of similar pauses, consolidation of beds, and boring by lithodomous molluscs, which we have elsewhere pointed out as observable in the inferior oolite at Ammerdown, near Kilmersdon, northward of the Mendip hills in Somersetshire, and at Doulting, on the south of the same hills. The boring by lithodomous molluscs into the carboniferous or mountain limestone of the Mendip hills, at the time of the accumulation of the inferior oolite beds, even through oyster shells, adhering now, as they did in the lifetime of the animals, to the subjacent carboniferous limestone, is well known. Their occurrence in the beds of the oolitic series is, however, still more geologically important, as it marks, though it may be locally, certain minor divisions in the geological time during which the series, up to the great oolite inclusive, was deposited. Similar borings, of the date of the inferior oolite, have been observed by Dr. Buckland and myself near Bridport, on the coast of Dorsetshire, and it would be well to search for evidence of this kind, or of any other, such as that seen in certain localities where the Bradford encrinites still adhere to the beds on which they grew, marking pauses in the accumulations known as the oolitic series generally.

Respecting the mode of occurrence of the Dinornis and other remarkable birds found fossil in New Zealand, and previously mentioned, Dr. Mantell has presented us with all the information which has up to the present time reached this country. This inquiry was attended with much difficulty, in consequence of the unsettled state of the orthography of the various localities where the fossil bones were obtained, and from the indefinite manner in which the collectors described those localities. They would appear to occur in gravel and other detrital beds cut through by the rivers, the bones being thus laid bare, and perhaps sometimes swept into other places, and again covered by mud and silt. In one locality they were found in peat exposed at low water, but covered at high tides. Again they are discovered in heaps, as if the birds had been eaten and the bones thrown indiscriminately together. According to the Rev. Mr. Taylor, the bones of the Moa (Dinornis) are found in a bed which is elsewhere covered by marine and freshwater deposits. Dr. Mantell remarks that the bones obtained from the various localities he enumerates, excluding those whence Mr. Walter Mantell procured his specimens, were in a state similar to that in which the bones of the Megaceros, Elephants, and other animals are found in the superficial accumulations of England.

The bones obtained by Mr. Walter Mantell presented a different aspect, being light and porous, and of a delicate fawn-colour. The remains are beautifully preserved, not only egg-shells and mandibles, but even also the bony rings of the air-tubes being uninjured. They were entombed in a loose volcanic sand, beneath pebbles and rounded portions of igneous rocks. In the sands there were no vestiges of molluscs of any kind. Dr. Mantell supposes Waingongoro, the river near the embouchure of which the bones were obtained, for maps do not contain the name, to have its origin in the volcanic regions of Mount Egmont, many parts of which rise above the line of perpetual snow. Terraces of loam and gravel, of comparatively recent formation, occurring from 50 to 100 feet above the sea along the coasts of New Zealand, are considered to prove changes in the level of sea and land at no remote period. The present rivers of the country are represented as cutting through the beds in which the birds' bones are contained, a fact in accordance with the supposition that changes of level had been effected after the remains of Dinornis and other birds were entombed in the mud and silt, peat, or volcanic ashes, as the case might be, since the uprise of the land would cause so much increased fall through previous level or nearly level districts, that the rivers would attain greater velocities over given distances, and consequently greater cutting powers into old channels.

We can scarcely yet consider ourselves possessed of sufficient information to say how deep down among the geologically more recent accumulations of New Zealand the bones of the Dinornis and other associated birds may be found. More extended researches will no doubt show this: in the mean time the information collected is extremely interesting. The birds may have readily perished in various ways, including showers of volcanic ashes upon them and their haunts, partially strewed with their eggs. During a certain lapse of time, ending with the introduction of man to these islands, they may have existed in great numbers, the gigantic species especially, with their great beaks, being too powerful for any other animals then intermingled with them.

The notice by Mr. Grant Dalton of a large tusk of an elephant fished up in the trawl of an Ostend smack, about ten or fifteen miles off the island of Texel, affords an additional example to those on our own eastern coasts where remains of elephants have been obtained in a similar manner. It is interesting to consider, that by the action of the waves on the sea-bottom, within depths sufficient to remove the mud, silt, or sand in which these remains have been entombed, they become mingled with the accumulations of the present time. Since bones have been thus detected with serpulæ adhering to them, and still alive, it will be evident, if these bones be again enveloped in detrital deposits, that they will be mingled with the shells now living, as well as with any which, like the bones, may have been enveloped in the original deposits, and which were too heavy to be removed with the mud, silt, or sand.

We have next to consider the superposition of rocks, their supposed equivalents in different regions, and general classifications of them. Mr. Beete Jukes has described a series of deposits in the vicinity of Sydney, New South Wales, estimated at about 2000 feet in thickness, which he refers to the geological date of the accumulations for which the name palæozoic has been employed of late. The lowest part of the series near Sydney, to which the term Wollongong sandstones is given, is commonly thick-bedded, fine-grained, often slightly calcareous, and contains many concretionary nodules, from two inches to two feet in diameter. This arenaceous deposit is estimated at from 300 to 400 feet thick, and contains the remains of *Stenopora, Producta, Spirifer, Pachydomus, Orthonota, Pleurotomaria* and *Bellerophon.* Above these sandstones come the strata associated with coal, the beds of which are represented as not likely to be important. The thickness of this accumulation is taken at about 200 feet. Surmounting this there are shales and sandstones, about 400 feet thick, and upon these comes the thick mass of sandstone named by Mr. Clarke the Sydney sandstone, from 700 to 800 feet thick, and composed of thick beds of white and light yellow sandstones, varying from fine-grained to coarse, containing quartz pebbles. In lithological appearance these beds were found to resemble the millstone grit and lower coal-measures of the north of England. Crowning the whole are shales at least 300 feet thick, in which are a few small fragmentary vegetable impressions and pieces of leaves. Fish are also stated to have been discovered in them. As a general fact, perfect conformability of the whole series, and a gradual transition of their divisions into each other, were observed.

Mr. Beete Jukes also notices sandstones and limestones, referred to the same palæozoic age, and igneous rocks in the south-east of Tasmania. The igneous rocks are very confusedly mingled with the two former, while they sometimes traverse and are intermingled with them, and sandstones rest undisturbed against old cliffs or ledges of trap-rock at others. Limestones near Hobartown afforded the remains of *Stenopora, Fenestella, Caryophyllæa, Producta, Spirifer* and *Pecten.* An argillaceous sandstone at Point Puer gave *Producta, Spirifer, Pterinea, Orthonota, Allorisma, Pachydomus* and *Pecten.* The rocks of Eagle Hawk Neck, where occurs the tessellated pavement (one of the celebrities of Tasmania), formed of a hard, fine-grained and compact grey sandstone so split up by divisional planes as to have a tessellated aspect, furnished *Fenestella, Producta, Spirifer, Platychisma* and *Pachydomus.* Among the sandstones of Norfolk Bay coal occurs and is worked, and in the sandstones *Pecopteris Australis*, a *Sphenopteris* and a *Zeugophyllites* were found. In a fine compact quartz rock of Spring Vale, on the east coast of Australia, *Fenestella, Producta, Spirifer*, and a Crinoid were obtained.

Mr. Richard Brown, in a notice of the gypsiferous strata of Cape Dauphin, in the island of Cape Breton, admitting the view taken by Mr. Lyell, that these beds belong to the palæozoic series, further points out that, on the western boundary of the Sydney coal-field, and exposed along a lofty cliff, the lower part of the coal-measure accumulations is distinctly seen to repose on carboniferous limestone and associated marls, containing gypsum. Of these beds, commencing with that termed 'millstone grit,' Mr. Richard Brown gives a detailed section, their total thickness amounting to 1056 feet. This, no doubt, is a valuable addition to our knowledge respecting the mode in which sulphate of lime occurs among rock accumulations,—a subject of much geological interest. From the remains of animal and vegetable life entombed in the coal-bearing beds of this part of North America, and in the limestones supporting them, these rocks have been referred to the date of the coal-measures and carboniferous limestone of the British Islands; and—without assuming that, part for part, they are exactly equivalent, since in the area of the British Islands themselves we find that the conditions for the growth of plants, the remains of which subsequently formed palæozoic coal-beds, obtained in the north earlier than in the south,—we may fairly conclude that they were of about that date, regarding the subject generally.

Mr. Lyell, while describing the coal-field of Eastern Virginia, above noticed, points out that the only accumulations of North America which occupy a similar position with these sandstones, shales and coal beds, the lower portion of the deposit resembling granites or syenites, having been formed from the detritus of the rocks on which they rest, are the red sandstones which repose unconformably on the palæozoic series of the Appalachian system, and which were, consequently, deposited after the movement that gave the palæozoic, carboniferous, and still more ancient groups of the Alleghany mountains their present strike, dip and direction. He then proceeds to inquire if the accumulations under consideration may be either newer or older than this so-called new red sandstone, and finds a difficulty, from fossil fish and the foot-tracks of birds, without plants, being the only evidence of life presented by the red sandstone, while the organic remains of the coal district near Richmond are almost exclusively vegetable. It is remarked that most of the fossil fish hitherto discovered in this coal district are referable to a new genus of the homocercal class, while all the fish hitherto obtained from the so-called new red sandstone of Connecticut river, four or five species in number, are heterocercal. "Could we, therefore," Mr. Lyell observes, "feel sure that the beds containing the ichthyolites and the foot-prints of birds in the valley of the Connecticut were triassic, it would afford strong ground for presuming the oolitic age of the Virginian coal strata." He however considers the question whether the Connecticut sandstone be Permian or of triassic date, to be still open.

Mr. C. Bunbury observes, that the geological evidence afforded by the fossil plants found in this accumulation is, to a certain extent, ambiguous; that the most characteristic species appear to be the *Equisetum columnare*, the *Calamites*, the *Tæniopteris magnifolia*, and the *Zamites*; that the first is a well-known plant of the lower oolite of Europe, while the *Calamites arenaceus* is discovered in the Keuper on this side of the Atlantic, and that the great abundance of these conspicuous Calamites strikingly distinguishes the flora of the Richmond coal-field from that of the Yorkshire series, of which it otherwise reminds us by many of its forms. He at the same time remarks on the geological value, in the Virginian coal-fields, of *Pecopteris Whitbiensis,* one of the most common plants in the coal of the Yorkshire oolites. As a whole, Mr. Bunbury considers the evidence of the vegetable remains to be in favour of the Richmond coal-field belonging to the geological age of either the triassic or jurassic series, and with equal plausibility to both; an opinion in which Mr. Lyell so far coincides, as to suppose that the Virginian beds may be equivalent either to the inferior oolite or lias, observing that we have not in Europe any large development of a fossil flora in these older divisions of the oolitic series, and that such might present more of a triassic character than in the coal-strata of Yorkshire. Viewed generally, Mr. Lyell infers with Prof. W. B. Rogers, who had previously noticed the coal-field of Eastern Virginia, that it agrees in age with the lower members of the oolitic or jurassic group of Europe, and takes occasion to point out, that while we find so much resemblance in the quality of the coal, and in the mode of accumulation of the rocks and plants associated with it, to the palæozoic coal deposits, we should be cautious with respect to popular generalizations respecting a peculiar state of the globe during the more remote of the two periods.

Though no doubt the views here taken by Mr. Lyell and Mr. C. Bunbury respecting the probable age of these coal accumulations may be founded on our present knowledge of the association of certain organic remains with the mineral accumulations of Western Europe, and that we have yet much to learn regarding them, as well as how far this knowledge may be applied, without considerable modification, to any deposits which may have been effected in the area now occupied by North America, nevertheless such views are of great value and importance: they enable us to classify the knowledge we possess, and thereby to render it available in a manner that it would not otherwise be, and the very accumulation of such views may often point out their own modification, should that be necessary. The labours of our colleague, Mr. Lyell, in America have been attended with the happiest results for the progress of our science, and by making them and his opinions known through this Society, he has not a little contributed to the aid which we have been enabled to afford to the advance of geology during the past year. We cannot also but with great satisfaction see his near connection, Mr. C. Bunbury, assisting in giving these labours still further value, by his investigations into the fossil flora of the transatlantic lands traversed by Mr.

Lyell; investigations which not only do Mr. Bunbury so much credit, but which give promise of yet more extended researches in the field of fossil botany by our Foreign Secretary.

Sir Roderick Murchison, in his introductory remarks to the memoir of Captain Vicary on the geology of parts of Sinde, has shown, from the observations of that officer, the probability of the nummulitic limestones of the Hala mountains being surmounted by tertiary shelly conglomerates and beds charged with the bones of quadrupeds (many of which are of the same character as those found or described by Major Cautley and Dr. Falconer), and that the western limits may be defined of the coast-line, first laid down by Dr. Falconer, along which terrestrial animals lived at a tertiary epoch, for a very considerable distance in Asia. In this respect the information afforded is highly valuable, proving the extent and magnitude of those accumulations, skirting coasts, while the mass of the lands of India was depressed beneath the sea.

In the descending order of the Sinde formations Captain Vicary notices, beneath the ossiferous beds, a coarse arenaceo-calcareous rock with *Cytherea exoleta*? and *exarata*, and *Spatangi*. Under this comes a pale arenaceous limestone with *Hyponyces*, *Nummulites* and *Charoideæ*; then the mass of the nummulitic rock of the Hala range, supported by black slates of which the thickness is unknown. The continuation of these nummulitic rocks over so great a distance, one extending across from Hindostan to the great Mediterranean accumulations of the same kind, would point to the prevalence of similar general conditions over a very great distance; conditions also continuous during a long lapse of geological time, during which contemporaneous accumulations took place in many parts of Europe of so varied a character, that convenient geological divisions can be made in them, and of which those great nummulitic deposits afford little or no trace. Indeed, all attempts to divide them, with reference to the former, have hitherto failed, and at present no good lines can be drawn between beds which may be of the tertiary epoch, and others which may even represent part of the oolitic or jurassic series of the British islands and many other parts of Europe.

Although Mr. Prestwich's memoir on the probable age of the London clay and its relations to the Hampshire and Paris tertiary systems was read at the meeting of this Society immediately preceding the last anniversary, and therefore does not strictly come within the number of those included among the communications to the Society during the past year, yet as it is intimately connected with his paper on the main points of structure and the probable age of the Bagshot sands, and on their presumed equivalents in Hampshire and France, and these memoirs are printed together in our Journal of 1847, it is desirable to consider them together. It was the chief object of Mr. Prestwich, in the first of these papers, to prove that the London clay of Highgate, Sheppy, and other places in the vicinity of London was not, as had hitherto been considered, synchronous with the *calcaire grossier* of the Paris tertiary district, nor with the clays of Barton, and the clays and sands of Bracklesham in the Hampshire tertiary district, but that it was of older date, occupying a lower position in the tertiary series.

Upon comparing the fossil remains of the calcaire grossier with those of the London clay, Mr. Prestwich finds that not quite four per cent. of the testacea discovered in the former have been observed in the latter, and that even this small number is of little chronological value; for, with few exceptions, all of these have a wide vertical range in the Eocene series of France. The general character of the testacea is stated to differ, and if the fishes, plants, foraminifera, crustaceans and zoophytes be compared, the same marked distinctions are found throughout.

In comparing the tertiary deposits of Hampshire with those in the so-called London basin, Mr. Prestwich notices sands and mottled clays as the lowest, presenting a remarkably uniform mineral character, the beds formed of red mottled clay and of siliceous light-coloured sands, varying in proportions, and non-fossiliferous. Above this deposit there is, in Hampshire, a thick and important mass of fossiliferous brown and grey clay, well-seen in Alum and White Cliff Bays, 200 feet thick at the former, 300 feet at the latter, and in the well at Southampton, therefore thickening gradually in its range northward and eastward. To this accumulation Mr. Prestwich had formerly assigned the name of "the Bognor beds." In the London district the mottled clays are covered by a similar accumulation, and the latter in both districts is described as reposing upon a peculiar water-worn and irregular surface of the former. The pebble beds and sands at the base of the London clay are pointed out, as also the calciferous and usually fossiliferous band at Hedgerly and other places around London and near Salisbury and Southampton. It is shown that, where the superposition can be traced in the London district, the pebble beds are subordinate to sands, chiefly yellow, but sometimes green and dark gray, laminated with clays, with subordinate sandy clays. These deposits constitute the bulk of the London clay, the upper beds brown, and usually sandy near the top. As regards thickness in the London district, it is 320 feet near Odiham and about 400 feet at Highgate and Hampstead. Thus from the lithological structure alone the author concludes that the Bognor beds of Hampshire and the London clay are geologically the same.

Mr. Prestwich then examines the fossil contents of the beds, and finds that, taking the 390 described species of Testacea, of which 133 occur in the London clay near London, 193 in the beds at Bracklesham Bay, and 209 at Barton Cliffs, only 35 species are common to all these localities, 8 species common to London and Bracklesham, 11 to London and Barton, and 55 to Bracklesham and Barton. Adding to these fossil remains those of the crustacea, fishes, reptiles and plants peculiar to the London district, he concludes that the London clay is not synchronous with those of Bracklesham and Barton, but, viewing its relations with the mottled clays, lower than the former, and still lower than the latter. The author would not restrict the synchronism of the Bognor beds of Hampshire to the lower part only of the London clay.

In his second communication, Mr. Prestwich describes the sands resting upon the London clay, and commonly known as the Bagshot sands, from their exposure in the vicinity of that town. He divides these sands into lower, middle and upper Bagshot sands, respectively of the thickness of 100 to 150 feet, 40 to 60 feet, and 250 to 300 feet; the middle division containing the greater amount of clays, with one or two beds of green sands. The Bagshot sands are considered by our colleague equivalent, though comparatively poor in organic remains, to the rich fossiliferous deposits of Bracklesham in the Hampshire district, and as synchronous with the central vertical strata in White-Cliff Bay, and with the great central mass of variegated and light-coloured sands of Alum Bay, including probably the Barton clays, and as being at all events older than the freshwater or fluvio-marine series. Mr. Prestwich regards the Bagshot sands as forming an uninterrupted sequence of deposits to the London clay, and that they may be represented in the Paris tertiary district by the lower part of the *Calcaire grossier* and *Glauconie grossière*.

Taking a general view of the tertiary accumulations in the western London and Hampshire districts, (for he considers that there are other beds developed beneath the London clay in the eastern London district,) Mr. Prestwich divides the deposits into three chief groups: the first, or lowest, argillaceous, consisting of the mottled clays and London clay, containing a few subordinate beds of sand, chiefly confined to the former, its fauna presenting forms of which a considerable proportion is restricted to it. The central group embraces the Bagshot and Bracklesham sands; and the third or upper group contains accumulations of freshwater or fluvio-marine origin. All the groups are developed in Hampshire, while in the West London district the two lowest only are discovered.

These inferences of Mr. Prestwich not being deductions from hasty examinations, but the result of careful investigations and of long-continued labour, we may regard the views he has taken as placing us in a position respecting the Parisian equivalents of our tertiary deposits in Southern England, and of these with each other, far in advance of that which we previously occupied. So much of these tertiary accumulations has been removed by denudation, which has not only cut away a large amount of these rocks, but of those also which supported them, that great difficulties may always attend our endeavours to ascertain the shores washed by the sea during the accumulation of these tertiary beds, or the range of the deeper or shallower portions of it, at successive times, during the lapse of the same geological period. However this may be, the labours of Mr. Prestwich, who in the papers before us has combined lithological descriptions so carefully with palæontological comparisons, are in the right direction. It is from such investigations that we may expect a still more extended knowledge of our tertiary deposits, up to the changes now in progress inclusive, not restricting ourselves to supposed marked groups, the names for which, however convenient and indeed necessary, so often interpose to prevent an examination into the continued changes and modifications of geological conditions, the more abrupt local alterations of which have been marked by results to which we may frequently give a far more general importance than they really deserve.

Mr. Lyell, in his paper on the relative age and position of the so-called Nummulitic limestone of Alabama, refers to a former communication to this Society, in which he stated that the limestone containing the *Orbitolites Mantelli*, the supposed Nummulite previously mentioned, and occurring between the rivers Alabama and Tombecbee in the state of Alabama, was a member of the Eocene tertiary group, this limestone being higher in the series than that containing the gigantic remains of the Zeuglodon (Owen), a deposit above beds containing a great number of well-preserved eocene shells, such as *Cardita planicosta* and others. Subsequent explorings in Alabama have confirmed him in these views. After quoting the opinions of Professor E. Forbes, Mr. Lonsdale and M. d'Orbigny, previously noticed, that the so-called Nummulites are Orbitolites or Orbitoides, he describes sections, proving the correctness of the view he has taken, and while noticing the limestone of Bettis' Hill, where it is 70 feet thick, for the most part made up of Orbitoides of various sizes, with occasionally a lunulite and other small corals, and *Pecten Poulsoni*, he refers its origin, like that of our white chalk, the softer varieties of which it resembles, to the decomposition of corals.

As it would appear that Orbitoides have been mistaken for Nummulites, though, as M. d'Orbigny observes, they differ from them by the most marked characters, this communication is not only valuable as regards American geology, but also points to the use of more caution on the part of those who may not be sufficiently skilled in palæontology when they mention nummulitic rocks, a class of deposits possessing considerable interest both as regards questions relative to the age of such accumulations, and to the vertical and horizontal range of the nummulites themselves.

Mr. Dawson has presented us with a memoir on certain red sandstones and conglomerates resting unconformably upon the palæozoic carboniferous rocks of Nova Scotia, for which he retains provisionally the name of new red sandstone, this term being at least locally appropriate. In this communication he describes this deposit as it occurs skirting the shores of Cobequid Bay. It appears that calcareous matter is occasionally mingled with the red beds, as near Truro. In the vicinity of Shubenacadie this matter shows a tendency to arrangement in large concretionary balls. Trap rocks seem also associated with this red accumulation.

The detailed descriptions of Mr. Dawson afford proof that the palæozoic rocks of Nova Scotia, from beds referred to Silurian rocks to those containing coal and the remains of plants similar to those discovered in the palæozoic coal-measures of Europe, were formed and subjected to pressure, by which they were thrown out of their original positions, prior to the deposit of these red sandstones and conglomerates. Making due allowance for local variations and chemical differences in the associated igneous rocks, we might suppose ourselves reading descriptions of the manner in which the great red deposits of the British Islands, known as the new red sandstone, were accumulated, viewing the subject on the large scale. Whatever the geological age of these American deposits may finally be found to be, when we compare them with the detrital deposits on the east of the Atlantic, this upsetting of the palæozoic rocks, the accumulation of pebbles and sand, with such an abundance of intermixed peroxide of iron as to produce a general red tint, here and there variegated with others, and the association of igneous rocks (such as that so common in Devonshire), bear a general resemblance to the accumulation known to us as the new red sandstone. At the same time it should be borne in mind, that though this red deposit may not be older than our new red sandstone, supposing the Nova Scotia coal a true equivalent to the palæozoic coal-measures of the British Islands, we have as yet no sufficient evidence as to how far it may correspond in geological time with that during which the oolitic or jurassic series of Europe was formed. We have already seen that inferences have been drawn as to the equal geological date of a coal-bearing series of deposits in Eastern Virginia with the lower part of that series; and though physical changes may have so taken place in Western Europe, that they have been productive of mineral accumulations which we may conveniently divide, as has been done, into Permian, triassic and jurassic or oolitic deposits, it by no means follows that the like have taken place in precisely the same geological times on the area of North America. We may have marked accumulations there formed at geological times requiring other convenient divisions for classification. The red deposits of Nova Scotia are due to certain physical conditions which may have been often repeated. Thus while we give due weight to the resemblances between the new red sandstone series of Western Europe, viewing it on the large scale, and the Nova Scotia red sandstone, we should still look for further evidence respecting the latter. Should it eventually be found probable that the two are of the same date, this contemporaneous disturbance of certain districts composed of palæozoic rocks in Western Europe and North-eastern America will offer a subject of no slight interest connected with great disturbances of portions of our earth's surface at different geological times.

Two communications from the Rev. W. B. Clarke, one on the genera and distribution of plants in the Carboniferous system of New South Wales, and the other on the occurrence of Trilobites in the same country, refer to the classification of the rocks in which these organic remains occur with the palæozoic series. According to Mr. Clarke, the same genera of plants which are characteristic of the carboniferous epoch in Europe prevail in these Australian formations, and though the species are different, they are not more so than might be expected at the antipodes of Europe. Mr. Clarke considers that there is evidence of coal deposits along the flanks of the mountain range of Tasmania and Australia for a distance of 1200 miles. After adverting to the notice of Trilobites in the work of Count Strzelecki, our author mentions the discovery of many others by himself, one a *Trinucleus*, which has been named by Mr. MacLeay *T. Clarkei*. Mr. Clarke considers these older deposits of the Australian series, with Mr. Beete Jukes, as representing the Silurian and Devonian rocks, including the carboniferous series of England, the whole forming one uninterrupted and conformable series of beds.

In his paper on the Silurian rocks in the valley of the Tweed, Mr. Nicol points out that it is only recently that any organic remains have been found in this district, or indeed in any of the older palæozoic rocks of Southern Scotland. Dr. Hutton was the first, he observes, who discovered these remains. He noticed them in his 'Theory of the Earth,' as occurring at Wrae near Broughton, on the road from Edinburgh to Dumfries. Mr. Nicol, who had visited this locality some years since, again examined it last autumn, and by diligent search obtained fossils. The only other locality where he found any such remains was at Greiston slate quarry, near Traquair, whence he procured *Graptolites Sedgwickii*, these occurring in profusion, as a mere surface-covering of a single bed. In the same bed there are fragments of anthracite and elliptical carbonaceous impressions, not unlike the leaves of a plant. A seam or vein of anthracite was once known among these rocks about a mile distant, affording, Mr. Nicol observes, additional evidence of the existence of vegetable life at this time. Mr. Salter having examined the organic remains obtained by Mr. Nicol, refers them to *Asaphus tyrannus*, another *Asaphus*, like the young of *A. megistos* (of the American lower Silurian rocks), *Phacops Odini* (Eichwald) or *P. alifrons* (Salter), and other trilobites, as also to *Leptæna tenuistriata* and other shells, *Orthis calligramma* being abundant: all, Mr. Salter considers, illustrative of forms and grouping such as are detected in the Llandeilo flags of Wales. Mr. Salter adds, that the researches of Lord Selkirk near Kirkcudbright would point to the occurrence of upper Silurian rocks also in that part of the Lammermuir range, *Terebratula semisulcata* being common among the fossils found, as also *Leptæna lata* and others.

Looking at the general evidence, Mr. Nicol considers it best to retain, for the present, the old name transition, or merely class them as Silurian, without attempting any more precise definition, and remarks as not improbable that the beds whence Lord Selkirk obtained his fossils, may be connected with some in Liddesdale, also on the extreme south of these deposits, in which he found numerous fragments of plants. The Wrae limestone, he infers, would thus range with the limestone near Girvan, in which Professor Sedgwick discovered Silurian fossils, and with other limestones in Colmonel parish, found by Mr. Carrick Moore to be fossiliferous.

Though we may regard, with him, any classifications of the rocks described by Mr. Nicol, which should extend to minor divisions, as premature, the general evidence adduced is important, and of an order which may eventually lead, by continued and detailed research, without which little can be accomplished in such regions, to subdivisions which may be compared with accumulations affected in the same range of geological time in other portions of the British Islands. The traces of supposed vegetable remains, and the anthracite noticed, possess no slight interest; for though, from carbonaceous deposits low down in the Silurian series of Wales, we might infer the existence of vegetable life prior to these accumulations, anthracite, from what we know respecting it in other rocks and localities, is a substance affording something more approaching to a proof of this inference. No doubt the carbonaceous substance in question might be produced from animal matter, but with our present knowledge we should rather refer it to a vegetable origin, so that in these rocks of the valley of the Tweed, we seem to attain evidence pointing to the entombment of vegetable remains amid the mud, silt and gravel of this remote geological date.

In a report on the fossil remains of Mollusca from the palæozoic formations of the United States, contained in the collection of Mr. Lyell, Mr. Sharpe compares the older fossiliferous accumulations of North America with those of Europe. He endeavours "to ascertain what species are common to the American and European formations; how far such species have had the same duration in the two continents, and how far similar forms of animals have existed in both at what may be supposed to have been the same periods, thus collecting data illustrative of the history of the earlier marine animals." Another object was to apply this knowledge to the classification of the American formations, and to see how closely they may be compared with those of Europe. The comparisons of the American and European fossils were made with specimens themselves, and Mr. Sharpe refers to the constant assistance he has derived from Mr. Morris in this labour. The number of American specimens compared was about 200, and the bulk of the collection was from New York, with many specimens from Canada and Pennsylvania. There was also a good collection from the blue limestone of Ohio.

After noticing the divisions among the palæozoic deposits of North America adopted in that country, Mr. Sharpe observes that, however convenient these may be for local purposes, there is a necessity for larger grouping when we compare the American with the European accumulations of this date; and he also considers that the supposition of older fossiliferous beds occurring in the American than in the European series is not borne out; on the contrary, that the oldest fossiliferous beds of the United States were not accumulated anterior to the Tremadoc or Lingula-bearing beds of North Wales. Mr. Sharpe also adverts to the inconvenience arising from the too minute classification which has been made in these palæozoic beds of North America, a multiplication of species having ensued under the view that each division only contained certain of them, so that consequently a great number of synonyms have become necessary in his tables.

Mr. Sharpe then enters into a detailed account of his examination of the American specimens, commencing with those discovered in the lowest rocks, and finally divides the whole series of deposits whence they are obtained into three great groups, considered as distinguishable as well by their lithological structure as by their zoological character. The lowest is a vast arenaceous accumulation, with occasional beds of limestone, and includes the lowest fossiliferous rocks in the ascending series up to the Medina sandstone. The molluscs discovered in this division are stated to present a great accordance with those in the Lower Silurian rocks of Europe, in this view including the Clinton beds.

The next group is calcareous, with some associated sandstones and shales, and commencing with the Niagara shale ends with the upper Pentamerus limestone, according to Mr. Conrad, or according to the views of Mr. Hall, with the corniferous limestone. This group is considered equivalent to the Upper Silurian series of Europe. The third, or upper group, consisting chiefly of shales and argillaceous sandstones, reaches upwards to the top of the Chemung beds, and is referred to the geological date of the Devonian or Carboniferous systems of Europe, or rather to an enormous development of the former.

In the lowest group about 30 per cent. of the species of molluscs agree with those known in the Lower Silurian rocks of Europe; in the second, or middle group, 40 per cent. of the species are the same with those detected in the Upper Silurian rocks on the eastern side of the Atlantic; and, in the highest group, 20 per cent. of species agree with those found in the Devonian or carboniferous series of Europe. To these numerical calculations of species Mr. Sharpe attaches, however, little importance, believing the sources of error in such calculations to be alike numerous and varied, and that collections must be far more extended, and comparisons made with greater care before they can be regarded as valuable.

No one is more aware than Mr. Sharpe of the difficulties attending even the larger grouping of fossiliferous accumulations, far distant from each other, or of the necessity of viewing the limits of the divisions above noticed as somewhat hypothetical. Indeed, when we consider the probable physical conditions under which the mineral matter was accumulated in which the older organic remains noticed on both sides the present Atlantic are discovered, the necessity of great caution on this head becomes apparent. We must, of course, dismiss from our minds the present geographical distribution of sea and land, extending from and including Europe and North America. The many rises and depressions of land which the study of geology teaches us has since happened within the areas in Europe and North America now above the sea, show how needful this must be. Moreover great disturbances of the earth's crust, producing crumplings, flexures, and fractures, round and against which subsequent accumulations were effected, have taken place since the deposit of these older rocks. Whatever the form of the ancient lands whence the mineral materials of the older palæozoic rocks were derived, we have a given general distance on the surface of the globe always interposed between the deposits. When we regard any extended line of coast along the shores of our present continents, and, therefore, conditions in the seas adjoining most favourable, generally, for continued similar deposits, we see so many causes for change and modification arising from physical conditions, that we could scarcely expect uniformity of result, even upon extended coasts ranging along the same parallels of latitude, or what might amount to the same thing, as regards temperature, if an internal heat of the globe may have been so felt at these geological times as to have given a certain temperature to the ocean, higher generally than at present. Always, under the latter hypothesis, duly considering the modifications in the position of such waters from the differences in specific gravity arising from differences of temperature. We have to look also to bays, headlands, shoals, deep waters, and all the modifications now observable, including tidal action in some places greater than at others,—estuaries and bodies of fresh water flowing over the heavier waters of the sea, until their power to do so ceased, and any detrital matter they may have held in mechanical suspension was deposited far outside the localities where the sea-bottoms may have been coated by mineral substances brought directly over them by river action. We have also to look to a fair proximity to land for the deposits generally, if we are to have any regard to the kind of marine mineral accumulations now observable, or which are at all probable. When we consider the thousands of feet of thickness which have to be given to these older deposits, we have to weigh the modifying influences exerted upon the life, existing upon the sea-bottoms of the time, in consequence of the filling-up of the deeper waters, unless we infer that the sea-bottoms were depressed as the mineral matter and the remains of animals were, bed upon bed, deposited upon them. Neither should we neglect, when great distances are under consideration, the chances of unequal depressions or elevations of the sea-bottoms and dry land during the lapse of the geological time when any large amount of accumulations in the sea may have been effected.

Independently of these physical considerations, we must not forget the time required for the dispersion of the species themselves, if specific centres are in any way to be regarded, even as a convenient hypothesis, and the chances that the germs of these species, floating away from the parent stock, only here and there, and over very uneven areas, found the physical conditions suited to them. Then also we have to take into account the views of the naturalist examining specimens obtained from the rocks which, or the remaining visible parts of which, represent to us the mud, silts, sand and gravel of these ancient times. He may be, as many palæontologists have been, inclined to attach a higher value to certain differences and resemblances of general forms, or of parts of forms, than another, and hence species may be so greatly multiplied in the cabinet, that our books may represent them to have been limited to a geological time, corresponding only with a given mineral accumulation, while the study of a greater number of specimens among the rocks themselves may not warrant these conclusions.

We have also to regard another point of no small importance, which is that our classifications of rocks in one part of the earth's surface, even taking an area equal to that occupied by Europe, is necessarily founded on the physical or zoological changes or modifications which have been effected upon it, and it were well, often, if these classifications took so wide a range and were not extended from minor portions of that area. The study of a limited district is frequently sufficient to place us on our guard against a too partial regard for subdivisions; the modification of physical conditions, and with them, allowing for a great adjusting power, of contemporaneous life, pressing upon our attention. True it, no doubt, is that, as regards temperature only, molluscs and other marine creatures may find the needful limits within which they can sustain life very extensively in the sea, the waters adjusting themselves to the specific gravities due to their relative heat. So long therefore as finding proper food, they can battle against changes of pressure from differences of depth, modifications of sea-bottom, of light passing through the waters, and of distances from shores, many species might contend through these difficulties and thus spread themselves contemporaneously over considerable areas. At the same time, this power of adjustment would enable them to live through changes of a similar physical character brought about within a limited area. This now seems a well-established opinion among palæontologists, who regard the species most widely spread at a given period as those which existed through the greatest length of geological time.

On this head Mr. Sharpe remarks that the comparison of the palæozoic fossils of Europe and of the United States bears out the view that those species which rise through the greatest thickness of formations have also the widest geographical range. "We find in New York," he observes, "European species, which are confined here to a single bed, as well as those which are common to several formations, and usually the species seem to have the same vertical range in both countries." Of this Mr. Sharpe enumerates some examples, stating that they could readily be multiplied, and he points out the importance of endeavouring to ascertain in different countries the first appearance of each species, seeing whether it is found in one at an earlier geological period than in another, and thus to learn the region of which it was originally native. Respecting this he also mentions facts which he considers may tend to show that *Spirifer Urii* appeared earliest upon the area now occupied by North America, as also *Terebratula reticularis*, and *Orthis resupinata*. On the other hand he remarks that, when observations are more multiplied, and we discover certain species to have first appeared upon the European area, *Leptæna depressa* may perhaps be found among them. Mr. Sharpe remarks that if, without regarding species, we look only to general forms, we shall find some groups of shells common in the United States long before they lived in the European area.

Viewing all the causes of modification and change in physical conditions at equal dates and during the lapse of a certain amount of geological time, and the power of marine life to adjust itself to certain of these changes and modifications, as well contemporaneously as during such lapse of time, by no means neglecting the great changes in animal life so evident when we look at its remains entombed in the general mass of geological accumulations; on the contrary, always bearing it fully in mind, we are convinced, with Mr. Sharpe, of the necessity of comparing the older accumulations of North America and of Europe in great masses, and even to regard the groups pointed out rather as affording us the convenient means of comparison than as positively representing, to their boundaries, the divisions which the study of European geology may at present make it desirable to adopt.

While Mr. Sharpe's paper refers to the comparison of deposits so wide apart as North America and Europe, now separated by an ocean, a portion of which may or may not have existed between them in that olden geological time, a communication from Prof. Sedgwick, made to the Society at its last meeting, on the organic remains found in the Skiddaw slate, with some remarks on the classification of the older rocks of Cumberland and Westmoreland, brings us to a consideration of the divisions and subdivisions which can be effected in the accumulations of this early date, as they are found in the British Islands. Professor Sedgwick divides the Cumbrian and Westmoreland rocks into eight groups, above the granite, namely,—1, the Skiddaw slates, commonly dark-coloured, the lower part altered by the granite; 2, a great group composed of a mass of trappean rocks, indefinitely alternating with quartzose, and more or less chloritic roofing-slates, generally of a green colour, the igneous matters, whether erupted or recomposed, being contemporaneous with the ordinary sedimentary accumulations with which they are associated; 3, a series of deposits, chiefly dark-coloured flagstones and slates, more or less calcareous, the lowest beds passing into a limestone (Coniston limestone); 4, coarse and hard, light-coloured sandstones; 5, thin beds of sandstone, like the last, associated with large masses of roofing-slate and sandstone, in some places a thin band of impure concretionary limestone is found in the lowest part; 6, a complicated deposit of sandstones, flagstones, &c., in the upper part of which are some greenish and reddish flagstones, appearing, Professor Sedgwick thinks, to occupy the same place as the tilestones of the Silurian system in Wales and the adjoining parts of England. The seventh group is the old red sandstone, resting unconformably upon the above, and upon this comes the eighth group, formed of the carboniferous limestone, resting conformably upon the old red sandstone, or overlapping its boundaries, and then resting unconformably upon the older groups.

All these groups Professor Sedgwick points out are true physical groups, the results of certain changes or modifications of the physical conditions under which they were accumulated. And here the Professor insists upon physical groups being "the foundation of all geology, and out of all comparison the most remarkable monuments of the past physical history of our globe, so far as it is made out in any separate physical region." "Organic remains," he continues, "are, in the first instance, but accessories to the information conveyed by good sections. But when the successive groups of organic remains are once established in coordination with actual sections, they then tell us of successive conditions of organic life which were (as we know by experience, and might perhaps have conjecturally anticipated) of far wider geographical distribution than the local physical movements which produced our great physical groups of deposits. Hence," he adds, "it follows, that in comparing remote deposits, organic remains become no longer the secondary, but the primary terms of comparison."

After pointing out that the lower part of the group No. 3, the Coniston limestone, contains fossils considered as those characteristic of the Lower Silurian rocks, and that the higher groups, up to the base of the old red sandstone, are equivalent to the Upper Silurian series, he refers the group No. 2, that replete with various trappean rocks, contemporaneous with the common sedimentary accumulations of the time, to the Snowdonian series of Wales, an opinion of his as old as 1831–32. The Skiddaw slates occurring beneath these beds had, until lately, yielded no organic remains, though from some traces of carbon long since found by him in them, Professor Sedgwick had inferred that such traces had been derived from some obscure form of vegetable life, such as a fucoid. Referring to his note-books of 1822, the Professor, his engagements preventing an examination of the localities personally, despatched Mr. John Ruthven, of Kendal, to the Skiddaw slate-district, and the result was the discovery of graptolites and other forms considered organic, and referred to fucoids. These fossils have been described by Mr. M'Coy, as previously mentioned, and with the exception of one species referred to *Graptolites sagittarius*, are considered by him to be new, namely one species of graptolite and four species of fucoids. The remains discovered in these slates Professor Sedgwick regards as those of the earliest organic life, nearly marking its descending limit,—no new opinion of his, he adds, as he has often stated his conviction that traces of life disappeared with descending sections, independently of their obliteration by metamorphic action or mineral change. He infers that the base of the Cumberland series is more perfect and symmetrical than that of Wales, and that the Lingula beds of Merionethshire are higher, in the geological series, than the Skiddaw slates. He then points to the great Cambrian and Cumbrian group of the slate and trappean rocks as the most remarkable physical group in the British Islands; and, after detailing his views on the subject, includes it in his lower division of the palæozoic rocks, by whatever name it may be thought desirable to designate it. That there are accumulations of older geological date in the British Islands than the equivalents of the Llandeilo flags of South Wales, there is now good evidence; indeed, the continuation of the Llandeilo flags rests upon older rocks in the St. David's district of Pembrokeshire; and when the labours of the Geological Survey upon the older palæozoic rocks in other parts of Wales, with adjoining portions of England, and in Ireland, become sufficiently completed for publication, other evidences will be adduced of anterior accumulations of great thickness. For the present it may be sufficient to observe that there is every probability of the physical causes which produced the great mixture of contemporaneous igneous and common detrital products in Cumberland and Wales having extended also to Ireland, and that there was at this time a great upburst of igneous matter, fluid molten rock rising through fissures and cracks amid the older accumulations, while ashes and lapilli were vomited forth from volcanic vents, partly perhaps in the sea, and partly into the atmosphere, where they were borne about in mechanical suspension, as ashes now frequently are for distances of many hundred miles, until finally they fell upon sea or dry land as the case might be.

When we read the descriptions of volcanic eruptions, such as that of Tomboro, in Sumbawa, given by Sir Stamford Raffles, the explosions during which were heard so loud at Macasar, 217 nautical miles from Tomboro, that, considering there was an engagement with pirates somewhere in the neighbourhood, a cruiser, with troops, was despatched to look after them, these explosions also reported to have been distinctly heard at Ternate, 720 nautical miles distant,—miles around the volcano darkened by the ashes thrown into the atmosphere and falling in all directions,—we need not refer to larger volcanic eruptions, long continued, than now occur, for the origin of the mixed matter forming these great accumulations. When we hear of a darkness from the ashes thrown into the atmosphere, continued many hours, and so great that it was equal to the darkest night, that the seas around the island were covered with pumice and ashes, that the waters were greatly agitated by earthquake waves, and that the ashes which fell so far off as Bima broke in the Resident's house in several places, we see causes and their effects well-suited in our own days to produce deposits similar to those which seem to have required physical agencies of a like kind over the area now occupied by the British Islands at this old geological epoch.

We have to look back to a time, after a thick accumulation of matter now forming the Skiddaw slates, the lower dark slates of North Wales, with their capping of variegated beds, and of sandstones and conglomerates, and the continuation of these beds, variously modified, into Ireland, when volcanic forces burst out furiously, scattering ashes around, so that falling into waters, they formed the parts, or the whole of beds, or were interstratified with common detrital accumulations, according to circumstances. That there were times of repose, during even the accumulations of the ash beds, is evidenced by the occurrence of organic remains in them, just as we find these remains entombed amid the deposits of ordinary mud or silt. They occur in a manner whence we infer the existence of life upon the ashes as upon any ordinary bottom, and as many a mollusc and other marine creature must live at the present day in seas adjoining volcanic districts and islands. This volcanic condition of the area, productive of such marked results, in the end ceased, at least over part of it, and was succeeded by a geological time when the volcanic products became covered for a long period by ordinary mud, sands and gravel, mingled at times with calcareous matter, here and there, perhaps, some igneous action continuing, and producing its effects. So much of the accumulations of this geological time have been removed by denuding action, or remain concealed beneath the sea and more modern deposits, that it may be difficult to assign any marked interval of subsequent repose over more than minor portions of the general area of the British Islands, especially as we have had igneous action exerted in it at various geological times, up to that of the tertiary deposits inclusive. Great protrusions of granite have even happened at more than one time since. However this may be, we appear to have nothing so marked for the distribution and accumulation of volcanic ashes, and possibly also of pumice and lapilli, ground down by breakers to fine sediment on the coasts, as at this period. Though ashes were also abundantly scattered and arranged into beds in the area now occupied by Cornwall and Devon, and possibly also by a continuation of the same beds beneath the eastern covering of more modern rocks, when the deposits termed Devonian were formed, their accumulation does not appear to have been on so great a scale. It does not follow that more molten rocks may not have been ejected, for viewing the variations in volcanic action, it by no means follows that the amount of ashes and lapilli, driven off by the force of vapour and gases, bears a proportion to the molten matter heaved up and ejected.

It may here be convenient to mention a notice by Mr. Logan of the discovery of coal in Junk-Ceylon, one of the islands on the coast of the Malay peninsula, where it was stated to occur in a bed three feet thick; as also another notice by Mr. Bellot on the coal of Labuan, and on that of the east coast of Borneo. We shall have occasion to refer to the Labuan coals in the sequel, and it will here only be necessary to observe, that the geological age of both the Malay and Borneo coals is still uncertain.

Regarding the movements which mineral masses may have sustained subsequently to their accumulation, we have first to notice a communication by Mr. Smith, of Jordan Hill, on recent depressions of the land. He subdivides the "human period into the present, or that in which geological events are subjected to our own observation; the historical, or that in which they have been observed and recorded; and the antiquarian, in which, although we cannot assign a date to them, we can prove from human remains or works of art that they must have taken place since the earth was inhabited by man."

Mr. Smith first notices the movements of the temple of Serapis at Puzzuoli, which have often engaged the attention of observers, and in our own country that of Mr. Lyell, Professor Forbes (of Edinburgh) and Mr. Babbage, and which though so far local as to be referable to the causes and consequences of volcanic action in the vicinity of Naples, still possess considerable interest from the changes in the relative level of sea and land, which they prove may take place during the lapse of a very short time, considered geologically. The memoir of Mr. Babbage on the temple of Serapis, though read before this Society so far back as 1834, will be fresh in its recollection, since it was only published in the last volume of our Journal. In a note to that communication, dated during the past year, Mr. Babbage, referring to his views respecting the effects which may be produced on the great scale by the application of heat to rock accumulations under given conditions, observes, that "the joint action of certain existing and admitted causes must necessarily produce on the earth's surface a continued but usually slow change in the relative levels of the land and the water. Large tracts of its surface must be slowly subsiding through ages, whilst other portions must be rising irregularly at various rates; some, though perhaps few, may remain stationary." It is important that such views should be borne in mind, whatever other causes of change may also present themselves to us, when we consider the movements which geological evidence so clearly proves have taken place since the accumulation of the earliest sedimentary deposits with which we are acquainted; these movements sometimes raising masses of rocks above the sea, at others depressing them, forcing the dry land into all kinds of varied positions relatively to the sea, modifying the life for the time existing in the atmosphere or the waters, and often so entirely cutting off that in the one or the other, as the case may be, that, after a long lapse of geological time, the organic remains subsequently entombed over the same area differ completely from those intermingled with the sedimentary accumulations of a previous time.

From observations made at Puzzuoli in 1819 and in 1845, Mr. Smith concludes that there had been a depression of the temple of Serapis at the rate of about an inch yearly. In arriving at this conclusion, Mr. Smith makes every allowance for the small tidal action felt near Naples, and for the different altitudes at which the surface of the sea might stand from the pressure of different winds upon it, the latter a very material point when we estimate small changes of level. It appears to him probable that this depression may have been going on for many years, even since the last paroxysmal elevation in 1538, one which followed a gradual movement of elevation, itself subsequent to the stationary time when molluscs bored the columns, then necessarily so far depressed beneath the sea. Mr. Smith afterwards notices the relative changes of level of sea and land shown by submarine forests, so well exposed on the coasts of Brittany, Normandy and the Channel Islands, and alludes to evidence indicative of a depression of land in the islands of Malta and Gozo, wheel tracks, not connected with existing roads, passing beneath the level of the sea.

Another communication was made to the Society respecting the temple of Serapis by Colonel Macintosh, who visited it in May and June, 1847. From his observations he concludes that the land has been still further depressed since visited by Mr. Smith, of Jordan Hill. Colonel Macintosh also calls attention to the evidence of the sinking of the land on the Naples side of Puzzuoli; the Hospice of the Capuchins having so changed its level relatively to that of the sea, that the refectory, kitchens, &c., on the lower floor have been abandoned; and an aged monk who showed the Colonel over the premises pointed out a spot where there had formerly been a vineyard, and where he had for many years eaten grapes, this spot now covered by three feet of water and traversed by boats.

Captain James has also presented us with an account of one of those accumulations of wood and peat known as submarine forests, so frequent in certain localities around the British Islands, and observable on the shores of Western Europe from Spain to the Baltic, and which, often occurring partly beneath the present level of the sea and partly above it, mark a depression of the land, since the vegetation was the same as we now find it near the same coasts. The case noticed by Captain James was observed at Portsmouth during the progress of some works there. The peat, with the trees standing as they grew, rests on clay, considered as London clay, and extends even to 29 feet beneath high-water level. The 'forest' inclines northward, or towards the inner part of the harbour. Among the peaty matter *Lacuna Montaguei* was found, as also the *Zostera marina*, on which that mollusc feeds, indicating, Captain James observes, the presence of very shallow salt water. Indeed, these may have become mingled with the peat when the land first began to descend beneath the sea-level. Over the peat there is blue clay four feet thick, similar to the present estuary mud, and containing the shells now commonly found in the harbour. Above the clay there is shingle, which may have been forced over the mud by the sea during heavy gales; and the author calls attention to the effect which would be now produced if from any cause the narrow neck of land connecting the Block House with the main-land should be carried away, the mud of Haslar Creek being then liable to be covered by shingle in a similar manner. Above the shingle there is clay, a continuation of the bed of the present estuary, and upon this a mass of rubbish of various kinds rising above the sea-level.

We have seen that Mr. Lyell points to a depression of land to produce the vegetable and mineral accumulations of the Eastern Virginia coal-field, referred to the geological date of either the oolites or upper part of the new red sandstone series of Europe. We have next to notice the changes in the relative level of sea and land, supposed by Mr. Prestwich to have taken place during the formation of the tertiary rocks in the London and Hampshire districts. He refers to the view taken by him in 1846 as to the gradual subsidence of the sea-bottom during the production of the Bognor beds in the Isle of Wight, and considers that this depression extended over the western portion of the London district. He further supposes that the increasing depth caused by the subsidence was neutralized by detrital accumulations, so that the general conditions for the existence of a certain animal life remaining the same, this life was continued during the deposits. He infers that proceeding more eastwards deeper water prevailed.

Mr. Prestwich concludes that a sea first extended uninterruptedly over the London, Hampshire, and Paris tertiary areas; that at a period coeval with the change of conditions in the mineral structure and zoological character of the lower part of the London and Bognor clays, a separation took place between the Paris and Hampshire areas, leaving the latter still connected with the London district; that after the deposit of the London clay the communication between the French and English tertiaries was restored, and that this connection was probably in part prolonged until the completion of the Isle of Wight series, the London district assuming a more isolated form, and emerging sooner from the sea.

With respect to the movements which the land may have sustained at this period, it should not be forgotten that the tertiary deposits which may have been affected by them were once more extensive than we now find them in mass, traces of their former existence not only remaining between the London and Hampshire districts, but also far to the westward. Indeed the extensive denudations which have been effected westward since the great bend of beds took place which can be traced across the Weald of Sussex into Somersetshire, and of which the great bulge of the Wealden rocks exposed in the former is but a part, leave it very doubtful how far in that direction these tertiary beds may have once been formed. This great anticlinal bend runs parallel with that of the Isle of Wight, and both probably belong to the same exertion of force, one showing a repetition of east and west anticlinal lines of a different geological date from those which have affected the coal-measures, carboniferous limestone and old red sandstone of the Mendip Hills in Somersetshire, the east and west anticlinal and synclinal lines in which are shown to have been produced anterior to the deposit of the new red sandstone and oolites, since these accumulations rest unconformably upon the denuded edges of the beds which have been thus disturbed.

In his 'Notes on the Geology of the Coasts of Australia,' wherein he adds to the information and descriptions of others, his own observations, made while attached as naturalist to the surveying voyage of H.M.S. Fly, Mr. Beete Jukes speculates on the past geological history of that remarkable land. Without claiming novelty for the view, he points out the absence, as far as is yet known, of rocks accumulated in geological time intermediate between the palæozoic and tertiary periods, as also the occurrence of marsupial animals, shells such as the Trigonia, and plants like the Zamia, existing Australian forms, in the oolitic series of Europe. "If," he observes, "at the close of the palæozoic period Australia had been elevated above the sea, so as to have been dry land during the oolitic æra, and never since had been wholly submerged, marsupial animals and certain plants may have inhabited the dry land, and Trigonia and other forms of marine life have resided in the surrounding littoral zones of sea up to the present day, however the species may have died out." The effects of submergence of the old land and its denudation are also pointed out. Mr. Beete Jukes supposes that during the tertiary time four groups of islands would be formed, one running along the present high land of the eastern coast, to which others, due to volcanic action at the time, might be added. A second island would coincide with the range of high ground in South Australia, a third with the hilly country of Western Australia, and a fourth with the part of the north coast ranging between Buccaneers' Archipelago and the Gulf of Carpentaria. He considers that in these islands, or groups of islands, certain animals and plants might die out and be replaced by others during the lapse of time, peculiarities arising in the fauna and flora of each, so that finally, when the deposits in the surrounding tertiary seas were elevated above the water and became dry land, these islands constituted centres of terrestrial life, laying the foundation for the peculiarities now observable in different parts of Australia, though in equal latitudes and possessing similar climates.

However imperfect, from the present state of our knowledge, every attempt to take a general view of the geological structure of Australia must necessarily be, this grouping together of observations by Mr. Beete Jukes is highly valuable, especially as, from his personal inspection of several parts of the coast, he could the more readily seize resemblances and differences in rock masses which those accustomed to geological researches in the field know so well how to appreciate. It is by this gathering together of existing information, however imperfect it may be, that we possess a kind of base on which to work, and so long as we treat this as an hypothesis, which may take any direction, to be even totally changed, should the gradual development of facts require it, no impediment to the progress of our knowledge is presented, but on the contrary much assistance to it is afforded.

With regard to the changes and modifications mineral masses may have suffered since they were accumulated, and after any movements they may have sustained, we have to consider deposits formed in water and now elevated into the atmosphere, and others formed in comparatively shallow seas, depressed to various depths, and even covered by masses of mineral matter subsequently spread over them, as also some accumulations of mineral substances, such as many volcanic products, deserts of blown sand, and others, formed in the air and afterwards depressed beneath the waters.

We have first to notice changes produced in the coal deposits of Eastern Virginia, and pointed out by Mr. Lyell. After describing the character of the coal itself, the difference of its layers, and the beautiful manner in which its vegetable structure, examined by Dr. Hooker, is partially preserved, he shows that this coal in its chemical composition resembles that of the old palæozoic rocks of Europe and of North America. Analyses of specimens taken from three different localities (Clover Hill, Blackheath, and Deep-run) give carbon from 76·49 to 82·90 per cent.; hydrogen from 4·08 to 5·23; oxygen and nitrogen, taken together, from 5·97 to 8·41; and ashes, or foreign matter, from 6·36 to 9·87. Thus we see that the changes from woody fibre to the coal, commonly termed bituminous, have been as great, as regards the loss of oxygen and hydrogen, combined with the requisite proportion of carbon, as those in the more ancient deposits, so that the conditions for such changes have been similar in both cases. Although we now know that changes, even amounting to those required for the production of anthracite, are to be observed in the vegetable matter in still more modern rocks, yet the quality of the coal in the Eastern Virginia coal-field is one of value theoretically, and important practically, as it forms an additional instance to those already known of excellent workable coal being found otherwise than in the palæozoic deposits.

Independently of the more ordinary modification of the vegetable substances constituting coal, Mr. Lyell points out another due to the intrusion of matter in igneous fusion amid the coal-measures. At the southern extremity of the coal-field of Clover Hill, a dyke of greenstone is seen cutting through the coal and associated beds, altering the coal into a kind of coke. At another point the coal was found to be also affected, being more or less deprived of its bituminous qualities. Mr. Lyell traced the igneous rock to within 120 feet of the coal in this instance, though he did not observe it in contact; but he remarks that it may have more nearly approached the coal than he observed. There are also other instances of the same kind, reminding us of the effects produced upon coal in other countries, as in Scotland, where rocks in igneous fusion have filled up fractures, charring or coking the edges of coal-beds in immediate contact, and depriving them of oxygen and hydrogen, combined with carbon, so that a bituminous bed of coal shades off gradually into anthracite as it approaches the intrusive and igneous rock.

The most remarkable example of the so-called natural coke was observed by Mr. Lyell at Edge Hill, a locality five or six miles north of the James river, where a large quantity is extracted from an eight-feet bed. The rocks passed through, above the eight-feet bed, were 110 feet thick, and among them was a conformable bed of basalt 16 feet thick. The shale beneath the igneous rock was white for 11 feet, and then 25 feet of dark shale succeeded, below which came the bed of coke resting on white shale, and lower down coal-measures with two beds of inferior coal, each about 4 or 5 feet thick. The shale interposed between the basalt and natural coke-bed exhibits so many marks of rupture and friction, including slickensides among the latter, that Mr. Lyell attributes the change from coal to coke not so much to the heat of the intrusive basalt, as to its mechanical effect in breaking up the beds and rendering them permeable to water, or the gases of decomposing coal. He also points out, that where coke or altered coal reposes on that which retains its usual character, (as it is known to do in this coal-field, even the same bed having been found thus partially changed, the upper part altered and graduating into the lower,) the intrusive and molten rock, here as elsewhere, made its way among the beds, taking the form of a conformable deposit, altering the upper coal as far as its influence extended.

These facts constitute good additional examples of the alteration of common coal by the intrusion of mineral matter in a molten state, and the Eastern Virginia coal-field seems to have been much broken up in some places, and molten rock forced among it. No doubt, as Mr. Lyell states, the fractured condition of the mass would readily permit the escape of the gases, which deprived the coal of its larger proportion of oxygen and hydrogen. The white condition of the shales beneath, or otherwise in contact with the igneous rocks, would also, if their dark colour elsewhere were due to carbon, be accounted for in the same way. The coke-bed may, from its analysis (carbon 86·54; hydrogen 4·23; oxygen and nitrogen 4·53; ash 4·70), be considered in the chemical condition of an anthracite; many anthracites showing a much more considerable decomposition of the original vegetable matter, the carbon occurring in greater proportion to the oxygen and hydrogen.

Adverting to the scarcity of organic remains in the Bagshot sands, Mr. Prestwich supposes that this scarcity or absence of them arises, not so much from original causes unfavourable to the existence of testacea and other animals, or to the entombment of the remains of life, as to the subsequent operation of chemical agencies. He observes that where conditions for preservation were favourable, as in the central and upper divisions of these sands, traces of a fauna are far from restricted, and among other instances points out, that at Chobham Place, where a slight quantity of clay and peroxide of iron has consolidated the usually incoherent green sands, there is a semi-solid mass full of the casts and impressions of shells.

Mr. Prestwich, after remarking that in certain beds only the impressions and casts (and that rarely) at present exist, and that in this case there are favourable mineral conditions which do not generally prevail, proceeds to show that the hydrated peroxide of iron occurs commonly in the upper and middle Bagshot sands. He infers, that if a carbonate of iron were disseminated through the mass of these beds, and segregated in different places, it would, by decomposition, gradually evolve its carbonic acid, which being taken up by water percolating through the mass, would thus render this water capable of dissolving the carbonate of lime which might come in its way, thus acting upon the shells when it reached them in the pervious beds. It could scarcely but happen, where there may be sufficient free carbonic acid, no matter how derived, in waters percolating through rocks, that shells might be readily removed from beds, so raised into the atmosphere, that the waters containing the bicarbonate of lime in solution can readily drain off as springs, and the matter of the shells be thus removed to lakes and seas, perhaps to be again employed by molluscs for their harder parts.

The preservation of the matter of the shells themselves, in clays or other substances, usually called impervious, always however to be regarded as a comparative term, is well known to geologists, as also their absence in sandstones and other rocks. Even in some limestones, the carbonate of lime constituting the fossils is not that of the original shell, but a crystalline body replacing the actual shell, and therefore entering a cavity produced by the solution and disappearance of the original body. Every cast of a shell we find is an example of the solution and disappearance of the original. And not only do we find organic remains thus acted upon, but occasionally the carbonate of lime of rocks, in part formed of that substance, has disappeared partially or wholly. This may frequently be observed in some districts composed of the older rocks, and the original mixed rock, partly a mechanical accumulation of mud and silt, and partly a chemical product, from the admixture of carbonate of lime, presents only a sandy or silty appearance for many feet, where it has been exposed to atmospheric influences.

The manner in which the harder portions of animal remains have been removed and replaced by various mineral substances forms a subject of much interest, but upon which it would be out of place here to enter. It will be sufficient to observe, that the matter of a shell or of any other organic remain being removed, and the particles of matter surrounding the organic remain having been sufficiently consolidated to preserve its form or cast, the hollows are in the condition of any other cavity, whether produced by dislocations, cracks, or in any other way, so that the solutions of any substances entering them, it depends upon a variety of conditions what those substances may happen to be, or how far any of them may be retained to fill up the cavity. The siliceous fossil shells, so to speak, of the greensand of the Blackdown Hills, are familiar examples of the substitution of silica for the carbonate of lime of the original remains, and similar examples are common elsewhere. Sulphuret of copper was found to have replaced some shells adjoining a copper lode near Nether Stowey, Somersetshire, and sulphuret of lead may be seen occasionally filling up the cavities of shells in the lias of Glamorganshire. In a trial for coal near Cairo, bitumen was found filling up the cavities left by shells in the nummulitic limestone of that vicinity. All such changes are of an order similar to that of that section of pseudomorphous crystals, where one mineral disappearing from a cavity, its form is given to another mineral of a different kind of crystallization, when the particles of the latter could freely adjust themselves. The pseudomorphous crystals of tin from St. Agnes, Cornwall, is a well-known example of this change in the body of a rock. The original crystals are those of felspar, in a granitic substance; these disappearing, peroxide of tin has percolated in solution into the cavity, and occupied it. Mineral veins, and indeed the contents of common faults, often show us one mineral cast, as it were, in a mould left by another, the mould being apparent. While thus adverting to pseudomorphous crystals, it is necessary to observe that there is another section of them, where moulds are not apparent, and where, particle by particle, one mineral seems to have been replaced by another, so that the form of the first is preserved.

In his memoir on the agate quarries of Oberstein, our Secretary, Mr. Hamilton, shows that while agates are discovered in the cells or vesicular cavities of igneous rocks, chalcedonic deposits are also found in veins traversing a red conglomerate; whether referable to the base of the palæozoic carboniferous, or to the new red sandstone series, his researches did not enable him to determine. After pointing out that the agates taken from the cells or vesicles of the igneous rocks could not, from the nature of their formation, contain organic remains, as it has been supposed the Oberstein agates did, Mr. Hamilton describes the chalcedonic veins, which evidently filled cracks formed in the conglomerate since its consolidation, not only the red cementing matter, but occasionally the pebbles themselves being traversed by the chalcedonic veins. The successive siliceous coatings of the fissures are sometimes clearly shown, with even a space left in the centre, where the mammillated surface of the chalcedony is well-exposed.

Igneous rocks underlie the red conglomerate above-mentioned, and vesicular cavities in them not only contain the siliceous deposits, but also, as is not uncommon in such rocks, zeolites, carbonate of lime, and other substances. The base of the rock is compact, somewhat porphyritic, of a dark brown or chocolate colour, and when so weathered that the contents of the numerous small cavities have been decomposed, has the appearance of a vesicular trap rock. At a distance there is a faint appearance of stratification parallel to the overlying conglomerate. Proceeding westward from the town of Oberstein, the same amygdaloidal rocks continue, in places more porphyritic, nodules of small agates and chalcedony appearing sometimes to run in lines.

These rocks are underlaid by others of a more compact character, succeeded in their turn by a highly crystalline greenstone. It is at Idal that the principal agate quarries are worked. Two varieties of trappean rock, having the appearance of a slight dip to the E.S.E., alternate with each other, one much softer than the other, and of a more amygdaloidal character. It contains numerous nodules, varying from an inch to a foot in length. Remarking that these nodules are lengthened out in the plane of the bed, Mr. Hamilton observes that this form may be due to pressure on the cavities while still in a viscous state, a point of much interest, as also indicating a movement of the mass in the direction of the lengthened cavities, such as may be observed elsewhere in rocks of this class. The other kind of igneous rock is much harder and more compact, with a total absence of all nodules. Mr. Hamilton could not observe any marked line of separation between the two kinds of trappean rock, and therefore does not consider it probable that different *coulées*, some vesicular, others without air-, gas- or vapour-cells, flowed over each other. The appearances described by Mr. Hamilton more resemble, on the great scale, those igneous products where bands of vesicles occur in a mass poured out of some volcanic vent at the same time, portions without vesicles alternating with those in which they abound, and which may be seen in fragments as small as a hand-specimen. While the rock was in a molten state portions became vesicular, and when it was poured out, the viscous stream carried the parts in elongated streaks, often alternating with each other in minor portions of the general mass.

Respecting the agate nodules themselves, they are described as varying much in character, colour and substance. The smaller cavities are generally quite filled, commonly with a compact chalcedonic mass, while those of large size are usually lined with agate layers of different colours, and are invariably hollow. The outer layer of the large cavities varies in thickness, lined either with interior mammillated surfaces or by quartz crystals.

The mineral contents of vesicles and cavities in igneous and other accumulations, these hollows having never had communication with cracks or fissures of the rocks in which they occur, furnish us with excellent examples of the manner in which silica and other substances in solution have permeated through the pores of rocks, even of many exceedingly hard and compact. The hollows were thus necessarily filled with the solution at the time permeating through the rocks; and as no spring water is pure water, but on the contrary contains something in solution which it has taken up, in most cases, after the fall of the water as rain upon the land, we feel assured that there is no rock without a solution of some kind working its way through it, if it be above the level of the sea, and the water can percolate into the atmosphere. It will remain more stagnant if the rock be beneath the sea-level, the movement in the latter case being probably slight under ordinary conditions, though no doubt differences of temperature would produce the usual effects upon the moistened mass.

The replacement of the matter of fossil shells by other substances, as above noticed, is a filling up of cavities upon the same principle as the vesicle or hollow in an igneous rock by the siliceous matter constituting an agate. In agates we have frequently not only proof of the successive deposits of siliceous matter, but evidence also in the cavities of the interior hollows, such as are noticed by Mr. Hamilton, of the crystallization of silica in a more definite manner, the particles of silica having adjusted themselves under better conditions than in the chalcedonic bands forming the agate, so that rock-crystals are the result. The mammillated surfaces of the chalcedonic bands correspond with the mammillated surfaces of layers of many other minerals, being the grouping together of bundles of crystals radiating from a multitude of points on a previous surface of some kind, frequently not of the same mineral. The mammillated surface of malachite bands filling up cavities in mineral veins may be taken as a familiar example of this arrangement, and still better perhaps, as the crystals are better seen, such minerals as wavellite. Common crystallized carbonate of lime, filling large fissures of limestone, sometimes exhibits the succession of crystallized layers, with roughly-mammillated surfaces, in a very illustrative manner.

Mr. Hamilton remarks that the outer, or rather first-formed coatings of the large agates, these outer coatings sometimes too thin to be usefully employed, correspond in mineral structure with the whole contents of the minor cavities. This may perhaps be explained, if we consider that the siliceous solutions, the deposits from which entered both kinds of cavities, were abundant for a given time, after which they either entered less easily into the cavities, the first coatings of chalcedonic matter presenting a certain amount of obstacle to the free entrance of the solutions, or the solutions themselves contained less silica. In the well-known agate-form bodies found in the dolomitic limestones and conglomerates of Somersetshire and Gloucestershire, the evidence of changes in the kind of solutions which have entered the cavities in which these *potato-stones*, as they are commonly and locally termed, have been formed, is often very clear and interesting. Layers of chalcedonic matter, as in the agates of Oberstein, are usually first formed, after which the silica had better conditions for forming rock-crystals. The siliceous infiltrations ceasing, carbonate of lime, iron in some form, or other minerals, the results of the percolation of different solutions into the cavities, became crystallized in the hollows still left.

While some agates show concentric bands of chalcedonic matter, entirely filling the cavity, the original sides of the vesicle or hollow evidently giving the form, however modified in parts, to the general arrangement of the layers, others, commonly termed onyxes, have a system of flat layers, parallel to each other, and considered to be also found parallel to the main bedding of the rocks in which they are discovered. In the one case the inside of the cells or cavities has been coated without much regard to gravity, while in the other the deposit more accords with a deposit having reference to it. In some agates we find that the cavity must have been filled in one way at one time and in another manner afterwards; sometimes the one kind, sometimes the other, having been the first formed. Again, some cavities in igneous rocks have been found partially filled with parallel layers of chalcedonic matter, with small pendent stalactites of the like substance depending from the upper part of a hollow still left.

The change of colour produced artificially in the agates by the workers in them at Oberstein, an art learnt from the Italians, and to which Mr. Hamilton calls attention in his communication, stating his belief (referring also to the labours of M. Noeggerath) that not a few of the onyxes which have come down from ancient times were thus treated, is of much interest mineralogically, since it shows the very different porosity of different layers in the agates, the least porous bands not being necessarily the nearest to the centre, but dispersed irregularly through the mass. To this porosity Mr. Hamilton calls attention, citing the researches of M. Noeggerath, who states that in some layers the minute hollows can be seen by means of a magnifying-glass; that while some are round others are long, and that they sometimes run into one another. These hollows Mr. Hamilton considers may form interstices between the radiating crystals. By immersion for some time in honey and water, or olive oil, so that the pores of the agate become more or less filled with a substance to be carbonized, a subsequent soaking of the stone in sulphuric acid produces a difference in the tints of the agate according to the porosity of the layers the most porous becoming black, while the least porous remain white or uncoloured. By immersion in a solution of sulphate of iron and a subsequent heating of the agate, a carnelian-red is in like manner obtained for the most porous layers, the iron being converted into a peroxide, while the least porous layers continue unchanged in colour. It would be out of place further to dwell upon the infiltration of mineral matter in solution into the isolated cavities of rocks. The mode in which the various minerals occur is highly interesting, as also their connection with the matter filling veins and fissures in adjoining parts of the same or adjacent rocks, as for example the filling of the fissures in the red conglomerate by the same kind of siliceous matter which entered into the cavities of the igneous rocks of Idal, the layers having in both cases adjusted themselves to the surfaces on which they were accumulated.

Such have been the labours of the Geological Society of London since the last Anniversary; they have neither been slight nor unimportant; they have extended from our own land to the antipodes, in one direction by North America, and in the other through India; they have embraced a variety of subjects, palæontology, and its application in identifying contemporaneous deposits having formed a prominent part of them. It is evident that we have not been idle or neglectful of that science for the cultivation and extension of which we are associated, and that, therefore, we have assisted to promote the progress of knowledge generally, and consequently the well-being of our fellow-men.

Geological Society of Ireland.

Our sister society in Dublin has, as heretofore, been active in promoting the advance of our science in Ireland. The earliest communication made to it during the year was by Sir Robert Kane, on the occurrence, in the county Clare, of carbonate of manganese as a thin earthy bed, interposed between a decomposed surface of old red sandstone and a bog, two feet deep. To all appearance this carbonate of manganese is of comparatively recent origin. Respecting mineral substances a valuable paper was read by Dr. Apjohn upon an undescribed variety of hyalite from Mexico, where it is found in large glossy, transparent, globular concretions. It is considered a hydrate of silica, containing about 2·5 of water, and was found by the optical researches of Dr. Apjohn to be formed of a confused aggregation of microscopically minute rock-crystals. This result will be appreciated by those acquainted with hyalite, a mineral exhibiting at first sight few traces of crystalline arrangement, and it at the same time proves the value of optical methods of research in the examination of minerals.

Another communication of interest respecting mineral substances was made by Professor Oldham. Among the many alterations in the structure of the various beds of the older fossiliferous rocks of the counties Wicklow and Wexford, caused by the protrusion through them of the granites, is one wherein the component parts of the beds have been so acted upon that crystals of andalusite are abundantly formed amid micaceous slates, themselves altered argillaceous slates. The crystals of this mineral, sometimes of large size, occur in multitudes, crossing each other in all directions. Among these Prof. Oldham discovered some which had themselves been again replaced by mica, the latter occupying the space once filled by the matter of the andalusite, and its cleavage planes usually running across the principal axis of the original crystal, though sometimes occurring in planes perpendicular to every surface of it. This movement of the particles of matter, taking place at different times, without the bedded or laminated structure of the original rock being lost, in consequence of actual fusion by contact with the adjacent molten mass of granite, is one of no small geological importance when the laminated crystalline rocks, forming whole regions in some parts of the world, are under consideration. Prof. Oldham points out that Mr. Weaver had, many years since, remarked respecting the rocks of this part of Ireland, that "the character of this andalusite is altered by a more or less intimate mixture of mica."

Prof. Allman read a paper on erratic blocks of greenstone, found scattered over carboniferous slate, in the vicinity of Bandon, county Cork. As is well known, Ireland is in many districts covered by gravels and sands, occasionally mingled with blocks of large rocks, all of a comparatively recent geological date. If these be sea-borne, we should require the submergence of the land, and generally with its present physical features, to a depth of more than 1000 feet beneath the present level of its shores. The mode in which thousands of large blocks of granite are scattered over the flanks of mountains and over districts, facing great valleys, in the counties of Wicklow and Wexford, are often highly instructive. This 'drift,' as it is frequently termed, most materially influences the agricultural character of large districts in Ireland.

The communication of Prof. Allman was followed by another from Mr. Mallet, in which the latter endeavours to show that the transport of boulders or erratic blocks may be accounted for by the slow, or occasionally rapid movement of semi-fluid masses of mud, sand, gravel and blocks, forming the bed of the sea, (and either of sufficient depth and mass alone, or resting upon a base of rock or other materials of very moderate slope,) combined with the sorting and transporting power of the tidal streams upon the finer materials of the whole mass. Mr. Mallet considers that the mass of a loose sea-bottom may be constantly sliding outwards, forming a kind of *mud glacier*, as he terms it, the whole reduced to nearly one-third of its weight in air by immersion in water, and moving gradually over slopes of three or four degrees, and even less. In this manner he observes we may account for the grooving, furrowing and scratching so commonly remarked among these accumulations of gravels and blocks, pebbles and great fragments of rock being held firmly in the under part of the moving mass, and grating against the bottom. These scratches, now so commonly found on the surface of rocks in the northern parts of the earth, and which may be equally so in the southern, allowing for the difference of area there occupied by land, have been long pointed out by Dr. Buckland and others in the British islands, and have of late been frequently, as is well known, adduced as evidences of the former existence of glaciers upon the districts where such scratches are found. Mr. Mallet points to this view, and observes that the explanation he proposes will apply equally to the facts seen. Whatever hypothesis we may adopt in order to approach the truth in this matter, we must certainly bear in mind the scratches often so common among the pebbles themselves, as well as those upon the rocks beneath the gravel and blocks, as if there had sometimes been a grating of the harder parts of the mass upon each other, after its general deposit. This accumulation is often in distinct layers, its parts sometimes arranged in the manner observable upon beaches, while at the same time it is obvious that any rolling about of the pebbles by breaker action would speedily obliterate the scratches both on the pebbles and the rocks beneath. While this is true in some districts, and is more particularly worthy of attention over great flats, or floors of subjacent rock, sloping in various directions at exceedingly small angles, as is to be seen over the great central plain of Ireland, at other times we find huge blocks of rock perched about upon mountain summits, with scratches beneath and adjacent to them, as if we saw the very instruments which made them. These blocks, however, occur in situations which appear to show that they have been brought across deep valleys, as if ice-borne, and when the relative level of sea and land was very different from that which it now is, though we have only to look to comparatively recent geological times for their transport.

A memoir was communicated by Prof. Oldham, bearing upon the later geological changes which have been effected upon the area occupied by the British islands, as also upon the climate of the time. He announced the discovery of the undoubted remains of the reindeer (*Cervus tarandus*), in peat, marl and clay, near Kiltiernan, in the county of Dublin, in company with numerous antlers of the Irish elk (*Megaceros*). The evidence on this head is valuable, more particularly when added to the inference of Prof. Owen, in his Report on British Fossil Mammalia, that these animals once existed in our islands, and to the statement of Dr. Mantell respecting the remains of reindeer found in the Isle of Wight. Two other Irish specimens, in bad preservation, had previously been under the notice of Mr. Ball of Dublin. The value of this undoubted occurrence of the reindeer in Ireland will be at once apparent to those who remember the views taken by Prof. Edward Forbes, and published in the Memoirs of the Geological Survey, respecting the comparatively recent separation of the British islands, by elevation of the mass and subsequent sea action, from the main continent, thus cutting off the animals and plants which emanated thence from the remains of the parent stock. And this discovery is of the more value, when we connect it with the inferences to be drawn from the mixture of the reindeer bones with those of the Megaceros.

Mr. Mallet stated in another memoir, that having been struck with the unusual appearance of stalagtites and stalagmites discovered in the Cave of Dunmore, county Kilkenny, he found upon examination that they contained phosphoric acid, probably in combination with lime. He referred to the researches of M. Dumas respecting the extreme solubility of phosphate of lime in water charged with carbonic acid, so that bones or ivory-shavings immersed for a few hours in Seltzer water are softened and have many of their phosphates removed, pointing out that the phosphates in this case must have been derived from the dolomitic and limestone beds surmounting and including the Cave of Dunmore. The late labours of chemists have shown us that the phosphates, so important for the growth of cereals, are far more diffused through rocks than was at one time supposed, and this discovery of phosphoric acid even in the stalagtites and stalagmites of a limestone cave, is another proof of this diffusion.

In another communication to the Geological Society of Ireland, Mr. Mallet brought under its notice some views as to the circumstances under which the quartz rocks and slates of Wicklow have been arranged, with some remarks upon a peculiarity of lamination in the finer-grained and micaceous slates. His object was to show that the component deposits were all due to the sorting and transporting power of water in motion, the cleaner-washed sand and pebbles having formed the base of the present quartz rocks. He referred to the different conditions under which deposits were now being effected in the upper lake of Glendalough, in the county of Wicklow, as a good illustration of the sorting and arrangement of deposits at different depths. Regarding the ridges and furrows resulting from the friction of water upon loose sands, Mr. Mallet points to their occurrence in the lake beneath shallow waters, and while remarking upon the supposed accumulation of certain Silurian deposits in deep water, directs attention to the ripple-marks found so frequently among them, observing that these must either be confined to shallow waters, or to situations where streams of water moving with sufficient rapidity can produce them.

That the quartz rocks of the counties of Dublin, Wicklow and Wexford are but clean sands or quartz pebbles agglutinated by silica, which while in solution, probably often by the aid of an alkali, not unfrequently dissolved the outer edges of the siliceous sands and pebbles, appears very probable, indeed is now well understood, and the quartz rocks in the district above-mentioned afford good illustrations of this view. Respecting the 'ripple-marks,' as they have been commonly termed,—a bad name, inasmuch as they may readily be produced at any depths where a current of water can move with sufficient velocity,—we would direct the attention of observers to a study of those really made by the to-and-fro motion of waves in shallow water, or where tides drain off extensive flats, and to those really due to a constant friction of water in a given direction, in order duly to appreciate their differences in form. Such a study readily leads to a knowledge of the different arrangements of the grains of sand or silt, according to the forces acting upon them; a knowledge very material when the ridged and furrowed surfaces of various beds (and we find them among our oldest accumulations) are brought under our notice.

Considering it a duty on the part of the Geological Survey to aid the progress of the Geological Society of Ireland, Mr. Du Noyer read papers on the sections observed on the Dublin and Drogheda Railway, and Prof. Edward Forbes made a communication respecting the probable geological age and British equivalents of the Silurian rocks of the hills commonly known from one in particular,—the Chair of Kildare. Having with Prof. Oldham examined, during the last autumn, the succession of rocks there seen, and ascertained that they constituted a thick series of older accumulations, in which volcanic ashes or detrital matter derived from igneous rocks, as well as molten masses of the latter, were mingled with common sands and mud, forming its lower part, I have little doubt of the true relative position of the limestone, in which the organic remains are chiefly found. Indeed, the whole group of these hills seems little else than an old island of palæozoic rocks of the date to which allusion has been previously made, on the shores of which conglomerates and other rocks of the old red sandstone were accumulated. These again were covered up by the beds of the great carboniferous limestone, one of the most marked accumulations of the British series, especially for the evidence it affords of general similar conditions having existed over a large area at the same period, the modifications of these conditions being very gradual, though at the same time very marked, in different parts of that area.

It is probable that, like the Mendip Hills at a subsequent geological period, this island-land became covered up, as it was depressed beneath the sea, by the accumulations of the old red sandstone and the carboniferous limestone;—these accumulations again to be in a great measure removed by those extensive denudations which we have abundant evidence to show took place over this region.

Reposing on the part of the series in which the igneous rocks occur, and beneath a thick accumulation, chiefly arenaceous, the beds of limestone are found in which the fossils noticed by Prof. E. Forbes were discovered. Many of the fossils from the Chair of Kildare had previously been obtained by members of the Geological Society of Ireland, and are to be found in the collections of Mr. Griffith, where they have been described by Mr. M'Coy. Availing himself of all the sources of information presented, Prof. E. Forbes, taking zoological evidence for his guide, considers that these limestones of the Chair of Kildare are not only referable to the Lower Silurian series, but members of the lowest part of it, and equivalent to the Bala limestones and their associated beds in North Wales. A comparison of the fossils from the Chair of Kildare with those obtained from the limestone of Courtown, county Wexford, leads Prof. E. Forbes to regard it as highly probable that the limestones are equivalents, and that both are representatives in Ireland of the Bala limestones, a point of much importance as regards the accumulations during the same time in the British area.

Geological Societies of Cornwall, Manchester, and the West Riding of Yorkshire.

Societies formed for the purpose of advancing our science are not confined even in this country to London and Dublin. For thirty-four years the Royal Geological Society of Cornwall, instituted for "the discovery of facts to enrich science and the application of science to improve art," has endeavoured to promote the knowledge of Geology in the great mining districts of Cornwall. To induce agents and others connected with mines to join the Society in its pursuits, practical miners have been admitted during the past year to nearly all the privileges of the other members, at one-fourth of the annual contribution of the latter. The seventh volume of the Transactions of this Society is now in progress, and among the papers made public through these Transactions, many are well known to us as possessing great value, and as having aided the progress of Geology generally. The fifth volume is almost exclusively occupied by an elaborate account of the mineral veins of Cornwall, by Mr. Henwood; and other valuable notices of Cornish and Devonian lodes are scattered through the other volumes. Sir Charles Lemon, the zealous President of this Society, finding that there was a hesitation on the part of many practical men to communicate their observations in writing to the Geological Society of Cornwall, (and those who are acquainted with the Cornish miner know full well the value of his observations,) has during the last year, and at his own cost, engaged the services of Mr. Rundell, the secretary of that highly useful body the Polytechnic Society of Cornwall, to obtain information from the miners and communicate it to the Society. The experiment has been attended with success, and the result has been some interesting details, read before the Society, respecting certain peculiar circumstances in Gwinear Consols and Wheal Seaton mines. It is to be hoped that the experiment thus tried and found to be successful may be followed up by the friends of the progress of knowledge in Cornwall, and of the practical Cornish miner.

Though read in 1846, it is desirable, being now only published, to notice the communication to this Society by Mr. Pattison, on the geology of the Tintagel district, one of considerable interest, from containing the junction of the carboniferous series of Northern Cornwall and Central Devon with the range of rocks which come up westward from the Petherwin district, wherein so many interesting organic remains have been detected, and not a few by Mr. Pattison himself. In a carefully considered paper the author details the order of succession of the rocks, the admixture of igneous products with them, and the organic remains detected, remarking respecting the latter, on the absence of Trilobites and the rarity of Cephalopods which distinguish the Tintagel beds from those found near Petherwin, and the entire absence of the remains of fish, such as are found in South Cornwall.

We find Mr. Peach occupying himself as actively as ever with organic remains entombed in the Cornish rocks, accumulations which not many years since were supposed to be entirely non-fossiliferous. His communication to the Cornish Society was this year on the fossil geology of Lantivet and Lantioc Bays, near Fowey. It will be in your recollection, that last year, being then in Cornwall, Sir Roderick Murchison read a paper before the Geological Society of Cornwall respecting the probability of the occurrence of Silurian rocks in that part of England. His opinion was chiefly founded on the researches of Mr. Peach, who had obtained many organic forms, usually considered referable to that geological period. Mr. Peach in this communication enters into further detail on the subject, expressing his satisfaction that his views had been confirmed. The subject is one of much interest, particularly when we regard the physical structure of the part of Cornwall noticed, and trace the run of its beds. It is more particularly so when we examine the district generally with reference to its connection and relative position as regards the Plymouth limestone and the run of the rocks towards Torbay and

Totness; in fact, into districts the organic remains of which have engaged so much attention under the name of Devonian fossils.

There has also been a paper by Mr. Richard Couch, entitled 'Remarks on the Present State of Geology in Cornwall,' in which, while taking a general view of the actual knowledge respecting the geological structure of that county, he remarks, speaking of the general range of rocks, that after passing the Looe river westward, the Devonian fossils become more rare, that the organic remains assume more of a Silurian character, and that the peninsula formed by the Looe and Fowey rivers is composed of rocks partaking of the characters of the Devonian and Silurian series. Further westward, Mr. Couch observes, the characters of the fossils change: "there are many things to remind us of the old red sandstone, and yet sufficient to recall the idea of their being the deposits of the Upper Silurian rocks." It can be only by a careful study of all the great bends of the sedimentary rocks of Cornwall, with a constant attention to the minor flexures, and by an endeavour to trace out either overlaps or the fining off of beds, amid the contortions, that the true history of these deposits will appear.

Sir Charles Lemon, in a notice on the stump of an old tree, found in Heligan, pointed out many peculiar circumstances attending its mode of occurrence. He infers that the phænomena may be accounted for by an extensive change in the face of the country, due to local causes, since the time of the great drift, and after the growth of existing species of trees. There was also a notice by Mr. Edmonds on the rapid diminution of the sand-banks of Mount's Bay. Details are given of the loss of land sustained, and the removal of sand has been so considerable, that not only a meadow has been carried away, which seventy years since lay outside the sea-wall at the entrance to Newlyn, as well as ground occupied formerly by cottages and gardens near Penzance, but numerous rocks between high- and low-water mark, forty years since buried beneath four or five feet of sand, are now uncovered. The author attributes this loss to the quantity of sand removed as ballast for the shipping at Penzance, and employed as manure.

During the past year also, Mr. Percival Norton Johnson read a paper to the Society upon the electric action affecting metalliferous deposits. He has availed himself of every opportunity in endeavouring to establish, by observation and experiment, the effects of various rocks acting as positive and negative poles for the deposit of metalliferous substances. He infers that the existence of such deposits depends not only on the difference of the rocks, but also that the electric action must be kept up by the moisture percolating through the joints or cleavage of the rock in which they are found. From his experience he concludes that a bunch of ore or metalliferous deposit is never seen without proving its origin to have been the percolation of water through the joints or cleavage of the adjacent rock, with a difference of character in the contiguous rocks. The researches of Mr. Were Fox and others on the electric condition of mineral veins, and on the manner in which the ores of the metals have been accumulated in them, are well-known to this Society, not only as having a scientific but a practical bearing. All investigations of this kind, therefore, which can be carried out by competent persons in the mining districts of Devon and Cornwall, will necessarily be important, and it is to be hoped that the Transactions of the Geological Society of Cornwall may be enriched by many communications on this subject.

Mr. Henwood sent a note on the detrital gold deposits of Brazil, in which the author points out the differences between the characters of the 'diluvial and alluvial' gold of that country, comparing the former with the stream tin of Cornwall. Respecting the last a communication was made by Mr. Pearce.

The MANCHESTER GEOLOGICAL SOCIETY has existed for ten years. One of the chief purposes of its foundation was "to inquire into the statistics and machinery of mining, and to collect books, maps, models, sections and mining records, to be registered and preserved in a public depositary for the use of posterity, and to direct them where their researches may be most successfully and securely carried on." This object of the Manchester Geological Society has not been attained; and though every encouragement has been given to papers connected with the district, the proceedings of the Society have tended more to advance a general knowledge of geology as a science, than to elucidate the geological features of the district. The museum of the Society has rapidly augmented, and it is stated that the visitors to it have increased in 1846 and 1847, as compared with 1845, at the rate of 60 and 80 per cent. respectively. The communications made to this Society during the year ending the 28th October, 1847, were—'On some Main Lines of Fault traversing Cheshire,' by Mr. Ormerod; 'On Modern Geology and its Fallacies,' by Dr. Sleigh; 'Observations on the Primæval Condition of Matter composing the Crust of the Globe,' by Mr. Jobert; 'An Eclectic View of the Coal Formation,' by Dr. Black; 'An Account of the Coal-fields of Derbyshire and Yorkshire,' by Mr. Elias Hall; and 'On the Coal of the River Coti, east coast of Borneo,' by Mr. Bellot.

The GEOLOGICAL SOCIETY OF THE WEST RIDING OF YORKSHIRE still continues; and a paper on a new Safety Lamp, by the secretary, Mr. Thorp, has lately been read before it. It has published several communications, among the rest one by Mr. Thorp on the Yorkshire coal-field, and another by Professor John Phillips, on the 'Microscopic Texture of Rocks.'

PALÆONTOGRAPHICAL SOCIETY.

To the list of Societies instituted in this country for the cultivation and diffusion of geological knowledge, we have to add the PALÆONTOGRAPHICAL SOCIETY, formed during the past year, upon the principle of the Ray, the Hakluyt and other societies of that class, the members of which receive publications for their annual subscriptions in greater or less amount according to the total number of members, and consequently according to the amount of the general fund collected. Though these societies have become popular of late, perhaps there is as yet no instance in which a society of a similar kind has numbered so many members in so short a time, showing that no little general interest is entertained for the palæontological works to be published by it. Though only founded on the 23rd of March, 1847, four hundred members had been enrolled in June of the same year, and the Palæontographical Society now numbers six hundred and one subscriptions to it. In consequence of this support two works will be distributed this year to the members, one a Monograph, by Mr. Searles Wood, of the Univalves in the Tertiary Deposit named the Crag, illustrated by about 550 figures, and another by Professor Bell, on the Reptilia of the London Clay, also properly illustrated. It is but justice to our colleague Mr. Bowerbank to state, that the formation of the Palæontographical Society is due to him, and that to his continued zeal and untiring activity it is indebted for its present prosperous condition.

Geological Survey of the United Kingdom.

Being charged by Her Majesty's Government with the general direction of this branch of the public service, I should feel some hesitation in alluding to the aid which, by its progress, the Geological Survey was affording to the advance of our science in this country, if it were not abundantly evident that the members of this Society cheerfully co-operate with the Survey, and consider that by this branch of the public service objects are accomplished which could not be otherwise attained; so that the purposes for which we are here associated are promoted by the labours of the Survey. The progress of the Survey has during the past year been considerable, and maps will soon be published completing South Wales, and extending into North Wales. The map of Herefordshire will be finished, and a large part of that of Shropshire published. Somersetshire will be completed, with adjoining portions of Dorsetshire and Wiltshire. The knowledge necessary for the maps of North Wales and of Derbyshire is considerably advanced, and these will follow the above-mentioned.

With respect to the Irish branch of the Survey, a map of the county of Wicklow, with numerous sections, including those, with proper plans, of the more interesting mines, will speedily be published. The sections extend to the counties of Carlow and Kilkenny, and illustrate the mode of occurrence of some of the coal-fields in the latter county. It is hoped that geologists will be satisfied with the manner in which sections on a true scale,—that is, the scale for height and distance the same,—illustrate the mode in which granite has upborne masses of the older deposits among which it has been protruded, altering the latter, and sometimes entangling or enveloping huge fragments of them. The publication of the maps of Carlow and Wexford will follow that of Wicklow.

Museum of Practical Geology, London.

This establishment, which, but for the reasons before assigned for the Survey, I should have had some hesitation in naming, has also, by the fostering care of Government on the one side, and by the kind co-operation and support of the public on the other, considerably advanced during the past year. Thanks to the donations so frequently and liberally bestowed, its collections became so greatly increased that the Government is now erecting the considerable building which the members of this Society may have observed extending from Piccadilly to Jermyn Street, where these collections, illustrating both the science and applications of geology, can be made properly accessible to the public. There is much satisfaction in adding, that even to the limited portion of the museum which can now be exhibited, the number of persons admitted during the past year far exceeded that of the year previous, the admissions being daily and as a matter of course gratuitous. Among the various subjects investigated at the Museum of Practical Geology during 1847 for the public or the Government, perhaps one for the Admiralty may be specially mentioned to this Society, inasmuch as it relates to the British coals best suited to our Steam Navy. A first report on this subject, one so important in many respects, will be presented to Parliament in a few days.

It may be right to notice that a second volume of the Memoirs of the Geological Survey of Great Britain and of the Museum of Practical Geology in London will be speedily published, and that it was even once hoped to have placed a copy of it on your table this day.

British Works on Geology.

Our last Anniversary closely followed upon the publication of a sixth edition of Mr. Lyell's 'Principles of Geology,' so extensive and long-continued has been the public demand for this work, now, though including the needful additions which the progress of our science demands, comprised within a single volume. Our present Anniversary closely succeeds to the publication of a sixth edition of Dr. Mantell's 'Wonders of Geology,' a work which its author has contrived in a great measure to rewrite during the intervals of arduous professional engagements, and also, amid the same avocations, to accomplish the publication, during the past year, of his work on the Isle of Wight. To this we would refer for a very valuable account of the geology of that island, founded as well upon long-continued personal observation, as upon the labours of his predecessors and contemporaries. When a general work on geology attains a sixth edition, it is manifest that the public have marked their view of its merits; at the same time it cannot but be gratifying to the Fellows of this Society to see that the desire to acquire a knowledge of the science they cultivate is now no longer restricted to a few, but has become so extended, as to require the publication of repeated editions of works written to convey the information desired.

During the past year also we have to record the appearance of a new work by Prof. Ansted, entitled 'The Ancient World,' in which the author chiefly occupies himself with views founded on the organic remains discovered in rocks of different ages; these views communicated in a simple form, and more especially intended for the use of the general reader.

To our colleague, the Professor of Chemistry at Oxford, Dr. Daubeny, we are indebted for a second edition of his 'Description of Active and Extinct Volcanos, of Earthquakes and of Thermal Springs,' published a few weeks since. When we consider how important a correct knowledge of volcanic action now is, even when we study the detrital deposits of the oldest accumulations, facts observed giving rise to the inference that even in such early geological times, ashes and lapilli were showered into the atmosphere and falling into the water became mingled with mud or other deposits effected round the dry land and in the seas of the period, this work, wherein the whole subject is brought up to the knowledge of the day, by one so competent, cannot fail to be most acceptable to geologists. The work is so much altered that there is scarcely a chapter which remains as in the former edition. A new classification of felspathic rocks is given, founded upon the analytical researches of Abich, Gmelin, Rose and others. There is a sketch of the Lago di Lugano, with a new theory of dolomitization. We have descriptions of the thermal waters of San Filippo, of the Lagunes of Volterra, and of the Alban Hills, near Rome. The observations on Rocca Monfina are new, and chiefly from his own investigations, as also those on Mount Vultur and the Lago di Ansanto. Additions are made to the notice of Vesuvius, the result of two visits to that volcano, subsequently to the publication of the first edition. His former theory respecting the Dead Sea is much modified, and a far more complete account of the volcanos of the American continent is given. Two entirely new chapters are dedicated to a sketch of the phænomena of earthquakes, compiled from various sources, and the like number to an account of those of thermal springs, to an extended tabular view of their physical and chemical phænomena, and to statements, chiefly his own, considered to afford proofs of their volcanic origin. A much fuller account of the chemical theory of volcanos, as suggested by Davy and developed by himself, is given than is elsewhere to be found, and additional information in support of that view is brought forward. New proofs of the truth of the chemical theory are considered to be derived from Grove's researches respecting the repulsive force of heat annulling strong chemical attraction, from his own observations on the gases of volcanos and of thermal springs, from Pilla's notices of flames issuing from craters, and from the gradually increasing proportion of *bases* found in volcanic as compared with granitic rocks. Respecting the great heat which in the opinion of many of us produced the condition of the matter composing the earth that enabled it to take the form it now possesses, and which, diminishing by radiation into the surrounding planetary place, finally left a solid crust to be abraded by waters when they could form and act upon the hard rocks, partially reducing them, with the assistance of atmospheric influences, to sedimentary accumulations, these entombing the remains of life, when such was called into existence, Dr. Daubeny willingly admits that the researches of Mr. Grove show that, given sufficient heat, the constituents of our globe might have been mutually diffused, "and though thus intermixed, would have continued in a state of perfect chemical indifference one to the other." "Now," he adds, "if under these circumstances we suppose the temperature to have sunk down to that point at which the elective attraction of certain of the elements for each other prevailed over the repulsive force of heat, we have a right to infer the occurrence of those very phænomena and the formation of those very products, which the one theory (the chemical) assumes to be going on at the present day, wherever volcanos exist. There is therefore," he continues, "no antecedent absurdity in imagining that volcanic action may consist in a process of oxygenation, caused, in part at least, by the presence of these substances, and all that seems necessary is to ascertain how far the known phænomena accord with such an hypothesis." We would refer to the chapter on the chemical theory of volcanos for an able exposition of that theory, one which Dr. Daubeny continues to advocate as affording the better explanation of the facts observed.

Voyages of Discovery and Survey.

The publication during the past year of three voyages of our countrymen has added to our knowledge of the geological structure of the earth's surface in distant places. The voyage of Sir James Ross to the Antarctic regions has proved, not only the great extent of a mass of land in the South Polar regions, but also that volcanic forces are still in full activity there. A mountain estimated to rise 12,000 feet above the sea, and named Mount Erebus, is described as throwing out jets of dense smoke to the height of 1500 and 2000 feet, the diameter of the jets being estimated at 200 to 300 feet. Even streams of lava were thought by some persons to be ejected. Not far from Mount Erebus another mountain, named Mount Terror, exhibited a form leading to the inference that it was an extinct volcano, and crater-like hillocks were observable on its sides.

An icy barrier for the most part prevented access to the land, but wherever a landing was effected igneous rocks alone were found, and all the fragments or pebbles obtained from icebergs, and by soundings, were of the same character, granitic rocks being discovered among them.

It is not a little interesting to consider the different conditions under which rocks would be placed in a region like that of Victoria Land, and in those parts of the world where snow never falls and frost is not felt, as also in those exposed alternately to the cold of winter and the heats of summer. On the Antarctic land no great river appears to bear detritus into the sea, and decomposition from the action of many atmospheric influences, such as aid the disintegration of rocks in temperate and tropical regions, can be little felt. As far as was seen by our navigators a great mantle of snow covers all, with the exception of some bare spots, probably either too precipitous to be thus enveloped, except by sufficient accumulation around them, or still too warm, after flowing as lava currents, to permit a covering of snow.

Though we can look to little else, for the wearing away of the land, than the action of the breakers upon the portions of the coast, which may for a time be free from ice, with such aid as any marked difference of temperature during a very short period in the summer of these regions can give, by detaching pieces of rock from the cliffs, yet the volcanos may throw mineral matter into the sea, to be distributed by tidal streams or oceanic currents. There is no reason to suppose that lofty volcanos, like Mount Erebus, do not occasionally eject ashes and cinders in the manner of numerous other great volcanic vents, scattering the finer ash around, much of it borne by the winds to great distances. The form itself of the mountain points to the ejection of such substances, its conical shape being the result of their accumulation immediately around the chief vent.

By consulting the notices of soundings obtained by Sir James Ross off this land, we find a green mud frequently mentioned. For about 450 miles this green muddy bottom seems common from Victoria Land along the great icy barrier. The same kind of bottom extends beyond it, and some detached portions of the icy barrier are mentioned as aground upon it in 1560 feet of water, 60 miles from the edge of the barrier and 200 miles from the land. When we consider that the fine detritus so commonly borne down by great rivers in the temperate and tropical regions cannot be so transported here, the presence of this green mud over so considerable a submarine area may possibly be in some measure due to the ejection of fine volcanic ashes during a long period of time, these ashes mingling with such fine detritus as can be ground off the coast by the breakers, or carried outwards by icebergs.

Glaciers are mentioned as descending from a range of mountains (the Admiralty Range) varying from 7000 to 10,000 feet in height, and projecting in many places several miles into the sea. As bare rocks were seen in a few localities, such glaciers may be the means of transporting masses of rock to the sea, a portion of them to be afterwards borne by ice into more temperate climates, supposing the glaciers to have a movement outwards, however modified this movement may be by the climate of Victoria Land.

Although the great icy barrier of these desolate regions extends far out beyond the land, and beyond where it can be aground, some portions rest on the bottom. Icebergs which have so rested upon the ground seem often to be turned bottom upwards, the previously lower portions bearing to the surface mud, sand and stones, some of which may thus become transported considerable distances; more particularly should the icebergs not again capsize, since the mud, sand and stones would be borne on the higher parts of the icebergs. Sir James Ross mentions one remarkable instance of the appearance of the mud and stone-covered bottom of an iceberg, which capsized off Victoria Land so suddenly that it was for the moment supposed to be an island not before observed.

The amount of mineral matter borne away from this region by ice during the lapse of centuries, must tend to cover the bottom of the southern ocean not only with fragments of large size, but also with the finest mud, and this over extensive areas where no other means are apparent, under existing conditions, for the distribution and accumulation of such detritus. An iceberg was noticed in latitude 66° S. nearly covered by mud and stones. One large block of volcanic rock was estimated to weigh many tons. We may expect that not only angular but rounded blocks would sometimes be thus transported, for the beaches upon which the surf breaks in summer would be frozen in winter, and worn masses might occasionally be caught up in the ice, removing away from the shore, and be carried within the power of some iceberg to pick them up, and by capsizing bring them to the surface and transport them. Occasionally also we may anticipate that a part of the barrier itself, previously attached to, and partly covering a beach, formed before the ice adhered to that part of the land, may from local causes break away and be carried northwards. In all cases the mineral matter borne away by the icebergs would cover all inequalities in the bottom of the ocean which it may fall upon, and thus the resulting accumulation may be a mixture of large and small fragments, angular and rounded (some perhaps scratched), mingled with mud and sand, the whole arranged in the most irregular manner, large masses of rock strewed over and scattered through clay.

With respect to the turning up of blocks of large size by the capsizing of the icebergs off these southern lands, Captain Wilkes, of the United States' Exploring Expedition, which descended into the Antarctic regions in 1840, considers that he landed upon an upturned iceberg, part of the icy barrier, weathered by storms, about eight miles distant from the main land, in latitude 65° 59′ 40″ S. On this he found boulders, gravel, sand and mud or clay, the larger specimens being described as of red sandstone and basalt. There was also a kind of icy conglomerate, the matter cementing the stones being formed of hard compact ice. One piece of rock imbedded in it was estimated at about five or six feet in diameter. The same navigator also mentions many icebergs discoloured by earth. Indeed the evidence of the frequent overturn in these regions of icebergs which had been aground, bearing the mud, gravel and fragments of rock on the bottom upwards, appears complete, and is very important as regards the distribution of detritus by means of icebergs.

As not without its geological bearing we may here glance at the formation of the barrier itself. All the drawings made and information received point to its accumulation in layers, in at least that part of it projecting beyond the land into the ocean. The portion above water is generally described as from 150 or 180 to 200 or 210 feet. Captain Wilkes refers the formation of the ice in the first place to ordinary field ice, upon which layers accumulate, varying from 6 inches to 4 feet in thickness, from rain, snow and even fog, so that the mass descending by the increasing weight, part takes the ground, and the other portions run out to sea over deeper water.

The layers are proofs of successive accumulations, and as they vary in their texture, they would point to modifications in the conditions of the deposit at different times. We may assume that similar accumulations are effected on the land, disturbed only by volcanic outbursts and the showering of ashes and lapilli from volcanic vents, for the time in a sufficient state of activity, such showers extending as well over any portions of the icy barrier within reach, as over the snows of the land. The uniform, or nearly uniform height of the barrier, when covering various depths of water, and not aground, would apparently indicate some counteracting cause, preventing such an accumulation of layers of ice, as by giving a total increased thickness should enable a greater height to rise above water in the deeper situations. It is here assumed that the thickness of the barrier is not increasing, and remains generally the same, a fact which may perhaps be thought not as yet sufficiently proved. Nevertheless, when we consider that the sea-water beneath the icy barrier is not exposed to that great depression of temperature, to which when directly in contact with the atmosphere, it is subject, and that beneath the lower part of the barrier, deep as that lower part is, it would be only water of greater specific gravity than that above, which could there find its way, the experiments of Sir James Ross lead us to suppose that after a certain depth the ice would cease, the temperature being too high for its continuance. Upon this hypothesis the general thickness of the barrier would be the same as long as there was a sufficient depth of water to secure the needful temperature, the accumulation of snow and ice above being met by the melting of the ice beneath.

We should expect the rise and fall of the tide to act upon the barrier, tending to break off portions at its outer edge, where, if the lower part plunge into water of sufficiently high temperature, a melting beneath would assist in detaching fragments. The needful support by the proper amount of submersion being thus to a certain extent withdrawn, the masses would strive to rend themselves off and adjust themselves in the water relatively to the floatation line now become proper to them. It is evident by the upsetting of the icebergs, so often observed, that their centres of gravity become changed, so that the masses take a new floating position relatively to them. In regions where the cold of the atmosphere is so great that little general change is produced upon the upper part of the icebergs compared with that which is experienced beneath by plunging into water above the freezing point, we should expect such changes in position frequently to happen, any load of mud or stones of the remaining portion beneath being comparatively of little importance.

Great tabular masses varying in size, some even several cubic miles in volume, float away from the parent barrier, the tidal streams and ocean currents sweeping them onwards. And it should be borne in mind that the solid barrier presents a submarine cliff of ice, by the side of which a large volume of water would readily pass without the interruptions usually produced by land. According to the seasons so must the icebergs float, little altered in general form, to different distances from the barriers, many of them capsized with their load of mud, sand, gravel and blocks uppermost. A large tabular mass of ice about three-quarters of a mile in circumference was seen floating, 130 feet above the water, in about latitude 58° 36′ S. As the icebergs passed into regions where the decay, in the atmosphere, of the higher portions of them became more considerable than of those beneath, they would cease to upset, and would carry their loads of mud and stones uppermost or below, according as they may have been upset more than once by remaining a sufficient time within the needful conditions.

Whenever opportunities occurred, Sir James Ross was indefatigable in trying for soundings and the temperature of the sea at different depths. The results are highly valuable. He was enabled to ascertain that a belt of sea of uniform temperature, from its surface to the greatest depths, extends round the southern regions in a mean latitude of about 56° 26′. Though this may be the mean, it was found to vary in position from 58° 36′ in longitude 104° 40′ W. to 54° 41′ in longitude 55° 12′ W., being a difference 3° 55′ of latitude. Such variations are to be expected from local causes, and even in the same locality from modifications due to great changes of seasons. Sir James Ross points out that this belt forms a barrier between two great thermic basins, the temperature of 39°·5 (that of the most dense sea-water according to the observations made during this voyage) descending on the north of it to the depth of 3600 feet in latitude 45° S., and in the tropical and equatorial regions to that of 7200 feet, the surface temperature being 78°, while in latitude 70° S. the line of uniform temperature descends to 4500 feet, the surface temperature being 30°.

When we compare the distances with the depths of uniform temperature here noticed, and assume, for the sake of easy illustration, a level plain from the equator to latitude 70° S., we find that from the surface belt of 39°·5, the inclination of this line of temperature would be to the equator on the one side about 1 in 1723, and to latitude 70° about 1 in 1136 on the other. Thus the slopes would be most gradual, and the depressions on the north and south so slight compared with the distances that a tolerably long section would show these two thermic basins as slight depressions, and in a section less long as scarcely distinguishable from a thick line.

With such a section before us we experience little surprise that the tendency to occupy the same relative level, from the greatest density, should be greatly modified by the atmospheric influences on the surface of the ocean.

These observations respecting a belt of uniform temperature in the ocean in the southern hemisphere would lead us to anticipate that, similar causes being in action in the northern hemisphere, similar results would be found there, though no doubt modified by the prevalence of land in the north as compared with the south. The temperature of 39°·5, obtained by Sir James Ross for the apparent greatest density of water in the ocean, is not that which experiments in the cabinet would have led us to expect. Dr. Marcet found that sea-water decreased in volume until it reached 22°, when it expanded a little, and continued to do so down to a temperature of between 19° and 18°, when it expanded suddenly and became ice with a temperature of 28°. According to M. Erman, salt water of the specific gravity of 1·027 diminishes in volume down to 25° Fahr., not reaching its maximum density until congelation. The temperature of the most dense sea-water observed so constantly by Sir James Ross, is about that which numerous experiments show as that of the greatest density of fresh water. Dr. Hope and Professor Moll found the latter to be between 39°·5 and 40° Fahr., and Professor Hällstrom states it to be 39°·394 Fahr. The observations of Sir James Ross would show that the temperature of the ocean-waters, which may be considered to vary in specific gravity from about 1·027 to 1·028, is the same with fresh water, and the mass of evidence he adduces, supposing no instrumental errors, would prove that the temperature of 39°·5 is that of the most dense water of the sea, and if not corresponding with experiments in the cabinet, shows either that there is some modifying cause beneath the waters of the ocean, producing a higher temperature than should otherwise be, or that there were sources of error in the cabinet experiments not observed.

It did not escape the Commander of this voyage, that the uniform temperature of so much of the ocean might be favourable for the passage of marine animals from northern to southern regions, if the animals were such as to disregard the pressure of water under the equator and in the tropics. He observes that arctic marine creatures might pass to antarctic regions with only a difference in temperature of 5°, and a pressure of 2000 feet of water in the tropics.

In the region of Victoria Land we see a striking example of the extension of marine life, and of aquatic mammalia and birds dependent upon it, beyond terrestrial vegetable life and the animals consuming it. To this, no doubt, the equal temperature of the mass of waters beneath certain depths gives great aid, and as a whole these temperatures are less variable in the sea, and fall less low than in the atmosphere, the covering of ice protecting the waters from the intensity of cold to which they would be otherwise subject.

Live corals were taken up from the depth of 1620 and 1800 feet off Victoria Land, and from the same situations *Chitons* and other molluscs, with *Serpulæ* adhering to stones and shells, were obtained*. Looking at the temperature of the sea obtained off Victoria Land by Sir James Ross, and the probable changes effected during the winter months, due allowance being made for an ice-covering, these animals would appear exposed to very moderate changes of temperature.

* These corals were examined by Mr. Charles Stokes, who found them to consist of three species of *Lepralia*, *Retepora cellulosa*, *Hornera frondiculata* (Lamouroux), *Primnoa Rossii*, *Melitæa Australis*, and *Madrepora fissurata*. He remarks that *Primnoa lepadifera* is found in from 150 to 300 fathoms, off the coast of Norway, and Prof. Forbes is given as authority for a species of *Primnoa* in 278 fathoms off Staten Land.

The marine creatures mentioned as obtained from the depth of 6000 feet were within the range of uniform temperature (39°·5), and therefore would not be exposed to any change in that respect.

The existence of live corals and molluscs at these depths in the cold regions of the globe, beyond the range where life based on the consumption of terrestrial plants is found, has a geological bearing of much value, since we might infer that no part of the sea-bottom, viewing the subject as a whole, is deprived of animal life. It might as well extend to the south pole as to the latitude of the seas visited off Victoria Land, if the depths be not so considerable as to interfere with its existence by a pressure too great, or by an absence of vegetable food upon which the marine life is based.

While corals abstract carbonate of lime from the sources around, and add, after death, to the sea-bottom by the accumulation of their harder and calcareous parts, a multitude of infusoria obtain and accumulate silica in the same manner. They not only appear to swarm in the muddy bottoms off Victoria Land, but were also seen in such numbers on the pack ice itself as to stain it of a yellowish tint. Thus in these remote and desolate regions, as regards terrestrial vegetation and the animal life feeding upon it, where the ordinary decomposing and degrading effects of atmospheric influences are checked, and to a certain extent unfelt, no running waters conveying detritus or saline solutions to the sea, we find marine animal life busy in obtaining and leaving solid carbonate of lime and silica. So that the forms given to these substances mingling with the inorganic matter otherwise accumulating, here, as elsewhere in the temperate and tropical regions, records are preserved of the life now existing on the face of the globe.

Among the islands visited during this voyage, a stay was made at Kerguelen's Land, sufficiently long to permit a slight insight into its geological structure. Though, like so many of the ocean islands, it presents us with igneous products, we here find detrital matter mingled with them, with coal also and fossil wood. Mr. M'Cormick describes basalt, columnar and horizontal, amygdaloidal rocks, greenstones and porphyries, as also slates termed arenaceous, with veins of basalt and hornstone traversing the igneous rocks. We seem to have the latter so mingled with detrital matter as to show that the mass of the island may have been elevated since the accumulations were effected, volcanic ashes having assisted in forming with the ordinary detritus from greenstones, porphyries or other igneous rocks, the sedimentary deposits pointed out. However this may be, we have coal and fossil wood in a locality where now the most scanty vegetation is alone found, leading Dr. Hooker, who accompanied the expedition, to remark, that the conditions for the growth of plants must have been far more favourable than at present prior to the entombment of the vegetation forming the coal and the fossil trees (one of which, dug out at Christmas Harbour, was seven feet in circumference). The coal of the same harbour was in a horizontal bed, four feet thick, requiring no small amount of vegetable matter to form it, and another coal bed was found in Cumberland Bay. Fossil wood is also noticed as scattered through the igneous rocks. How far some of these rocks may be consolidated ashes does not appear, but it might well happen, that not only lava-currents may have flowed over a mass of vegetation, perhaps sometimes a thick peat-bog, but also that a body of ashes may have been vomited over them from a neighbouring crater. Whether enveloped by ashes, subsequently consolidated, or by molten rock, the conditions for silicification of some of the wood remind us of those in Tasmania. The prevalence of the remains of a vegetation now no longer found is a fact of much geological interest, for we can scarcely doubt, from their mode of occurrence, that the plants entombed grew on the spot. Here, therefore, upon a small point of land, projecting through the waters of the southern ocean, far remote from continents (that of Victoria Land being probably the nearest), we have evidence of changed conditions regarding the growth of plants. The mere chance of such an investigation as could be given affords the remains of a tree seven feet in circumference, in a region where small plants only can at present grow, and we are left to infer that when such trees flourished a milder climate reigned over this land, now so desolate.

Mr. Beete Jukes has, in his account of the voyage of the 'Fly' to Torres' Straits and Australia, furnished us with much valuable information respecting that coral accumulation known as the Great Barrier Reef, which extends for about 1000 miles in length, with about 30 in mean breadth, from Breaksea Spit, off the eastern coast of Australia, in lat. 24° 30′ S., to Bristow Island, off the coast of New Guinea, in lat. 9° 15′ S. During the needful examinations by Captain Blackwood, in command of the surveying expedition, Mr. Beete Jukes lost no opportunity of studying this interesting mass of matter, due to the power of myriads of polyps to obtain from the sea and secrete carbonate of lime. He divides the accumulation into, 1st, linear reefs, forming the outer edge or actual barrier; 2nd, detached reefs, outside the main barrier; and 3rd, inner reefs between the shore and the barrier. The linear reefs vary from half a mile to 15 miles in length; the detached reefs take more or less the circular or oval form, with lagoons inside, to which Mr. Darwin has assigned the name of *atolls*, and the outlines of the inner reefs are noticed as of different shapes. On the outer side of this great mass of coral accumulations, or of matter derived from them, the sea suddenly becomes deep, while on the inside it is comparatively shallow. The edges gradually slope, or are rounded to the depth of 12 or 24 feet, after which they plunge with equal slopes suddenly into 120 to 1200 feet, as the case may be. On the weather, or more exposed side of the reef, great blocks of coral, six to nine feet across, are detached by the force of the breakers from the main mass, and the surface of the reef is described as having the appearance of a great flat of sandstone. Loose slabs lie about, with here and there an accumulation of dead coral branches, or banks of white sand, and the whole is checkered with holes and hollows, in which living corals are growing. Coarse sand occurs inside the barrier and near the reefs, while finer matter is found more towards the main-land.

We have here upon a great scale, occupying an area which may be roughly estimated at 30,000 square miles, that variable mixture of organic, mechanical, and chemical accumulations which has been so often remarked among coral reefs and islands, and of which Mr. Darwin has given so valuable a summary, illustrated with such important original reasoning, in his work on Coral Islands. Although it would be out of place here to enter into the interesting details afforded by Mr. Beete Jukes, it is important to notice that he found corals able to sustain life when left by the tide several inches out of the sea. He observed living Astrææ, the tops of which were 18 inches above water, and he believes that an exposure to the sun and air for two or three hours will not kill many coral polyps, the cells retaining moisture so long as they are in a position of growth.

When we consider the accumulations of the great barrier reef as a mass of matter obtained by animal life for its uses, having formed the hard parts needful to it, (including the shells of molluscs, the spines and coatings of echinoderms and the like,) before it became sand, and furnished the materials for chalky and calcareous mud, or crystallized out in fitting situations and under the proper conditions, we are forcibly struck with the means by which the same matter has probably passed from the solid form, (often perhaps from the fossil remains of pre-existing life,) into solution, whence it was abstracted by the coral polyps, molluscs and other creatures for their wants, again to be accumulated in a solid form, partly in that given to it by animal life, partly as sand and fine mud, and partly in a crystalline state. Mr. Darwin has pointed out the mixture of organic and mechanical matter forming coral islands, the growth of the reef-making corals outwards, their abrasion in part by the breakers, and the accumulation of an outside talus at a high angle, over which the living corals gradually extend, and cover the fragments and worn portions by masses of their calcareous secretions. The observations of Mr. Beete Jukes would confirm these general views, but at the same time he remarks on the possibility of corals, with whose habits we may still remain unacquainted, laying the foundation of reefs and islands in deeper water than is assigned to the existence of the known reef-constructing corals which flourish from near the surface of the sea to the depth of twenty or thirty fathoms.

In the examination of Heron Island, the coral beds, one to two feet thick, were observed by Mr. Beete Jukes to have a tendency to split into slabs, and joints were found to cross each other at right angles, parallel to the dip* and strike respectively, dividing up the coral rock into blocks of one or two feet in the side. This jointing of an accumulation, forming as it were under the eye, has no small geological bearing.

It is interesting to consider the accumulations now collecting for 1000 miles inside the outer ridge of the great barrier reef. The surf-

* The dip was from 8° to 10°.

loving corals probably extend over broken or triturated coral outwards, slowly advancing the main mass. While great depths bound the outer edge the inside becomes filled up by a multitude of corals, which can there adjust themselves to the needful conditions; and by coral sand-banks, which Mr. Beete Jukes shows are but "the washings of broken coral swept by tides and winds towards the lee side of the reef, until that is made the shallowest." "When this is dry at low-water, the sand is piled up by the wind into a heap, with a sloping bank, till it is at last reared above high-water mark."

Amid these corals and sand-banks, numbers of molluscs, radiata, and fishes live, and at death leave a large proportion of their harder parts, adding to the general accumulation, and often doubtless in a stratiform manner. Nor are these the only classes of animal life, the remains of which aid in increasing the general mass. Turtles frequent the reefs, banks and islets, where their skeletons and bones are found scattered, and the conditions are such that these remains can scarcely but be entombed amid the calcareous sands and coral growth. Their eggs are known to be so imbedded. The bones of birds also may probably be enveloped, for immense flights of them are seen on the islets. Raine's Islet, mentioned as not more than 1000 yards long and 500 yards wide, and only 20 feet above the sea, was found covered with them.

The conditions for the solution and chemical deposit of carbonate of lime would often arise, and a slight to and fro motion from a ripple in sheltered situations, where carbonate of lime was being thrown down from solution, would so roll about fine grains that they became covered by concentric concretions, forming oolites. Mr. Beete Jukes found such upon Raine's Islet. Where circumstances were favourable the crystalline arrangement would be upon a larger scale, and definite forms would be presented. Our author found drusy cavities in coral rock containing crystals of carbonate of lime, as also some of sulphate of lime.

While this order of accumulation was progressing from the clean sea and outward reefs inwards, different conditions would obtain along the shore of the main land. It is well known to those who have studied coral reefs that most coral polyps cannot support life where the waters are charged with muddy matter or fine detritus. We have often had occasion to observe this fact around Jamaica. As the Australian coast is approached, notwithstanding that it is protected from the ocean breakers by the outer reefs, there is still enough abrasion by the sea to produce detritus, adding to that which may be brought down by the rivers. These are known to be of so little importance that water is scarce along the whole coast bounded by the coral barrier. Indeed if it were otherwise the barrier would be broken through, or rather would never have been formed where the muddy waters of large rivers interfered with the coral growth.

Towards the coast, therefore, there would be conditions, antagonist to the growth of the reef-making corals, which would gradually cease towards the clear water outside the reefs. Though interfering with coral life, they would necessarily have no influence on the extension of the coral pebbles, sands and finer calcareous mud towards the shore, where all such would be sorted and deposited in the usual manner. Detritus from the land would mingle with the calcareous sediments towards the coast, and especially when any was forced out of river-mouths, where, and in other sheltered situations, those detritus-collecting plants, the mangrove-trees, appear to be, from the descriptions of Mr. Beete Jukes, very common.

Respecting the volume of this accumulation, including any detritus obtained from the shores, chiefly, it would appear, granitic, and even supposing it to repose on a sea-bottom gradually sloping to the great depths found immediately outside the great barrier reef, we have to measure it by no small amount of cubic miles. If to this we add the mass of similarly formed matter now constituting the atolls or lagoon-islands, the encircling reefs and the shore reefs of the Indian and Pacific Oceans, and now constantly increasing, the various coral and other germs settling and flourishing wherever they find the conditions suited to them, we have an immense mass of carbonate of lime transformed from a state of solution to that of a solid by the agency of animal life, adding most materially to the rocks now accumulating in the tropical regions of our globe.

When we consider that heavy breakers are favourable to, and do not impede, the growth of certain corals, indeed such situations must prevent the attacks of many coral-feeding animals which would otherwise crop down the polyps and their fragile cells ; and that the germs of the surf-loving corals are floating about ready to settle wherever the sea is clear enough, and the temperature and other general conditions are suited to their growth, there seems little limit to their extension where such conditions obtain. These existing, a reef is formed, and the mechanical destruction of portions of it follow. If the power of the polyps to secrete their harder parts be as a whole greater than that of the surf to break them off,—the parts which can be broken off falling into deep water beyond the range of surf, and part ground down within its influence into sand, the general mass increases.

The reason why the great barrier reef is interrupted off the southern coast of New Guinea,—for the coral conditions, and with them the coral reefs, again obtain on its western shores,—would appear to be made apparent by the voyage of the 'Fly.' A bottom of mud, the sediment from some great river or rivers flowing into the sea out of this part of New Guinea, extends over the ground which we can scarcely doubt would be occupied by coral reefs if the waters were clear. These muddy waters, every gale of wind stirring up the bottom for a long distance out, effectually keep off the coral growth ; and clays, by the accumulation of the mud where it can find sufficient repose, represent in geological time the calcareous accumulations on each side, any difference which such conditions make being impressed upon the animal life, remains of which are being entombed in the different parts of the general sea-bottom.

Mr. Beete Jukes shows that at Erroob and the Murray Islands there has probably been igneous action during at least the formation of a part of the Eastern Australian and Torres' Straits' coral accumulations. Volcanic substances are mingled with white limestone, some of the pieces of the latter and of lava even showing that they have been rounded. In Erroob, rocks that have been in a molten state are seen to cover the sandstones and conglomerates. These volcanic vents at the northern part of the great barrier reef are supposed to form part of a great belt of volcanic operations, ranging at no great distance to the northward and eastward along the north coast of New Guinea into the Solomon Islands, New Hebrides and New Zealand.

As connected with the formation of the present reefs off Eastern Australia by slow depression of the land, thus causing the corals to raise the reefs in proportion as the general mass of land and the neighbouring shore sank down, in the manner by which Mr. Darwin accounts for the atolls and barrier reefs round many islands, our author points out a fact of much importance. There are flats of coral conglomerate, half a mile wide, frequent on the north-eastern coast of Australia, in and upon which, and upon other flats of the same coast, pumice pebbles are abundantly scattered, about ten feet above the present high-water mark. Indeed these pumice pebbles are found at the same elevation for nearly 2000 miles along the eastern coast. Hence Mr. Beete Jukes infers the coast to have been equally affected as regards elevation or depression since these pebbles were accumulated, and that it has been slightly elevated, or at least has not suffered any depression during a long period of time. He allows for the piling action of breakers, which no doubt during the heaviest gales of wind throw pebbles on shore far beyond the usual average of high water, and would readily force before them such light bodies as pumice pebbles ; and during such times, no doubt, they could be easily floated over extensive flats covered by the sea. It would appear that these pumice pebbles are mingled with the coral conglomerates, and were noticed in the coral rock of Raine's Island.

The accumulation of pumice at one time more than at another would depend upon the nature of the supply, and would last no longer than the eruptions continued which produced it in some situation whence it could be drifted to the Australian coast and be ground into pebbles. That there has been elevation and depression of the land and adjacent sea-bottoms in many localities in different parts of the world, producing the effects connected with coral reefs which have been pointed out by Mr. Darwin, is exceedingly probable : indeed, respecting the elevation of coral reefs we have abundant proofs, and therefore there is little reason to doubt depression, which the accumulation of rocks of all geological ages shows to have been very common and often very extensive. Upon such points the geologist can have little doubt, but he may sometimes doubt the application of depression to every case of a barrier reef, seeing the power of extension through long-continued time of the reefs outwards into deep water. The study of reef-making corals shows us how they seek clean water and the surf, and the manner in which they avoid waters charged with mineral matter in mechanical suspension. Hence we commonly find them either attached to, or at a distance from the shore, according to the clearness of the water, though certainly here and there they seem to struggle hard with adverse conditions in this respect. Where by their increase the surf fails them, they seem to be soon covered by other corals and Nulliporæ; the latter Mr. Darwin points out as especially creeping over them towards the surf. When we consider that many a volcanic island rises through the sea by accumulating erupted masses of ashes, cinders and molten rock, and that the permanency of its continuance above the sea-level depends upon its power to resist the cutting and levelling action of the breakers, we perceive that such an accumulation may be either cut down entirely by this action, as that of Graham Island, which came through the waters of the Mediterranean in 1831, and now remains a shoal, or be notched by it, if the mass be sufficiently hard to resist entire removal. When partly cut back, the matter removed is distributed over the talus of the general volcanic protuberance, not very materially increasing its angle of slope, since it would be piled over the talus much in the same manner as the detrital coral is accumulated in front of the coral reefs. The island reduced to a shoal would have the matter distributed over the flanks of the latter in the same manner, considering the accumulation to have been conical, though more flat than the cones formed in the air. Supposing no subsidence, and this is by no means necessary, such a volcanic mass as Graham Island might be reduced to a shoal, the depth of which, beneath the surface, would correspond with the power of the waves during heavy gales of wind to remove ash and cinders from the top and scatter them over the sides, and we have the foundation for a coral reef. From the edge of a continuous or nearly continuous notch, due allowance being made for the effects of prevailing winds and breakers round a volcanic island, keeping its main mass above the sea, there would be shallow water to the cliff or new shore, having a breadth depending upon the time the breakers have been employed in cutting it back, and upon the power of the rocks to resist this abrading force. In the case of the shoal there might be a coral reef having a round or oval form, or some modification of this form, according to circumstances, the habits of the reef-making corals causing them to work outwards, so that a kind of lagoon might be inside, especially if the old crater should permit a hollow to remain. In the case of the notched islands, the abrasion of the coast and the readiness with which detritus from it would be raised in mechanical suspension by heavy gales, would cause the reef-making corals to keep the outer edge, where the proximity of the deep sea would give them clear water. Here once established they would form a barrier, and working outwards would cover the slope with their debris, and gradually rising would protect the island coasts from the heavy action of the breakers, which would then fall upon the coral reefs. These would correspond with the old shape of the island, and therefore would probably differ little from its shores, round which they would form an outer rampart with shallow water inside, better fitted for the presence of other corals and of molluscs and marine animals loving quiet and clearer water, than could have been found over the same shallow ground while heavy seas rolled over it. As regards both the shoals and the notched sides of conical accumulations, the outside of the barrier or atoll reefs would plunge into deep water. In making these remarks we by no means doubt the correctness of Mr. Darwin's reasoning respecting the effects of depression in the formation of coral lagoon islands and barrier reefs; on the contrary, we coincide with his views, the application of which can scarcely but be correct in so many instances. The foregoing appeared to us, however, to be conditions which might often obtain, and that therefore they were deserving of consideration, to be taken, with other conditions, for what they might be worth, it being so desirable that in questions of this kind the subject should be regarded from all points, and that the various probable causes should be considered in our pursuit of that truth which it ought to be our constant endeavour to attain.

In the account of the voyage of the Samarang, under the command of Sir E. Belcher, there are several scattered notices respecting the rocks observed at different places, such as the raised coralline limestone of the west side of Abayat, near Batan between Formosa and the Philippines, the basaltic character of Hoa-pin-san, the igneous rocks of Quelpart and the Korean Islands, and others. Numerous remarks upon the habits of various marine animals, which by application may have geological value, are given by Mr. Adams, who accompanied the expedition. Sir E. Belcher notices banks of mud, at the Säbānon mouth of the Balungan River, east coast of Borneo, covered by a living pavement of oysters, their hinges in the mud, and their mouths upwards.

In lat. 6° 14′ S. and long. 4° 41′ W. bottom was struck at 9690 feet; four days previously no bottom was found with a line of 18,390 feet. It is very desirable that soundings in the ocean should be multiplied. No doubt very deep soundings require calm weather and a considerable expenditure of time, as was necessary when Sir James Ross took his deep soundings in lat. 15° 3′ S., and long. 23° 14′ W., 27,600 feet of line having been run out without finding bottom; but this would be amply compensated by the knowledge which might be thus obtained of the inequalities of the ocean-floor.

Two visits were made to Labuan, now a British possession, not only important for its geographical position, but also for the coal discovered in it. From communications made to the Museum of Practical Geology, chiefly from the Admiralty, we are enabled to state that the coal observed on the north-east coast of Labuan by Mr. Brooke (the Rajah of Sarawak), Captain Bethune and Mr. Wise, in March 1845, and a specimen of which, weighing 280 lbs., was brought by Mr. Wise to this country, and presented to the Museum of Practical Geology, is now found by Lieut. Gordon and others to form part of a nine-feet bed, extending from the N.E. point in a W.S.W. direction for about four and a half miles, and dipping about 24° to the S.S.E. This coal rests upon a clay bed, and is noticed as containing a quantity of small lumps, described as resin, which were not found in the specimen above mentioned. The coal of Labuan is merely a portion of a mass of associated sandstones and shales, apparently intermingled with many seams and beds of coal, varying in thickness, and which form a portion of the adjacent main land of Borneo, extending to, and more inland than the town of Brunai. The most considerable bed yet noticed is up a stream named the Kiangi, tributary to the Brunai river, and not far from the town, where it occurs eleven feet thick, and in a highly inclined position. Close to it is another bed three feet thick. From the statements of Mr. Hiram Williams, who was sent by the Admiralty to examine this coal district in 1845, it has evidently been much disturbed and contorted. Its relations to other accumulations (limestones, igneous rocks and others) in this part of Borneo, is as yet not clearly determined, but subsequently to its contortion this coal-bearing deposit has been subjected to denuding action, and the edges of the beds left are covered by others containing shells similar to those in the adjacent seas. The coal beds vary much in composition, as may be seen by the following analyses, made for the Admiralty at the Laboratory of the Museum of Practical Geology.

	Labuan *.	Kiangi.	
		11 feet bed.	3 feet bed.
Carbon	64·52	70·30	54·31
Hydrogen	4·74	5·41	5·03
Nitrogen	0·80	0·67	0·98
Oxygen	20·75	20·38	25·23
Ash	7·74	3·24	14·45
Sulphur	1·45		
	100·00	100·00	100·00

It should be observed that several hundred tons of the Labuan coal have been raised, and that the bed is now worked. The steamers which have used this coal, though it more approaches the character of candle or cannel coal, than the ordinary bituminous varieties, report well of it.

Geological Society of France.

Although it would too far extend the limits of this Address to detail the labours of the Foreign Societies which more or less devote their attention to geology, we must not omit a brief notice of so much of the proceedings during 1847, as have already reached us, of the Geological Society of France; since, though so named, its members are not confined to one country, the Society, without any distinction as to foreign members, being open to all fitting persons, wheresoever they may have been born, or now dwell.

In a communication on the variations of the igneous rocks, M. Durocher points out many examples of change, such as the passage of greenstone (diorite) into diallage rock and serpentine in the Côtes-du-

* With respect to this analysis it should be stated, that the specimen was from the crop of the bed, long exposed to the sea, and therefore that it is scarcely a fair example of the component parts of the coal deeper beneath the surface, and in a more favourable situation.

Nord and the Loire Inférieure, and in other places in Brittany into syenite. He also mentions that they sometimes present the appearance of quartziferous porphyry and petrosilex, and not only pass into diallage rock, but like serpentine contain oxidulated iron, as in Scandinavia. After citing various other examples, such as the passage in Norway of granite into the syenite, in which so many rare minerals are discovered, M. Durocher remarks that the variations are not so extraordinary as they appear, these igneous rocks containing the same elements,—silica, alumina, potash, soda, lime, magnesia and oxide of iron; granite being the most rich in silica and alumina, the poorest in lime, magnesia, and oxide of iron. When a granite becomes hornblendic and passes into syenite, the proportion of lime and oxide of iron augments, while that of alumina and potash or soda diminishes. In the change of the hornblendic into augitic, diallagic and hypersthene rocks there is but little difference in the elements; the hornblendic rocks are richest in silica and alumina, the augitic in lime and oxide of iron, and the diallage and hypersthene rocks in lime, and more especially magnesia. The hornblendic rocks being those which contain most silica, often too much to be altogether combined, form as it were the transition from those in which free silica is found, such as granite, to the augitic, diallage and hypersthene rocks, where silica is altogether combined with bases.

M. Frapolli read a paper on M. Desor's notice of the erratic block phænomena of the north, as compared with those of the Alps, in which he calls attention to the immense quantity of fragments of ice armed with blocks and pebbles, which are driven about the coasts of the north by the storms of winter and spring, grinding against the cliffs and the rocks. The coasts of Scandinavia, he remarks, are well known to be encased by a thick coating of ice, which when broken up carries the blocks and pebbles with it. The masses of block- and shingle-bearing ice put into motion by the tides and winds range along the shore, polishing and scratching the rocks according to their surfaces and position; the cliffs being scratched in horizontal lines along the fiords, and in other similar situations. M. Frapolli cites a map of M. Weibye, of Kragero, upon which the latter has laid down with great precision the scratches and furrows on the rocks of the country bordering the sea in the Bradsbergsamt, and quotes the inference of M. Weibye, "that the scratches and furrows on horizontal or nearly horizontal surfaces take a direction always perpendicular to the general line of coast in open bays, and always parallel to the range of the channels in narrow fiords; that the horizontality, or the greater or less inclination of the scratches on the inclined or vertical surfaces depends on the relief of the coasts of the locality, and always corresponds with this relief, and with the action of the different winds."

From personal observations M. Frapolli considers that the scratches and furrows observable in Scandinavia may be referable to the action of ice floated about, always taking into consideration the configuration of the coast when the levels of sea and land changed. And certainly the freezing of the sea on coasts, the consequent encasing of blocks and shingles in ice, the drifting of this ice, together with the crushing and grinding of ice-floes on the coasts, as they are to be found detailed in our voyages to the northern regions of America, are points of importance not to be neglected when we take a general view of the phænomena connected with erratic blocks. Indeed there are cases in our own land where this explanation would accord best with the facts observed.

In a notice on the Heights of the Jura between the Dôle and Reculet, M. Jules Marcou gives a detailed account of that portion of the Jura range in which its chief heights are included. He observes that the four groups of Jurassic rocks are not exposed on these heights, the upper and Oxfordian divisions being alone visible, whilst the two lower groups occur more eastward in the lower range of the department of the Ain. The lower part and the great valleys of the Dôle and the Reculet are composed of neocomian rocks, and the author infers that when the latter were deposited the mass of these mountains and of Mont-Crédoz formed an island bathed by the sea, in which the neocomian deposits were effected. M. Marcou points out, that while the Oxfordian group, surrounding the ancient Hercynian and Vosgian islands, is characterized by a considerable development of marls, containing numerous pyritous fossils, the same group of the Jura is formed of a great thickness of greyish-blue limestones, more or less compact and marly. This difference of lithological structure the author attributes to the more littoral character of the Hercynian and Vosgian deposits, and the more pelagic conditions under which the accumulations of the Jura were effected at the same date. After pointing out these changes, M. Marcou states that the palæontological character of the deposits corresponds with their lithological. Thus in the littoral regions the species are numerous, and more especially belong to the cephalopods, the gasteropods and acephala; in the subpelagic regions the individuals have much diminished, the cephalopods are stunted, and many species which did not occur in the littoral districts appear, as also many spongy polypifers and large Terebratulæ. In the localities occupied by the deep seas, such as those of the Colombier and the Reculet, fossils are extremely rare; those found are exclusively cephalopods, and hitherto confined to two species of Ammonites and one species of Nautilus.

The upper group of the Jurassic rocks occupies the highest crests and summits, and is formed of a great mass of compact limestones, without any interstratified marls. Although the mass is not very divisible into sub-groups, that considered equivalent to the coral rag of England is stated to be distinguishable both from its position above the Oxfordian group and from its fossils. The author subsequently enters into a detail of the various dislocations and contortions which the Jura may have suffered.

M. Scheerer discusses the plutonic nature of granite and of the crystalline silicates associated with it, in a communication translated by M. Frapolli. In the first part of this memoir the author enters upon an investigation of a peculiar kind of isomorphism, an account of which it is difficult to present without the formulæ and detail employed. Referring to the composition of dichroite and aspasiolite, he states that while in the proportions of silica and alumina they are the same, the aspasiolite contains a considerable quantity of water; both minerals also possessing, though in different proportions, magnesia and oxide of iron, the former some lime, the latter only traces of it; and he asks if the differences in other characters of these minerals may not be due to the water acting as an isomorphous base as regards the magnesia, oxide of iron, &c. After investigating the component parts of serpentine, he observes that if we infer that all the basic water of serpentine is replaced by magnesia, we should have the formula for olivine, so that we should expect these two mineral substances to have the same crystalline form, which, adds M. Scheerer, is the fact. This he considers as a proof of his new kind of isomorphism, so that olivine is to serpentine what dichroite is to aspasiolite.

Taking this view, M. Scheerer calculates the proportion of oxygen in more than one hundred minerals containing water, and examined with care, and infers that by considering this water as basic water, the formulæ become more simple, and more in accordance with the composition furnished by chemical analysis, than when we consider the water in a state of hydrate. From his researches he concludes that one atom of magnesia, or of protoxide of iron, manganese, cobalt, nickel, and oxide of zinc, may be replaced in this kind of isomorphism, to which he assigns the name *polymeric*, by three atoms of water, and one atom of oxide of copper by two atoms of water*.

Reasoning upon the water contained in many of the elements of granite, in which he includes mica, iron pyrites, talc, hornblende, schorl, gadolinite, orthite and allanite, M. Scheerer opposes the theory of granite having been in a state of igneous fusion, though he does not deny that heat may have given the humid mass of granite the plasticity and softness which it cannot be denied it must have possessed, and thus he so far admits heat as having been an essential agent in the formation of granite. He considers that this pasty mass, impregnated with water and heated under great pressure, would melt at a temperature much less elevated than if, in other respects the same, it were anhydrous; remarking that from this fusion, which should not be confounded with simply igneous fusion, results would follow of a very different nature than if the mass cooled down from igneous fusion alone. The minerals which had the greatest tendency to crystallize, those of which the crystalline power was greater than the opposing action of the watery vapours, would be the first to separate. All the water, continues M. Scheerer, not appropriated by the minerals during their crystallization would be concentrated where the free silica abounded. This silica would not become solidified until late, when the temperature of the granite was considerably reduced, and when the water not chemically combined with the component minerals had escaped from the mass, a process requiring a long lapse of time. M. Scheerer then applies this hypothesis to the alteration

* In thus giving this view of M. Scheerer, it is but right to observe that it is opposed by Prof. Naumann and Dr. Rammelsberg, who consider that it requires further proof.

of rocks brought into contact with the granite, plastic with water and highly heated.

This communication was followed by one from M. Virlet d'Aoust, on normal metamorphism and the probability of the non-existence of true primitive rocks on the surface of the globe. He refers to the memoir of Scheerer as supporting the opinions he had previously advanced on metamorphic granites, and points out that it is not necessary, as is too commonly supposed, that the temperature capable of producing normal metamorphism and granitic transformations should be very high, since M. Schafhäutl has shown that, under pressure, steam above 212° Fahr. can dissolve silica, and that probably, as has been pointed out by Sir David Brewster, other gases may have considerably influenced crystallization in altered rocks. M. Virlet considers that geological discoveries, as well as the advance of inorganic chemistry, tend to show that there does not probably exist, and cannot now exist, any really primitive rocks on the surface of the earth; that is to say, any rocks which have not suffered some chemical or molecular transformation, including water chemically combined, since their original cooling. Normal metamorphism, thus extended to all the rocks commonly called primitive, is only, he observes, a corollary of the theory of central heat and of the original igneous fluidity of the earth; conditions during the consolidation of the crust having caused changes of surface heat, and the returns of great heat at various times having assisted considerably in producing normal metamorphism. M. Virlet refers to the mechanical aggregation of crystalline rocks as affording a proof of general metamorphism, and as due to conditions which the researches of Schafhäutl, Brewster, Biess and Scheerer would lead us to expect.

In an elaborate account of analyses of some of the siliciferous thermal waters of Iceland, M. Damour considers that water, acting at a temperature of more than 120° Cent., under very considerable pressure and during a long period, upon the trachytic and zeolitic rocks beneath, would dissolve many of the elements of which they are composed; among others silica, alumina, soda, potash and lime. The alumina and lime would not long continue dissolved in the siliceo-alkaline solution, while the silica, potash and soda would remain in different proportions, as is found in the thermal waters of Iceland.

M. Descloizeaux communicated the results of investigations made jointly with M. Bunsen, of Marbourg, on the two principal Geysers of Iceland. Experiments were made in the pipe of the Great Geyser, by which it was found that the temperature at the bottom was variable, being highest immediately before and lowest immediately after the great eruptions. It is inferred that the source of heat is not situated immediately beneath, but at a distance, probably considerable, and that the column of water communicates by a long and winding channel with the space where the direct action of the subterranean heat is felt. After a great eruption, during which a large body of water and steam is ejected, the lower part of the liquid mass becomes colder, and the steam arriving from where it is formed, not being able to force the water out, is condensed by that filling the channel, the increased heat of which is transmitted to the bottom of the pipe. The water in the channel becomes boiling, and the steam, no longer condensing, acquires great power by compression, and finally drives out the water through the pipe. The same facts having been observed at the Strokkur, the same explanation is offered.

M. Dumont, in a memoir on the value of the palæontological character in geology, endeavours to ascertain the aid geology may derive from organic remains: first, as regards the relative age of superimposed beds in the same country; secondly, in comparing the dates of rocks situated in countries remote from each other; and thirdly, in order to fix the limits of formations. He concludes, after entering upon detail, that fossils are valuable in the same country in determining the relative age of rocks formed at epochs very distant from each other, while they gradually lose this value as the formation of the beds approached each other in geological time. Under the second head he infers that analogous beings have existed in different localities at different times, that the series of organisms belonging to different latitudes have commenced at distinct epochs by analogous species, and that the organized beings existing at the same time in the various geographical zones were as different formerly as they are now. With respect to the limits of formations, M. Dumont concludes that palæontological divisions cannot exactly accord with the geological divisions founded on the revolutions of the globe.

In some reflections on the nature and application of characters for determining rocks, M. Frapolli remarks that, zoological characters being only of comparative value, and mineralogical considerations constantly leading us wrong, it is to superposition of rocks, or their stratigraphical arrangement, that we must look for the sole true base of geological science, and that our principal attention should be directed to it when determining unknown formations. M. Frapolli passes in review the hypothesis of the original igneous fluidity of the earth and its consequences, as the heat radiated into space and the crust became solid, adverting to times of repose and fracture, the accumulation of sedimentary deposits and their upheaval, and especially referring to secular upheavals and their results.

M. de Verneuil read a note on the parallelism of the palæozoic rocks of North America and Europe, followed by a table of the fossil species common to the two continents, with the indications of the groups in which they are found, and a critical examination of each of the species. In this communication M. de Verneuil, describing the composition of the palæozoic rocks of New York, of which he enumerates the twenty-eight groups into which they have been divided by the New York State geologists, points to the excellent succession of beds observable in that part of North America. He also gives an account of the groups, thirty-eight in number, into which the palæozoic rocks of Ohio, Kentucky and Indiana have been divided, and then proceeds to examine into the parallelism of these North American deposits with the older fossiliferous rocks of Europe. He investigates this subject upon the principle, that if in two countries a certain number of systems, characterized by the same fossils, are superimposed in the same order, whatever may be the thickness or number of the physical groups of which they are composed, these systems should be considered as parallel and synchronous.

The American series is so complete, its parts being conformable and passing into each other, that marked divisions cannot be established. Hence it follows that the limits corresponding with the different European systems are in some cases uncertain, but this is considered as of less consequence if the middle parts of each system can be established. The important point, M. de Verneuil adds, is to feel assured that during the palæozoic period the animal kingdom upon the area occupied by the two continents has suffered simultaneous transformations, so that identical species occupy the same geological positions.

The six lowest New York groups, from the Potsdam sandstone to the Hudson river group inclusive, are referred to the Lower Silurian rocks, the *lingula* sandstone of Potsdam being probably equivalent to the *obolus* sandstone of Russia and the lower sandstones of Scandinavia. The siliceous limestone, with the Black River and Trenton groups, are referred to the bituminous slates and the orthoceratite limestones of Sweden and Russia, while the Utica slates and the Hudson river groups, with the Graptolites at their base, are considered equivalent to the graptolite slates of Sweden, succeeding the red orthoceratite limestone, and also to those of Bain in France. Trilobites were largely developed both in Europe and America at this period, and the genus *Isotelus* represents in the latter the *Asaphus* of the former. Orthoceratites were abundant, and *Bellerophon* appeared in connection with this early life, marked also by the presence of *Orthis*, *Leptæna*, and *Terebratula*.

The New York groups, rising above those mentioned, up to the Oriskany sandstone exclusive, are referred to the Upper Silurian rocks, the Niagara limestones and shales being considered equivalent to those of Wenlock and Gothland. Trilobites were still abundant, some species being rare and limited to thin groups of rocks, such as *Phacops Hausmanni*, *Sphærexochus minus* and *Cheirurus insignis*. Orthoceratites are less abundant than in the lower series. Spirifers and Tentaculites appear, and large corals are found, such as *Favosites Gothlandica*, &c., while Graptolites cease. Of forty identical species found in the Upper Silurian rocks of America and Europe, M. de Verneuil considers that thirty-two have neither lived before nor after this period.

The New York groups, from the Oriskany sandstones to the sandstones and slates above the Chemung group, inclusive, are all referred to the Devonian series. The characters common to the Devonian fauna of Europe and America are considered to be the appearance of the ganoid fishes with great *plaques* or scales, and the genera *Goniatites*, *Nautilus*, *Pentremites* and *Productus*.

Above these American rocks come the limestones referred to the carboniferous limestones of Europe, and M. de Verneuil considers this division as well-characterized in both continents; and it is remarked that the Trilobites, decreasing in a parallel manner in both countries, finally end with the small species of *Phillipsia* in the carboniferous limestones. The memoir of M. de Verneuil, of which the above is a very brief sketch, contains much detail, and terminates with remarks on the palæozoic fossils common to America and Europe, and on their distribution.

In a memoir on the mineral and chemical composition of the rocks of the Vosges, M. Achille Delesse remarks on the passage of the different igneous rocks into each other. M. Delesse observes that many minerals, even those widely spread and forming important portions of rocks, are but little known, and he points out the felspar family, though it forms fifty per cent. of the crust of the globe, as being one, the species of which are little understood. Their chemical properties are nearly identical, and their composition has reference to a common law; they all contain the same radical bases, in such proportion that the quantities of oxygen are as 1 to 3, and the different felspars are only saturations of these radical bases with silica. Hence the difficulty of determining the different felspars, though they belong to an easily distinguished natural family.

After taking a brief view of the formation of the stratified, M. Delesse proceeds to examine that of the unstratified rocks, and their igneous origin, glancing at the original fluidity of the earth, its consequences, and the metamorphism of rocks. Proceeding to the classification of the non-stratified rocks, he points out that too much importance has been assigned to their physical characters, and too little value given to their chemical composition, and that it is highly desirable researches in chemical mineralogy should accompany the geological study of the non-stratified rocks. He adds, that these researches in chemical mineralogy should be carried on with the rocks in place, inasmuch as the chemical geologist will not otherwise be enabled to observe all that is required. In this manner M. Delesse studied the non-stratified rocks of the Vosges, carefully separating the isolated minerals from the main mass and subsequently experimenting upon them, and as carefully also examining the main mass or base of the rocks. The crystals in the Belfahy porphyry were found to be a variety of labradorite. Augite is another mineral found in this porphyry, one of those termed also *Melaphyre*. Its base or paste contained water chemically combined, as in the crystals of felspar, and M. Delesse refers to the views of M. Scheerer on this subject. In chemical composition this paste contained silica in the same proportion as in the isolated crystals of labradorite, and in all the varieties less alumina, soda and potash, and more iron, manganese and magnesia, with sometimes more and sometimes less water and lime. The spilite of Fauconey, a vesicular rock, was found upon analysis to be nearly of the same composition as the base of the Belfahy porphyry.

In conclusion, M. Delesse points to the approximation which these researches on the Vosges melaphyres establishes between them and basalts. The base of the two rocks is the same, being labradorite, and they likewise contain augite and oxidulated iron in common; both also contain water. The differences consist chiefly in the greater or less proportion of bases in the constituent labradorite. Thus soda, potash and water form a notable part of the labradorite of the melaphyres, while these bases diminish and even completely disappear as the rock approaches to greenstones, basalts and modern lavas. They are replaced by lime, which then becomes the dominant base.

Besides these communications there have been others, also presenting much interest, such as the observations of M. Martius on the mass of the Jungfrau, which M. Studer refers to gneiss, masses of limestone being included among it; the note of M. Boué, referring to a memoir of M. de Hauer on the Cephalopods of the shelly limestone of Bleiberg, Carinthia, wherein three stages of cephalopods, each characterized by its fossils, is considered to be distinguishable in the Alps; a notice by Desmoulin of fossils in flints, which he infers are the remains in the south-west of France of upper chalk, equivalent to that of Maëstricht, the softer parts of these beds having been removed by denudation; a notice by M. Viquesnel on the chalk of Turkey; a note on the mode of occurrence of the sulphur in the Soufrière of Guadaloupe by M. Ch. Deville. We have also a note by M. Boué on pseudomorphism arising from the disappearance of crystals of rock-salt in rocks; a notice and analysis of a hydrosilicate of alumina, found at Montmorillon (Vienne) by MM. Damour and Salvétat; a note on the pisolitic limestone (of the Paris district) by M. Hebert; remarks by M. Paillette in illustration of notes on the mines in the south of Spain by M. Pernollet; reflections in favour of the hypothesis of the central heat of the earth, by M. d'Omalius d'Halloy; a note by M. von Buch on some points connected with the structure of Terebratulæ, and on the range of nummulitic limestones; a description of a gigantic Orthoceratite, six English feet long, from North America, by M. de Verneuil; a notice of the occurrence of a cretaceous Terebratula in some tertiary marls near Corbières, these marls considered equivalent with others full of cretaceous fossils in the Haute Garonne and Haute Pyrenées, by M. Leymerie. There are other notices and papers by M. de Collegno on the classification of certain rocks in Italy; on some peculiarities in the exterior form of the ancient moraines of the Vosges, by M. Collomb; on the genus Palæotherium, by M. Pomel; a notice of the rocks in the basin of the Adour, by M. Delbos; a notice respecting a geological map of the Subhercynian Hills, and an essay on the geological topography of that country, by M. Frapolli; a note on the mode of occurrence of the Iceland spar in Iceland, by M. Descloizeaux; and a note by M. Nérée Boubée on the relation between the nature of soils and the different antiquity of the alluvions in valleys marked by different stages or levels.

It should be observed that the Bulletin of the Geological Society of France contains the observations of those present at the different meetings upon the papers read before them, and that among them there are remarks of great value, both as respects the memoirs before the Society, and points of geological interest and importance connected with them. Indeed many a remark, as in the discussions upon papers read before us, may be considered as the foundation for subsequent researches and discoveries. This year the members of the Geological Society of France have had presented to them the first part of a History of the Progress of Geology, from 1834 to 1845, by the Vicomte d'Archiac, a closely printed octavo volume of 679 pages, published under the auspices of the French Minister of Public Instruction, M. de Salvandy. This part contains *Cosmogonie* and *Géogénie*, the *Physique du Globe*, *Géographie physique* and *Terrain moderne*.

Geological Notices.

As it would far exceed the limits of an address of this kind to attempt an account, in any useful detail, of the various publications either directly dedicated or having reference to our science, and which have appeared during the past year, the following notices have been selected, not because others of great importance to the progress of geology may not readily be found, but because they have reference to points of considerable interest.

Palæontologists have continued to add abundantly to our knowledge of the ancient forms of life, extending from the gigantic mammals of previous geological times down to the minute infusoria which have been found forming, by their immense numbers, a large proportion of certain rocks. While at our own meetings Professor Owen has made known to us the fossil animals previously mentioned, we find other comparative anatomists and palæontologists adding to our stores of this branch of our knowledge. Thus M. von Meyer describes a new fossil genus of the Carnassiers, found in the tertiary beds of Mombach. To this genus he assigns the name of *Stephanodon*, and to the species *S. Mombachensis*. We find him establishing a new genus by the examination of the reptile found in the Grès bigarré of Bohemia, and named *Palæosaurus Sternbergi* (Fitzinger). He adds also many new species to our fossil fauna, such as two new species of Labyrinthodon, in the Vosges sandstone of the Swartzwald, the *Homosaurus Maximiliani* from Solenhofen, the *Rhamphorhynchus longicaudis* from the calcareous slates of Eichstadt, and the *Emys Turnauensis* from the tertiary rocks of Styria, with many other palæontological communications of interest, such as his notice of the abundance of Batrachian remains (*Triton opalinus*, *Rana Luschitzana*, and *Asphærion Reussi*, the last a new genus) in the tertiary rocks of Bohemia, as also his notice of a fossil marmot (*Arctomys marmotta*) in the drift of Mosbach, near Wiesbaden. Von Meyer considers that the *Arctomys primigenia* of Kaup is the modern marmot, and the *Spermophilus superciliosus* of the same author the *Spermophilus citillus*.

We are indebted to Dr. Jeffries Wyman, Professor of Comparative Anatomy in Harvard College, Massachusetts, for a description of the cranium of *Casteroides Ohiensis*. The geological position of this fossil has been shown by Mr. James Hall to be similar to that assigned by Mr. Lyell, in his 'Travels,' to the *Mastodon giganteus*, the bones of which, as well as of the Elephant, accompany the Casteroides. They all in fact occur in superficial deposits, often of shell marl, and containing freshwater shells of the genera *Planorbis*, *Valvata*, *Cyclas*, and others identical with species now inhabiting the same region. Dr. Wyman, in his excellent paper, has pointed out that the Casteroides is a large extinct rodent, having greater analogies in its osteology to the Castors than to any other living genus. Its relation to the *Capybara Hydrochœrus*, the largest of living rodents, which it exceeded in size, is also alluded to, and the differences in its teeth carefully described. It is also shown to present some analogies with the genus *Fiber*, as well as with *Castor* and *Hydrochœrus*.

The discovery of the entire cranium of the *Zeuglodon* was announced in the course of last year by Mr. Tuomey, State Geologist of South Carolina, and a figure of it was published in the American Journal of Science, September 1847. It was discovered by Messrs. Holmes and Gibbes in the eocene beds of the Ashley river, about ten miles from Charleston. Mr. Tuomey observed that the double occipital condyle showed it to have been a mammal, while the squamous sutures have a symmetrical form, and refer it to the Cetacea, to which Prof. Owen first pointed out its relations. These conclusions are the more important, because they differ from those deduced by Dr. Carus from the imperfect skeleton of the Zeuglodon, submitted to him by Mr. Koch, and of which he has lately published a detailed description with plates. A full and complete notice of this singular fossil has just appeared in the form of a monograph on the genus *Basilosaurus* or *Zeuglodon* by Prof. L. R. Gibbes, who has shown that there are two species of the genus.

In regard to the geological position of the Zeuglodon, you have learnt from Mr. Lyell's paper on the so-called nummulitic limestone of Alabama, above-mentioned, that it occurs in one of the members of the Eocene group in all the places where he met with the bones. He has since informed me that the analogy of the whole group of tertiary shells, with which it is more immediately connected in the localities examined by him, leads him to infer that it belongs to that middle division of the Eocene which in Mr. Prestwich's paper is called the Bracklesham beds.

Various additions to our knowledge of fossil mammals have been made by M. Pomel, who has among other labours described a new genus of fossil pachyderms, approaching the hippopotamus, under the name *Elotherium*. To one of the communications by the same author, it may be desirable especially to call attention more in detail, inasmuch as it refers to the life upon, and physical conditions of a particular locality at a highly interesting geological period. This memoir relates to the fossil flora and fauna of the pisolitic formation, a name given to certain deposits in the Paris tertiary district, of a concretionary form, occurring between the plastic clay and the chalk, and which M. Elie de Beaumont, upon purely geological data, refers to the highest portion of the cretaceous series. M. Pomel points out that the observations of M. Desor show this formation not to be accidental, but to be clearly equivalent both geologically and palæontologically to the highest chalk of the Pays Bas.

At a few leagues from Sezanne, at Mont Aimé, and at the plateau of Faloise or of La Madelaine, the remains of fish and reptiles were discovered in this formation, without the trace of those of any mammal. The fish and reptiles differ alike from those of the tertiary rocks above and of the cretaceous rocks beneath. Among the fish was a Cycloid, a large species of the cretaceous genus *Istieus* of Agassiz, differing from any species described by him. Of Placoids, there was a species of the genus *Lamna*, and another probably of the same genus, and approaching *Lamna verticalis* of Agassiz, without being identical with it. It may belong to the genus *Otodus*. Teeth also were discovered, resembling those of the Pycnodonts, but the specimens were too imperfect to establish the presence of this family.

The most remarkable fossil was a saurian of the section of Crocodiles, and of the subgenus Gavial, to which the specific name of *isorhynchus* has been assigned. After giving a detailed account of this saurian, M. Pomel remarks, as deserving of attention, that a reptile should occur in the upper limit of the secondary rocks which should more remind us of the saurians of the Jurassic series than of those found hitherto in the European tertiary deposits. Many important parts of the skeleton show, it is observed, that it partakes of living types. At least one large species of tortoise is discovered among the reptilian remains.

With respect to the flora of the Sezanne deposit, there is an indeterminable species of moss, and the genus *Marchantia* is for the first time seen in a fossil state, in a species approximating to, but distinct from, *M. polymorpha*. A new *Asplenium* and *Aspidium* represent the ferns, and are very abundant. There is also a third species which may belong to the genus *Sphenopteris*. Leaves were found closely approaching those of *Cinnamomum* and the chestnut; a new *Corylus*, a *Caprifolium*, and leaves of *Salix*, *Populus*, &c. M. Pomel calls attention to the remains of a crustacean, of the genus *Oniscus*, as being abundantly discovered among the mosses and Marchantiæ. This he considers as confirming his opinion that the deposit resembles the travertine now forming in many parts of Central France.

During the year Mr. M'Coy has published an account of the fossil botany and zoology of the rocks associated with the coal of Australia, founded upon specimens sent to the Woodwardian Museum of Cambridge by the Rev. W. B. Clarke. Seventeen species of fossil plants, twelve of them considered as new, are described from the Mulubimba district, a portion of the Newcastle and Hawkesbury region. Of the ten genera noticed, two (*Vertebraria* and *Zeugophyllites*) are found in the coal-field of India, and one (*Gleichenites*) is considered provisionally as the same with *Pecopteris odontopteroides* of Morris. All the other genera (with the exception of *Phyllotheca*, which has hitherto been only discovered in Australia) are well-known in the oolitic coal deposits of Yorkshire; one species (*Sphenopteris germana*, M'Coy) is stated to be scarcely distinguishable from *Pecopteris Murrayana* (Br.) of the Scarborough shales. Mr. M'Coy concludes that the evidence of fossil plants is in favour of these Australian coal deposits being of the age of the oolitic rocks of Europe. It may be here observed, that upon an examination of a fine collection of fossil plants, obtained by Mr. David Williams from the Burdwan coal district of India, and transmitted to the Geological Survey, Dr. Hooker was also struck with the forms which corresponded with those observed in the oolitic coal deposits of Great Britain.

Respecting the animal remains of the rocks underlying the coal of this Australian district, Mr. M'Coy determined 83 species. These belong to 39 genera, all of which, with the exception of four, (*Tribrachyocrinus, Pachydomus, Notomya* and *Eurydesma,* forms up to the present time only known in Australia,) are abundant in the carboniferous rocks of the British Islands. Eleven of the species are considered to be identical with those in the same rocks, and nine more to be so closely allied that no difference of character can be observed, though from their imperfect state of preservation they cannot be absolutely identified. From the difference in palæozoic character, Mr. M'Coy infers, as not improbable, that there was a wide interval between the consolidation of the fossiliferous beds underlying the coal, and the deposit of these coal-measures themselves. This forms a subject of interest for further investigations, and it will be remembered that in his communication Mr. Beete Jukes considered the upper and lower series to graduate into each other, an opinion apparently participated in by the Rev. W. B. Clarke.

Considering the conditions under which the remains of insects are likely to be entombed, notices of any large accumulation of them in a fossil state possess much geological importance. In a communication by Prof. Heer to Prof. Bronn respecting the insects discovered in the tertiary deposits of Œningen and Radoboj, he states that 100 species of insects found at Œningen may be referred to 68 genera and 34 families; that 51 of these genera occur in the present Swiss fauna, 5 genera are absent in the Swiss fauna and discovered in the south of Europe, 1 is found in North America, 4 cannot be well determined, and the remaining seven appear extinct, these seven being *Glenopterus, Escheria, Protractus, Coprologus, Prologenia, Fusslinia,* and *Pristorhynchus.* By comparing the fossil coleoptera of Œningen with those now existing, they are found more to resemble the coleoptera of Southern Europe than of the district in which they are now found. They are considered to offer the general characters of the Mediterranean region combined with some American forms.

Sir Roderick Murchison, during his present absence on the continent, has not neglected the palæozoic rocks; and we find that, accompanied by M. de Verneuil and Count Keyserling, he traversed Bohemia for the purpose of still further examining that country, in which M. Barrande, whose labours on the trilobites of this region are so well known to us, had shown the occurrence of Silurian rocks. The Silurian rocks of Bohemia are described by our colleague as extending from N.E. to S.W. for about ten German miles, with a maximum transverse breadth of about three miles and a half. This mass is considered to be divisible into Upper and Lower Silurian rocks, and according to a section across the whole, from Ginetz on the one side to Skrey on the other, forms a great trough in which the Upper Silurian rocks occupy the central portion. Sir Roderick Murchison, while pointing out that geologists should refer to the great divisions of Upper and Lower Silurian rocks, when comparing distant countries with each other, and not to the minor subdivisions he adopted in Great Britain, at the same time remarks, that however the minor divisions may differ from each other, similar types of organic life frequently occur in distant lands when similar mineral conditions are repeated. The lowest fossiliferous schists of Ginetz and Skrey are said to remind the geologist of the Llandeilo flags and schists of England and the alum shales of Sweden, by the development of large trilobites, and the genus *Battus,* which together with *Orthidæ* and *Cystideæ* mark these deposits. The Bohemian quartz rocks reminded Sir Roderick of the Caradoc sandstones of the British types, with their abundant *Trinuclei.* The upper division is stated strikingly to resemble the British division of the same age, in being like it eminently characterized by a multitude of chambered shells, some of the characteristic species of which are most abundant in the shale between the Ludlow and Wenlock rocks in England. The middle group of the upper division of Prague contains large *Pentameri,* one of which cannot be distinguished in external form from *P. Knightii,* and in Bohemia, as in England, it is associated with *Terebratula Wilsoni.* In the same communication (a letter to M. Leonhard), Sir Roderick stated that certain rocks of the country round Olmutz should be referred to the Devonian series, the fossils discovered in them bearing out this inference.

As connected with the progress of geology, we must not omit to mention a lecture of Mr. Lyell, delivered during the past year before the Royal Institution, at one of those Friday-evening meetings at which so much that is important in various branches of science is first given to the public. He referred to the volcanic district of Auvergne as one of peculiar interest, since it does not appear to have been submerged beneath the sea during a period in which its geological and geographical structure, and the animals and plants by which it has been inhabited, have undergone a great succession of changes. Mr. Lyell thus brings before us terrestrial changes, so to speak, which should be equally taken into account when we consider the mode in which, on the great scale, rock-accumulations, as well igneous as aqueous, have been effected in all geological times since land rose above sea, affording by its abrasion the detritus among which the remains of animals existing at the time became entombed. It is highly useful to regard such terrestrial changes with reference to geological times, when the regions in which they took place may have been depressed beneath the sea and became buried beneath accumulations heaped upon them by the agency of water. Mr. Lyell dwelt much upon the antiquity to be ascribed to the Puy de Tartaret, a type of one of the most modern cones of eruption in Central France. After entering upon much interesting detail, he proceeds to show that a lava-current from this crater flowed over a bone-deposit, containing osseous remains referable to the genera *Equus, Sus, Tarandus, Cervus, Canis, Felis, Martes, Putorius, Sorex,* *Talpa, Arvicola, Spermophilus, Lagomys, Lepus,* and, according to Mr. Waterhouse, *Cricetus,* or hamster, and others, besides the remains of a frog, a lizard, and snake, and the bones of several birds. Prof. Owen recognized among these remains the *Equus fossilis* and *Tarandus priscus,* both extinct species, occurring in the caves of England, with the contents of which generally this assemblage of fossils of Auvergne is stated to agree very closely. Among the land shells found associated with the bones were *Cyclostoma elegans, Clausilia rugosa, Helix hortensis, H. nemoralis, H. lapicida,* and *H. obvoluta.* It was inferred that a similar fauna continued in Auvergne after the latest eruptions, the remains of many of the same group of animals having been discovered in the clefts of a lava-current at Aubier, near Clermont, as modern as that of the Tartaret; an observation of importance, since the covering of a bed by the lava-current of Tartaret would not prove the existence of the animals at the time of its flow, as it might have flowed over accumulations of an older date. Mr. Lyell remarks that in Auvergne it is possible to distinguish the relative ages of a great variety of alluviums containing the bones of terrestrial quadrupeds, partly from their position beneath lavas of different ages, and partly from their occurrence on the sides of valleys which were gradually deepened; "no flood or return of the ocean having disturbed the surface and mingled the fossils of one period with those of another, as has happened in England and most parts of Europe. The oldest fauna of land quadrupeds in Auvergne, —that found in a fossil state in freshwater strata of marl and limestone, older than the trachyte of Mont Dor,—consisted of species of *Palæotherium, Anoplotherium, Anthracotherium, Opossum,* &c., analogous in great part to those of the Paris basin, with some miocene forms associated, and belonging to an upper eocene group, newer than the Parisian tertiaries, or the uppermost freshwater beds of the Isle of Wight." "Hence," adds Mr. Lyell, "it follows that the whole succession of revolutions in the animate and inanimate creation which have occurred in Central France since the land emerged, vast as they are in duration, as compared to the æra of more modern volcanos, is, nevertheless, considerably posterior to the marine clay on which London is built; this last being one of those tertiary deposits which rank as but the monuments of yesterday in the great calendar of geological chronology."

To these palæontological notices it may be added, that the molluscs of the cretaceous beds near Geneva have been well-illustrated by M. Pictet, in a monograph of high character, and that the fossils of the chalk of Aix-la-Chapelle have been described by Dr. Joseph Müller. Brachiopods have engaged much attention. De Koninck has given a highly illustrated monograph of *Productus.* M. Barrande has described and figured the palæozoic brachiopods of Bohemia. D'Orbigny has commenced his account of the cretaceous brachiopods of France, and Mr. Davidson has illustrated many of our British palæozoic forms. We should also mention that the important work of Michelin on the fossil zoophytes of France is completed. Mr. Toulmin Smith has published a paper on Ventriculites, remarkable for minute investigation. He considers these bodies to be the polypidoms of Bryozoa. Of the highly illustrated monograph by Prof. Heer of the insects of Œningen, the first part, treating of the Beetles, has appeared; and M. Bosquet has published an important paper on the Entomostraca of the chalk of Maëstricht.

As regards geological interest, one of the most remarkable palæontological discoveries of the year has been that of a reptile skull by Von Dechen in a nodule of ironstone from near Lebach, in the Saarbrück palæozoic coal district. According to Goldfuss, who assigned the name *Archigosaurus Decheni* to the reptile thus found, it is a kind of crocodile-lizard, the skull not resembling that of the *Emydosauri*, which are nearest to it in geological date, but that of the true Crocodiles now existing. At the same time there are characters in the skull, which is 6½ inches long, (Rhine measure,) showing it to partake of the lizard. Regarding the skull to have formed the same proportion to the entire reptile as in the young crocodile, this specimen would have belonged to an individual measuring 3 feet 8 inches. Mr. Lyell stated the other evening, in a lecture at the Royal Institution, on the foot-marks of a reptile in rocks of similar age in North America, that Dr. Falconer, now on his road to India, has seen the specimen and had no doubt of the skull having belonged to a reptile. Here then we appear to have an example of the existence of crocodilian animals at the comparative early time when those remarkable plants flourished, parts of which grew upon, while others were drifted into, the districts in Europe and North America, where much of them, by subsequent chemical changes, forms the palæozoic coal.

Mr. Lyell, in the lecture above-mentioned, refers to the discovery by Dr. King, in 1844, of reptile foot-tracks upon sandstones in Pennsylvania considered equivalent to part of the palæozoic coal-measures of the British islands; indeed the Greensburg sandstone is stated to occur in the very midst of the Appalachian coal-field, the main Pittsburg seam of coal being worked 100 feet above it. Mr. Lyell visited the locality in company with Dr. King, and from all the evidence before him, concludes that these foot-prints are those of a new reptile, and that the tracks are different from the Cheirotherium foot-prints of England and Germany. The average length of the print of the hind-foot is 5½ inches, and of the fore-foot 4½ inches. The fore and the hind feet follow each other in pairs very closely, there being an interval of about one inch between them. Between each pair the distance is 6 to 8 inches, and between the two parallel lines of tracks there is about the same distance.

It would be useless before those now assembled in this room to point out the value of the evidence thus brought to bear upon the existence of reptiles at the date of the palæozoic coal deposits; footprints and other tracks and trails of animals upon the sands, and mud of various geological times being now acknowledged as important aids in palæontological inquiries. Indeed, the muddy banks of tidal estuaries in various parts of the world, particularly if there be much difference in vertical height between spring and neap tides, abundantly show how, if land be slowly sinking beneath any given level of the sea, or successive layers of mud and sand be accumulating, tracks of birds, reptiles and mammals may be preserved. Mr. Lyell pointed out the manner in which foot-prints of the sandpiper (*Tringa minuta*) are preserved in the red mud of the Bay of Fundy, and the drift of blown sand fills up the foot-prints of opossums and racoons on the beach near Savannah, Georgia. The tides rising high in our Bristol Channel and its continuation, the estuary of the Severn, and there being much difference between spring and neap tides, abundant opportunities are there often afforded for studying foot-prints of various kinds, mixed with estuary drift, such as different shells (terrestrial among them), terrestrial plants and sea-weeds, and other things. Many other localities around our islands also afford excellent opportunities for this study.

Professor Ehrenberg, to whom we owe so much for the discovery of the remains of infusoria in such abundance among some of our fossiliferous deposits as to form no unimportant part of them, has added further to the obligations of geologists by his examination of certain pumiceous marls of Barbadoes, brought to Europe by Sir Robert Schomburgk. In 1839 M. Ehrenberg made known some new microscopic polygastrica with siliceous shells, some living, one species fossil, so peculiar in their structure that he deemed it necessary to constitute a new order, under the name of *Polycystina*, for their reception. Up to the time of Sir Robert Schomburgk's visit to Barbadoes, only thirty-nine species of this group had been observed: in the marls before-mentioned no fewer than 282 species, belonging to seven families and forty-four genera of *Polycystina*, have been brought to light—all new. Whatever these singular organisms may eventually prove to be, this is probably the most striking instance of the sudden increase of our knowledge of any single group of fossil animals ever recorded.

The Parallel Roads of Glenroy, as they have been termed, have long and deservedly attracted the attention of geologists, and several explanations have been offered. Mr. David Milne, in his paper upon these terraces (published in 1847), considers that they should be attributed to the shore-action of lakes, formed by mounds of boulder clay and detritus across the valleys which barred the drainage. To the lowering of these barriers by river-action would be due, Mr. David Milne considers, the levels at which the successive pauses of the lakes continued sufficiently long to produce the so-called parallel roads. These are shown to be perfectly horizontal by actual measurements, and similar beach-lines are pointed out on hills in other parts of the country. Although around the prominent elevations of land which have risen through the sea, with sufficient intermediate pauses to permit a notching, or cutting back of the land by breaker-action at different times, we should expect evidence of such pauses in cliffs and raised beaches, such as we undoubtedly find, lake action as pointed out by Mr. David Milne must also be regarded. There is no difficulty in many lands, mountainous regions especially, in seeing that lakes have been drained by the cutting back of river channels, and in volcanic districts lakes may readily be formed and subsequently drained, the barriers which caused them being cut through or removed. It will depend upon obvious conditions whether any permanent records of these levels at different times be left or preserved. Lakes and isolated so-called seas, as is well-known, are inferred to have occupied larger areas than at present from evidences of this kind.

The beautiful manner in which silica has entered the interstices of vegetable matter, even showing the succulent parts of plants which must have been in a state of partial decay, is well known. We have the finest vegetable tissues most perfectly preserved by means of silica. It will be in the recollection of the Society that Dr. Mantell pointed out to us in this room what he considered the soft parts of molluscs also preserved in silica. Yesterday only I received a communication from Mr. Charlesworth, in which he informs me that in a collection which constitutes part of the well-known museum of Miss Benett of Wiltshire, he had found several examples of *Trigoniæ* with their branchiæ well-preserved in silica. As silica may have, and has filled up cavities left by shells, thus giving us the most perfect representation in silica of that which was once carbonate of lime, great care is of course required, so that the mere filling up of the interior of univalve and bivalve shells, before the matter of the shells themselves disappeared, or even when these are still left, be not taken for the preserved remains of the fleshy portions of the molluscs. We should expect, in cases of real preservation, as in those of vegetables, that the original tissue would be found by slicing in the usual manner. Mr. Charlesworth, who also forwarded a lithographic plate to appear with descriptions in the next number of his Geological Journal, considers that in the specimens he notices the fleshy parts of the Trigoniæ are really silicified, and states that the silica has only preserved some of the soft parts, without filling the entire cavity of the shell, and so that the filaments of the branchiæ have all the appearance of an elaborate piece of dissection. Certainly the entire cavity of the shell not being filled up is very important, and as we find that the tissue of succulent vegetables has been preserved in silica, it may be fairly asked, why may not the fleshy parts of molluscs be thus also preserved?

The slags from our furnaces are often, as is well known, found crystallized in drusy cavities, their component parts having in such situations been placed under the needful conditions for adjustment according to their affinities, and for taking the definite forms due to their combinations. In a Report to the British Association on Crystalline Slags by Dr. Percy (of Birmingham) and Professor Miller (of Cambridge), published during the past year, we have the analyses and crystallographic and mineralogical descriptions of many of these bodies, some of which, in the collection of Dr. Percy, are exceedingly interesting. Six analyses of crystallized slags from iron blast furnaces gave the formula $Al^2O^3, SiO^3+2(3(Ca, Mg, Mn, Fe)O, SiO^3)$, which differs from that of vesuvian in containing two equivalents of the lime series instead of one. The crystals of these slags were square prisms, some having their angles truncated by planes, making equal angles with the adjacent faces of the prism. In hardness they varied from 5·5 to 6.

Another slag from a hot-blast furnace at Oldbury is crystallized in thin square plates, the lateral faces of which are perpendicular to each other and to the terminal faces. Analyses lead to the formula $3(3CaO, SiO^3) + 3 Al^2 O^3, SiO^3$, one which appears also to represent the constitution of gehlenite. It is remarked, that admitting this slag to be the same with gehlenite, its production at a high temperature in an iron furnace is interesting when compared with the mode of occurrence of the natural mineral in the Fassathal, Tyrol, a description of which by Von Buch is appended. The analyses of another slag gave a formula nearly representing that of humboldtite, as deduced from the analysis of Von Kobell; at the same time it is observed that Damour gives another formula for humboldtite, which he believes to be identical with mellilite, and this formula is precisely that given for the first series of blast-furnace slags. Another beautifully crystallized slag was found in form and constitution to resemble olivine, the magnesia of the latter being replaced by protoxide of iron. A large series of slags from various metallurgical works have still to be investigated, and it is hoped that Dr. Percy and Professor Miller may ere long still further add to our knowledge of this class of substances, so important in their bearing on the minerals found in connection with igneous rocks.

All modes by which we can artificially imitate the minerals found in nature are valuable, and more especially if any of these minerals should be what is commonly termed infusible. We have to record very important and successful experiments of this kind by M. Ebelmen, who has employed a method entirely new. He observes that two modes have hitherto been adopted to produce definite and crystallized combinations. One consists in submitting to igneous fusion either simple or compound bodies, alone or mixed with each other in certain proportions proper to form the definite combinations, whence it often happens that crystals form and become isolated in the midst of the melted mass as it cools, thus presenting a substance of a porphyritic character. The second method is by sublimation.

M. Ebelmen proceeds upon another and very simple principle. He seeks for a substance which at a high temperature acts like water, as regards the substances dissolved, either at its ordinary or at a slightly elevated temperature. As by the evaporation of water crystallized combinations may be obtained, so by employing bodies capable of volatilization at very high temperatures, yet at a given degree of heat, while in fusion, capable of dissolving the greater part of metallic oxides, it was expected that certain calculated proportions of some oxides would crystallize, when the dissolving body was evaporated, at a great heat, in open vessels. Complete success has attended this view.

In this manner he has produced many minerals. He first mentions those composed of 1 equivalent of oxide consisting of 2 atoms of metal and 3 of oxygen, with 1 equivalent of oxide consisting of 1 atom of metal and 1 of oxygen, a class of minerals for the most part very hard, and some of which are gems. By mixing together

	gr.
Alumina	6·00
Magnesia	3·00
Green oxide of chromium........	0·10 to 0·15
Fused boracic acid	6·00

he obtained, after the mass had been fused, and the boracic acid had been volatilized, rose-coloured spinels in every respect identical with the natural ruby spinel in form, hardness and chemical composition, analysis giving for the latter the formula $Al^2 O^3 MgO$. The blue spinel sapphire (octahedral) was obtained by mingling

	gr.
Alumina	5·00
Magnesia...........	2·40
Oxide of cobalt	0·20
Fused boracic acid....	4·70

The crystals arising from the treatment of his compound were sufficiently large to be seen by the naked eye, while those of the rose-coloured ruby spinel required a lens; they were hard, readily scratching quartz. Analysis gave the formula $Al^2 O^3$ (MgO, CoO), that of the natural sapphire blue spinel. By employing the proper combinations, M. Ebelmen obtained the black and colourless spinels.

Referring to the analyses of M. Awdejew and M. Damour, as showing chrysoberyl to be an aluminate of glucina, he mixed together

	gr.
Alumina, slightly ferruginous ..	6·00
Glucina	1·62
Fused boracic acid............	5·00

The form of the crystals obtained resembled some from the Brazils; they scratched quartz and topaz, were infusible before the blowpipe, and their analysis gave the formula $Al^2 O^3$, GlO, that for chrysoberyl. To complete the investigation for this substance its optical properties were tried, and were found to accord with the natural mineral.

Many other aluminates were obtained by the same method, such as the aluminate of manganese, the aluminate of iron, the aluminate of cobalt, the aluminate of lime, and the aluminate of baryta.

Many combinations of the sesquioxide of chromium with bases may in this manner be formed, and among them M. Ebelmen obtained an artificial chromate of iron by mixing

	gr.
Green oxide of chromium	7·50
Alumina	1·60
Peroxide of iron	3·00
Magnesia.............	1·10
Boracic acid	8·00
Tartaric acid	1·50

The tartaric acid was employed for the reduction of the peroxide of iron. The octahedral crystals obtained, though they scratched quartz, did so with difficulty. The results of analysis sufficiently accorded with the formula ($Cr^2 O^3$, $Al^2 O^3$), (FeO, MgO), which it was inferred the analyses of the natural mineral by M. Abich would give.

Experiments, not yet completed, clearly show that silicates, infusible in our furnaces, may be prepared. Emeralds were obtained in crystals by fusing together, and treating in the manner mentioned,

	1.	2.
	gr.	gr.
Pounded emerald	2·27 (Ural.)	5·00
Melted boracic acid ..	1·25	2·00
Oxide of chromium		0·05

The first mixture gave a stony mass, well-melted, the upper surface of which was covered by a multitude of small regular hexagonal crystals. The second compound gave a beautiful green mass, full of cavities in which were crystals similar to those found on the surface of the first mixture. Chrysolite was also obtained crystallized.

By employing borax as a solvent, crystallized alumina was procured. A mixture was made in the proportion of 4 parts of fused borax to 1 of alumina, and to this was added 1 part of oxide of chromium, by weight, to 100 parts of alumina. Numerous transparent crystals of a beautiful ruby colour, disseminated through a vitreous mass, were the result. By dissolving the vitreous paste in which they were included the crystals were isolated, and found completely unattackable by acids. In form these crystals resembled those of *télésie*, and in their characters are identified with the real rubies and sapphires of mineralogists.

Seeing the results of his experiments, M. Ebelmen asks if, by adopting the method he has pointed out, we may not hope to obtain gems of a sufficient size to be valuable as such. His apparatus was small, and a few grammes only of the mixtures were employed. He anticipates that by using a greater quantity of the needful substances, and effecting the evaporation of the solvent in apparatus of larger dimensions, kept for a long time at a high temperature, crystals of greater size will be formed.

M. Ebelmen points out that the results of this inquiry, which can, as yet, be only considered as in its infancy, may be useful to geologists, as showing them that minerals completely infusible in our furnaces may be crystallized by aid of a solvent, at temperatures far inferior to that of their fusion, and thus we may account for the presence in many rocks of minerals associated with others of very different fusibility. He does not pretend that boracic acid and the borates have always been the natural vehicle for the crystallization of such minerals, though at the same time he remarks on the evolution of boracic acid from the earth, brought up at high temperatures by currents of gas and steam, pointing to the Lagoni of Tuscany, whence 500,000 kilogrammes of boracic acid are annually obtained, to the crystallized boracic acid found in the crater of Vulcano, and to the lakes in many parts of the world containing borax in solution. Boracic acid and the borates may be certainly more abundant than is commonly supposed. As a constituent of schorl the former is much intermingled with the granites of Cornwall and Devon, and is more especially common in the schorl rocks, often occupying the outer part of these granites. In estimating the relative amount of boracic acid in schorl-bearing rocks, we should recollect that the mean of six analyses of black tourmalines, by Gmelin, gives 3·49 per cent. of that acid in their composition. We have also to reflect, that other substances may play the same part relatively to certain mineral compounds which boracic acid and borax have done for the substances employed in the beautiful experiments of M. Ebelmen.

It is always cheering to witness the application of mathematics to our science, showing its connection with those of the highest order. The labours of our colleague Mr. Hopkins in this field have, during the past year, been extended to a consideration of the Internal Pressure to which Rock Masses may be subjected, and its possible influence in the production of laminated structure. Referring to the lamination, so commonly known as *cleavage*, he points to the finest and most regular as leaving "no doubt of its being the result of some kind of molecular action of the constituent particles on each other, analogous to that of crystallization, and not the direct and immediate mechanical effect of external forces acting on the mass." It is scarcely necessary to state that this is the view taken by Professor Sedgwick, and that it is one in which we have long participated. When we consider the discoveries and researches of Faraday and others respecting the properties of matter, we seem to have forces acting on the great scale amply sufficient to produce such minor effects as we have then to consider jointing and cleavage to be. Indeed, looking at the arrangements of the mineral masses, their varied composition, and the general conditions under which they are placed, it is difficult to conceive that the particles composing them should not be subjected to influences thus affecting their ultimate arrangement. When we find pebbles, even as large as the head, cut through by joints, and are unable, by the most careful examination, to detect any shifting on the two sides of the joints, the surfaces of the latter most beautifully plane, with no appearance of splitting according to minor differences of resistance, such as we might anticipate in a mechanical fracture through conglomerates, we seem to have before us the effects of some great power, which can cut through pebbles, often of the hardest substances, adjusting the component matter on the (to us) great scale, without reference to such comparatively minor bodies. While in the divisional planes, to which the term *cleavage* has been applied, we find a shifting of the particles in the finer rocks, so that organic remains in them are contorted or lengthened in given directions, this becomes less as the rocks take a coarser character. As is well known, while the cleavage, in alternating beds of sandstone and slate, may be clearly seen in the latter, it can be often only discovered in the former by fracture of the beds, and then frequently it is coarse, while the cleavage in the alternating slates may be fine. These are effects which we should expect from the causes to which we have before alluded.

Mr. Hopkins, after referring to the distortions of organic remains in cleaved rocks, observed some years since by Professor John Phillips, and more recently by Mr. Sharpe, remarks, that "these distortions of determinate organic forms indicate corresponding distortions in those elements of the mass in which they are respectively comprised." To the memoir of Mr. Hopkins, read before the Cambridge Philosophical Society, we must refer for the mathematical reasoning employed. In conclusion he points out that the shells, after being subjected to the pressure due to the weight of the superincumbent matter (and it may be here observed that the rocks cleaved, and thence termed slates, were originally clay, or at most silt beds), would be again exposed to pressure in common with the general mass, when the latter was folded into flexures and contortions so frequently observed in the cleaved districts composed of our older rocks. He observes, that none but small pressures or tensions would be called into action in the strike of the beds by their elevation into straight anticlinal ridges; and that two of the directions of principal tension or pressure would be in a vertical plane perpendicular to the direction of the anticlinal line and strike of the beds, with which the third axis of principal tension must coincide. "The axes of greatest and least tension," he adds, "through any point will lie in a vertical plane perpendicular to the strike of the beds, and consequently the intersections of the planes of greatest tangential action with the planes of the beds will be horizontal lines. Through every point there will be two planes of maximum tangential action perpendicular to each other, and therefore, dipping one of them in the same direction as the beds, and the other in exactly the opposite direction, the strike of all these planes being the same."

Mr. Hopkins further remarks, that if we recognise the probability of the influence of internal pressure, though not as a primary cause, yet as effective in determining the *positions* of the planes of cleavage, we must suppose that these planes must coincide more or less accurately, either with planes perpendicular to the directions of maximum pressure, or with those perpendicular to the direction of minimum pressure, or with the planes of greatest tangential action. He also points out, that on the last supposition the line of strike of the lamination must coincide with that of the planes of stratification, and considers that observation corroborates this inference. With respect to the opinion that currents of electricity have produced cleavage lamination, Mr. Hopkins remarks that such views, and those founded on the distortion of organic forms, are by no means to be considered as opposed to each other, but that on the contrary they may assist each other, and be mutually useful for arriving at a correct theory.

Even this notice of some portion only of the progress made in Geology during the past year (for it would require a volume instead of an address, necessarily limited as this must be, to enter upon its full detail) will be sufficient to show, that not only does the geologist advance by means of those labours which may be considered as more peculiarly his own, but that he also receives the aid of those cultivating various other branches of knowledge, and who find in his science objects of high interest, and not unfrequently obtain assistance for their own sciences, which otherwise would not occupy the advanced position they now hold. It may be that amid the communications made public, many may be defective, some even erroneous: in the advance of knowledge this always has been and will be: the approach to truth is often but the removal of error; but looking broadly at the state of our science, we find it occupying minds of no ordinary kind, dispersed over various parts of the world, and we cannot but anticipate that great as its advance has been within a very limited number of years, it is destined to move forward still more rapidly. Let us trust that these anticipations may be realized, and that by a continuance of the kind feeling and hearty cooperation of its members which has marked its course hitherto, this Society may ever be found taking its right place among those which seek only the advance of truth.

THE END.

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REPORT OF MUSEUM COMMITTEE*.

1848.

THE British Collection presents itself under several distinct phases. Chronologically considered, it is necessary to discriminate between the zoological part of the collection and the lithological, although no such distinction is made in the order of Council in which the chronological arrangement is prescribed, in express terms at least, for it is obscurely indicated; that order which bears date May 28, 1813, is conveyed in the following terms:—"There shall be a collection of specimens illustrating the nature of the rocks and strata of the British Isles, to be arranged in an order corresponding to their natural positions, as far as such positions can be ascertained. All specimens, the nature or position of which are not understood, shall be placed in a topographical collection arranged according to countries."

This resolution, dated May 28th, 1813, appears however to have been rescinded in little more than a fortnight; for on June 18th of the same year we find the following resolutions:—"All such series of specimens as refer to the British Isles shall be included in the topographical collection, and shall be placed in that county to which they principally belong.

"All series of specimens illustrative of papers published in the Society's Transactions, of sections presented to the Society, or presented as illustrating the works of an author, whether they relate to the British Isles or foreign countries, shall be kept entire, with the exception of such parts of them as may be considered superfluous by a committee," &c. &c.

These resolutions also soon ceased to be operative. The Report of 1814, drawn up by the then Secretary, Mr. Warburton, unfolds his principles of arrangement, and may be taken as the groundwork of the plan acted upon by his successors. In 1815 the Society was informed that "the pledge given at the last anniversary for the arrangement of the collection had been in part redeemed, and that as far as the present state of the apartments and of the cabinet would permit, the English rocks, together with their fossils, had been arranged according to the series of the beds, in the order of superposition." Upon the soundness of this principle, as far at least as organized bodies are concerned, recognized as it has been by common consent, both at home and abroad, the Committee are satisfied there can now be no difference of opinion: confining their remarks at present to that portion of the series, they would stedfastly uphold it as a principle

* See *ante*, p. ii. of Annual Report.

tending continually to the suggestion and establishment of highly important inferences and discoveries; it must not be disguised, however, that there is always more or less of difficulty in acting upon the principle. The first obstacle is its inapplicability to any beds that are not stratified—its irrelevancy to all such as are amorphous or intrusive. The second obstacle is, that individual beds are seldom of any great extent, and that their number is so large that no one would ever think of dealing with them singly: to deal with them at all they must be thrown into groups, which, as they must be in some measure capricious, has led to the construction of different systems. The chronological table, by which Mr. Lonsdale was guided in the arrangement of the British collection, as detailed in the Report of the Committee in 1842, will, it is presumed, be generally acknowledged to have been as judicious and unobjectionable as any which could at that period have been devised; and the question arises, whether it ought still to be adhered to in all its integrity; and, if not, what amount it may require of modification?

The leading cause of the difference observed in the several tables above-mentioned, results from the greater or less indulgence afforded to the practice of subdivision.

Where there is a marked change in the character of the fossils in a group hitherto represented as one and the same throughout, a subdivision of that group is obviously required. Upon this principle the Crag, formerly considered as a single mass or formation, is now split into three. On the other hand, it must be admitted that some advantage is to be obtained from a disposition to generalise, as well as from the contrary habit of running into detail, and multiplying distinctions. It has been well observed that few organic forms are monochronous—the greater number have had a range of existence exceeding the limits of any one chronological horizon; many have extended through several successive formations, and in all these cases the necessary consequence of splitting up groups is to multiply repetitions.

The Committee which sat in 1842 were the first to question the value of mineralogical characters when applied to chronology,—the first to point out the inexpediency of confounding in the same cabinet the fossiliferous specimens and the non-fossiliferous.

A very large proportion of the fossiliferous specimens are imbedded in a matrix, and this matrix should of itself be sufficient, or nearly sufficient, to furnish to the student quite as much lithological information as in this department he is likely either to expect or desire. More detail in that branch of information could only tend to bewilder him. The Committee apprehend that where the necessity of introducing lithological specimens into the British Collection ceases, the expediency ceases also.

The British Collection, which has ever been the favourite one, has naturally enough, perhaps harmlessly, become a continually encroaching collection. Its geographical encroachment has been already noticed, but it may be proper also to point out its zoological encroachments.

On the 28th of May, 1813, the Council passed the following resolution:—"There shall be a collection of organic remains arranged according to their forms, without reference to the bed in which they are found."

That resolution was acted upon for a number of years, somewhat sluggishly perhaps, but still continuously. During the administration of Mr. Webster, as Curator in the first instance, afterwards as Secretary, it was neglected, not abandoned or annulled. On his retirement hopes were entertained that a collection of such obvious utility would have risen again to its proper level, and many interesting series of fossils, the Egyptian for example, were presented to the Society with the avowed intention of effecting that desirable result. The whole collection, however, was hastily broken up, with or without conference with the Council, in order to give greater development to the English and foreign series. The want of such a collection, however, was soon evinced, though it did not take the form of complaint, and the hopes thus crushed at the Geological Society sprung up with new vigour at the British Association for the Advancement of Science.

In 1839 the following resolutions, originated in the Geological Section, were approved by the General Committee of that body:—

"Resolved, That with a view to supply one of the greatest desiderata at present felt by geologists in investigating the structure and history of the earth, as well as to advance a branch of zoology, for the study of which no adequate provision has hitherto been made in any of the public institutions of this country, application be made to the Trustees of the British Museum to form a conchological collection, and which may include, if possible, under the same roof, not only all known species of shells, whether recent or fossil, but likewise the varieties of form and size which such species assume at different periods of their growth, or from other causes, together with a series of the impressions of shells which are found upon different rocks, and plaster casts from their impressions—and that the Marquis of Northampton be requested to bring this recommendation before the Board of Trustees."

His Lordship willingly undertook to advocate the measure at the British Museum, but all his exertions there proved unsuccessful.

The then Presidents of the Linnean and other learned Societies in London advocated the same measure, but in vain.

In the British Collection the organic forms are intended to exhibit not only a chronological but also a zoological sequence. The collection professes to inform the student not only of the geological age of the several species, but of the relation they bear severally to other organic beings; they must be considered not only as medals of creation, but as objects of natural history; and in that character are entitled to be classed according to the rules which have been laid down for the classification of recent species. As there are numerous systems of geological formations, so are there many systems of natural history; and here again the question arises, which is the best? or rather, which shall be adopted? Where the objects to be arranged are so few in number, it may appear of little consequence which is adopted. Even if they were more numerous, it would probably be difficult to assign any sufficient reason why the vegetable kingdom should take precedence of the animal, or *vice versâ*—why the Mammalia should stand at the top of a zoological list or at the bottom; but the question does not refer to dignity; it refers to orderly distribution and regularity of procedure, and it is only with a view to method and consistency that the Committee invite a decision of the Council on points in all other respects immaterial. It seems necessary to good government in a museum, that questions which cannot be determined by reason should be determined by authority.

It is stated in the Museum Report of 1830, that the vertebrated animals are classed according to the system of Cuvier—the invertebrated according to Lamarck; and if by those words the Committee are allowed to understand the latest editions of the works of these authors, they see no reason why that classification should be superseded.

Your Committee are of opinion, that for practical purposes the most convenient order of sequence for the several classes of organized beings is that which, derived from the sources above specified, will be found prefixed to Mr. Morris's Catalogue of British Fossils, and they accordingly recommend this to the sanction of the Council. In the subjoined list exhibiting this order of sequence, the Committee have ventured to annex to the name of each zoological division the name of the author or authors whose writings, in reference to those divisions respectively, are in their estimation worthy of being consulted.

Plantæ	Adolphe Brongniart; Unger; Göppert; Count Sternberg, continued by Presl; Lindley and Hutton.
Infusoria	Ehrenberg.
Amorphozoa	Lonsdale; Lamarck (2nd edit.).
Zoophyta	Milne-Edwards; Michelin; Ehrenberg (Berlin Transactions).
Echinodermata	D'Orbigny; Prof. Forbes; Austin; Agassiz.
Crinoidea	(as above)
Echinidæ	(as above)
Incertæ sedis	
Foraminifera	D'Orbigny.
Annelida	Burmeister (Ray Society).
Cirrhipeda	Lamarck (2nd edit.); Darwin (book in preparation).
Insecta	Brodie (Fossil Insects of Secondary Rocks).
Crustacea	Burmeister; Bell; Milne-Edwards.
Conchifera dimyaria . .	Deshayes (Cyclopædia); Lamarck (2nd edit.).
———— *monomyaria* .	James D. C. Sowerby; Lamarck (2nd edit.).
Rudistes	D'Orbigny; Desmoulins.
Brachiopoda	Lamarck.

Gasteropoda	Lamarck.
Pteropoda	Deshayes.
Heteropoda	Lamarck.
Cephalopoda	D'Orbigny.
Pisces	Agassiz.
Reptilia	Owen.
Aves	Giebel.
Mammalia	Giebel.

The Committee recommend that this list, when revised and amended by the Council, may be transcribed, framed, and hung up in the Museum, and that no departure from the principle or plan of arrangement so laid down shall be permitted to be made without a written order of Council. Changes of this kind involve consequences so important that they should never take place at the mere fiat of an individual, or even of a committee.

The professed object of the British Collection is to exhibit the various species of organic life in the order of superposition, not of juxtaposition—those that are seen on the vertical plane, not on the horizontal. Yet in carrying out this object the practice has been to give the right of *entrée* not merely to an individual of any given species, or to different varieties of such species, but also to other individuals which agree exactly with that previously admitted, provided they are natives of a different district. Your Committee think that such repetitions should be allowed only when some peculiar geological interest is attached to the recurrence of the same fossil in two distinct localities in the same formation.

Naming of Specimens.

The naming of specimens of natural history is a very delicate, and at the same time a very laborious occupation,—one which can safely be entrusted only to few. It requires not only great experience, great erudition, great knowledge of the subject, an acquaintance with the scientific literature of Europe, but in addition to all these a kind of European reputation. The curators who have had for some years past the direction of the Museum of the Society have all been men of that stamp; but they, like their fellow-men, cannot be expected to arrive always at one and the same conclusion. Generic and specific names must necessarily change from time to time, as science advances, but all such changes should be rare, well-considered, and officially sanctioned. No curator can be expected to do his work well unless he has some guarantee for its durability. The generic and specific names which now attach to the specimens of the British Collection, as far as they are named, constitute, and ought to constitute, a very large part of its value; they are the result of an expenditure which cannot have amounted to less than £4000, not to take into account the unbought labour and experience which at different times have been so generously volunteered on their establishment or rectification: these names the Committee hope are, with few exceptions, correct; but they are not yet recorded in any official document;—the parties who imposed or devised them are retiring or have already retired, and there is no provision whatever as yet made for the duration of their work.

The Committee are sorry to observe in all the collections, that the law laid down in the early days of the Society, and frequently repeated, that every specimen should be distinguished by number, has not been rigorously adhered to. Much valuable time has been expended by different secretaries and curators in affixing to the specimens numbers which while they lasted were fertile sources of information, but which, for want of care or perseverance, have now become nearly worthless. It is very desirable that in future the admonitions of the Council on this subject should be strictly enforced. Without these distinctive numbers the Council has no means of knowing the actual extent of the collections, nor their rate of increase, nor can a general catalogue be drawn out without this important preliminary.

Although it is enacted by a resolution of Council in 1810, that the whole collection should be under the management of the President and Secretaries, your Committee apprehend that it ever has been and still is the undoubted right and duty of the Council to determine at least the principle upon which the several departments of the Museum shall be conducted.

To put a large collection in order, and still more to keep it in order (where there is continual ingress and egress of the objects to be arranged), there must be unity of design and a steady adhesion to established rules. Where no such rules exist, the most punctilious cannot obey them ; and if no such obedience is required, it is only natural that every new officer appointed, though he may not find fault with what has been done before, will yet endeavour to amend it. Hence each new appointment is apt to involve a change of system ; which, whether better or worse than its predecessor, must in either case occasion a halt. On every reversal of the engine the movement which should be progressive becomes retrograde, and it becomes doubtful, when once the arrear of business is allowed to accumulate, at what period, if ever, the ground lost can be recovered. It has at all times been a great object of the Society to have the collections properly catalogued ; the labour expended upon it at one time or another is prodigious ; but instead of perfecting the catalogues he found, it has been the ambition of each succeeding officer in charge of the Museum to construct a new catalogue of his own.

Attempts have been made again and again to form a Catalogue of the British Collection, but they have all been thwarted ; in some degree, no doubt, by the continual fluctuations to which it has always been subject, but still more by a want of perseverance on the part of those who began the task, and a love of originality on the part of those whose duty it has been to complete it. It were hopeless to expect that such a catalogue will ever be constructed unless upon a well-considered plan, distinctly laid down by the Council in the first instance, and then rigidly maintained and steadfastly followed out.

The plan of a catalogue should be regulated in some measure by the nature of the objects for which it is designed. A different plan should be framed for each separate collection.

It is stated in the Report of the Museum for 1834 that Mr. Lonsdale had introduced a regular systematic mode of *labelling*. In 1840 Mr. Woodward was employed to affix labels with general and specific names, localities, references to books and names of donors. How far this was a continuation of Mr. Lonsdale's system, or a deviation from it, is not mentioned ; it would appear desirable however at this time that some system of labelling should be now approved by the Council, and that once determined upon, it should be steadily and strictly adhered to throughout the collections.

Without going into further detail, it may, perhaps, be proper to observe, that there is not at present in the Museum a single specimen of that enigmatical formation the Speeton clay.

The series of Echinodermata is also said to be very defective.

Mr. Sowerby is of opinion, that if from the first exchanges of specimens had been allowed, the only reservation being that individual species described or figured should not be parted with, the Museum would have been much richer in many departments than it now is, and not poorer in any.

Your Committee recommend that the further arrangement of the British Collection should for the present be suspended, and the specimens newly presented should be prepared for admission into the cabinets on the earliest convenient opportunity after their arrival. They are disposed to think that, as a general rule, their actual admission should not take place till after the recess. They recommend further that the arrangement of all the different collections, as far as it involves only diligence, regularity and strict attention to routine, should be lodged in the hands of one person only: that the said person should have written instructions as to the mode of executing his commission: that each collection intended to be kept up should be distinctly recognised by the Council, and receive a distinctive name and a prescribed locality: that the name of each collection should be inscribed in conspicuous characters on or near the room or cabinet in which it is contained: and lastly, that no species shall in future be admitted into the collection, the features of which are too indistinct or incomplete for discrimination.

With a view to prevent in future the indefinite accumulation of duplicates and unexamined specimens in the crypts, a monthly return should be given in to the Council of all newly-arrived specimens, and of the manner in which they have been disposed of respectively.

Your Committee recommend that, on an interleaved copy of Morris's Catalogue of British Fossils be inserted in a column appropriated to that purpose, in pencil, the distinctive number of the prism and the letter of the drawer in which each several specimen is contained: that a further catalogue be drawn out after the pattern herewith sent, with such modification only as the Council may direct, and that the said pattern be in future strictly adhered to: that when any specimen is entered in the Catalogue, a mark be made on its label, to show that it has been so entered.

Foreign Collection.

This collection, which is rich in valuable objects, occupies almost the whole of the upper Museum, and there are detached portions of it dispersed about in other parts of the building, as will be noticed hereafter.

The observations which have been offered on the British Collection apply in great measure to the foreign; the Committee recommend in both the separation of the fossiliferous specimens and the unfossiliferous; in both they would wish to see the number of the former increased; of the latter, reduced. An extension of the fossil remains in the Foreign Collection is more especially desirable, because provision has been made in many provincial institutions, and is now making in the Museum of Economic Geology, for the reception and study of English organic remains, while those of foreign countries, the study of which is equally essential to a sound geological education, has hitherto received but very little attention.

A *systematic collection* of rocks was first resolved upon in June 1813, having been suggested by Sir Humphry Davy at a much earlier period. At the first starting of the Society he drew up a scheme for its arrangement, which accidentally turned up among a large quantity of papers recently removed from the crypts. About that period Dr. Babington presented to the Society a series of specimens from the Harz mountains, with a catalogue drawn up by Lasius; and another series was soon afterwards presented by Mr. Heuland, made under the direction of Werner, and illustrative of his system of nomenclature. Another collection of the same kind was afterwards given by Dr. Macculloch, in illustration of the geological constitution of Scotland, but there was no locality affixed to the specimens, nor were they catalogued. These specimens occupied at the time not less than ninety-one drawers: they were employed afterwards to form the basis of the series of Scotch rocks now incorporated with the English.

Your Committee cannot flatter themselves with the hope that the study of minute oryctognostical distinctions can ever be made of much use to geology; the accidental varieties of rocks are too numerous for registration or nomenclature; but there are broad distinctions at least which cannot be overlooked, and ought not to be confounded. Nature furnishes a considerable number of rocks which have a distinct character, and which, from the extent of their range, the frequency of their occurrence, the peculiarity of their aspects, the uses to which they are applicable, and other circumstances, have obtained distinct names; the number of such names is greater than would perhaps be at first surmised. On a rough calculation they may amount to three hundred. A list of these has been published by Boué in the first volume of his 'Guide du Géologue Voyageur,' and not being at the time aware of this circumstance, your Committee drew up a similar list, which will be found in the Appendix to this Report. In anticipation of what will be said hereafter in regard to duplicates and unappropriated specimens, your Committee beg leave to suggest that a collection of such rock-specimens, not exceeding the number above mentioned, might be easily made, to the great advantage of beginners in geology, and might be comprised within a very moderate compass.

To this collection might be appended with great propriety several small suites of specimens (which at present exist) illustrative of structure, cleavage, metamorphic action, the gradual passage of one mineral substance into another, &c. &c. (see Museum Report for 1842).

Size of a proposed Chest or Locker, necessary for containing an Elementary Collection of Rock Specimens.

Length, 3 feet. Width, $1\frac{1}{2}$. Height, $1\frac{1}{2}$.

If the chest be divided into five tiers, each containing 72 trays or stands, it will furnish accommodation for about 360 specimens, of the average size of three inches square.

Collection of Simple Minerals.

This collection is located in the Library. It is founded on a resolution of Council dated May 28th, 1813. In 1815 it is stated to be so incomplete as scarcely to deserve the name of a collection, yet it is referred to in the Reports of 1815, 1817, 1818, 1819, 1821, 1822, 1828, 1829, 1830, 1831, 1832, 1835, 1838, 1842, since which period it seems to have fallen into neglect. This is the more extraordinary, because immediately previous to its decline it appears to have been a favourite with the Society. The Report informs us that the number of drawers appropriated to this department had been increased since the last anniversary from sixty to seventy-four, but that such statement by no means conveys an adequate idea of the real extension of the collection, which might be estimated to have increased nearly one-third. Few additions have been made to it of late years, and it is but little consulted.

The simple minerals occupy at present seventy-four drawers; if it were thought desirable to increase the number, it were easy to do so. If the Council were to express a desire to extend the collection, valuable donations would flow in immediately; still those who feel an interest in this branch of science must always have better opportunities of pursuing it at the British Museum than ever could be furnished to them at the Geological Society.

The cabinet of simple minerals was arranged in the first instance after Brongniart; afterwards, in 1831, after Phillips: the arrangement was revised and improved in 1841. The (best?) English edition of Phillips's work was edited by Mr. Allan of Edinburgh; but there is a later and better one by Alger published in America. Dana has published also in that country a new and, it is said, an original system. The most recent and original system of any extent published in Europe is that of Glocker (Synopsis, large 8vo, Halæ, 1847): he, like so many of his predecessors, considers it necessary to have a nomenclature of his own. In 1830 Mr. Brooke published in the 'Encyclopædia Metropolitana' one of the most comprehensive treatises that has appeared. Breithaupt, Cleaveland, Jameson, Haidinger, Hauy, Mohs, Naumann,

&c., have still their respective admirers. Among so many systems it may perhaps be difficult to select the best; the object of the Committee, however, in making these observations has been, not so much to determine the respective value of the several authorities, as to guard against the capricious adoption of any or of all. If there be any settled plan of classification at the British Museum, it might be well perhaps to transfer it to the collection of the Society. The Professor of Mineralogy at Cambridge however would be the person to whom the Council would naturally look for the best information upon this subject.

Fossil Bones. Osteological Collection.

There are numerous specimens of these in the Museum, but they are not brought together, catalogued, numbered, classed or named. The only occasion on which the Council has interfered on this subject was when they directed that they should be classed according to the parts.

The bones from the Himalaya, of which several cases were presented, were, from the inability of the Society to accommodate them, transferred, with the approbation of Government, to the British Museum, and have been there examined and arranged by Messrs. Falconer and Cautley.

The Himalaya bones in the crypts have been looked over by Dr. Falconer: the completion of his investigations at the British Museum was transferred when he quitted England to Mr. Melville; but there still remain numerous specimens from this locality, some in boxes, some on the floor, some in the open area.

Your Committee are desirous that the Council should come to an early determination as to the expediency of maintaining these large collections of bones, and express an opinion as to the limits within which such collections ought to be confined.

A Catalogue and Index are much wanted of the several skeletons or parts of skeletons, which on account of their size cannot be placed in the drawers, and are therefore dispersed in the entrance-hall, the anteroom on the ground-floor, the staircase in the library, and the upper and lower museum; as also of the large casts (some of them presented by Cuvier), which for the same reason have undergone a similar dispersion.

Collection of Recent Shells.

This cabinet, founded on a resolution of Council in 1818, has hitherto engaged but little attention: the first notice to be found in its annual reports bears date 1830; it is noticed also in the annual report of 1842. Its groundwork is a collection bequeathed to the Society by Captain Apsley, whose zeal in the early days of the Society deserves even at this late period honourable notice.

G. B. Greenough.
Jno. Morris.
Cha. Lyell.

The following reports from Mr. Lonsdale and Prof. Forbes to the Committee appointed in December 1845 to report on alterations to be made in the plan of the Museum, have been ordered to be printed with the preceding Report:—

From Mr. Lonsdale.

In compliance with a request conveyed to me by a member of the Museum Committee, I beg with all deference to state, in reply to the points alluded to in the note with which I have been honoured, that I conceive the maintaining and the perfecting, as far as possible, of the British and Irish collections, to be the primary obligation of the Society as respects its Museum, and for the following reasons:—

1st. Because the British collections already in the possession of the Society are of great scientific value, constituting the most important portions of the Museum, and, taken as a whole, being unequalled.

2ndly. That Foreigners resort to the Society's Museum for the purpose of examining the British series, not only for the sake of comparison with the equivalent formations in their own country, but also to prepare themselves for proposed practical researches. Several instances of this previous study occurred during the period I had the honour of being connected with the Society. It may be farther stated, that Fellows resident in London have been in the habit of examining local series before they visited the districts composed of such formations.

3rdly. The liberal principles on which the Society was founded, and has been maintained by successive Councils, have permitted a Fellow to borrow specimens for comparison and attentive study at his own residence. The importance of this privilege cannot be too highly estimated, as the information to be obtained from examining specimens in a public Museum is far inferior to that which may be acquired by research conducted with full leisure and undisturbed attention; it is also only by repeated comparisons, as fresh light is thrown upon a subject, that an identification can be established or a distinction fully proved. The great liberality of the College of Surgeons in affording access to its Museum, and the extreme willingness of its officers to assist inquirers, render that fine collection of the greatest value to the student of organic remains; and the ready access afforded by the officers of the British Museum to the cases or cabinets under their care, as well as the promptness with which information is communicated, could not be farther extended. The same spirit pervades other public or metropolitan institutions; in no one, however, can Fellows of the Geological Society enjoy the privilege of resorting daily and without application to any cabinet or drawer; much less can the loan of specimens be obtained. The facilities for studying the collection supplied by the Library could not be enjoyed elsewhere; and the usefulness of the Library would be essentially diminished without the British series.

4thly. The Geological Society enacts its own bye-laws, and elects its own executive body, chosen from among the Fellows most intimately acquainted with the wants of the science and the means by which they may be supplied, or its further interests promoted; but Government establishments, in which alone Metropolitan Geological Museums can be formed, have no such Council; and the collections being public, privileges must be much more limited than in a Society, where the property belongs to the individual Fellows, and the numbers are comparatively very small.

For these reasons it is conceived that the British collection ought to continue in the possession of the Society, being there most available to scientific students, and constituting the most important portion of the Museum.

With respect to the rejection of rock-specimens from these series, it is believed that Organic Remains cannot be rightly understood without a reference to the formations in which they are found; and I hope to be excused for observing, that many of the most important problems connected with geology cannot be worked out without the aid of such specimens. Some British sedimentary deposits cannot be represented by fossils; others but very partially or locally; and where organic remains most abound, they cannot convey an idea of the series of strata in which they occur, or of the changes the latter undergo in different districts. A French geologist familiar with the Paris basin would, it is conceived, be most interested in the resemblance between the testacea of the calcaire grossière and the London clay, when he saw before him a drawer of argillaceous cubes and siliceous sands, representing the whole thickness of the deposits and the leading mineral changes, but without a trace of a calcareous bed. An equally vivid impression could not be derived from language. It is conceived that descriptions cannot convey to the mind a perfect knowledge of rock series, and that the best are far more difficult to retain in the memory than characters obtained from hand-specimens. The foreigners whom I had the honour of attending in the Museum previously to their field-researches, were as desirous of seeing rock-specimens as fossils. The value of stratigraphical series to the inexperienced in practical investigations, to whom the Society must look for its future effective support, and who will resort to the Museum for instruction, is almost beyond estimate. It was frequently regretted that the cabinets did not possess series illustrative of the changes in the carboniferous deposits from the south-west coal-field to Scotland, with suites of marine, freshwater, or terrestrial remains, for the purpose of conveying to the mind of visitors, by actual inspection and comparison of successive series, proofs of the changes from one condition to another, which the earth underwent at only one remote period of its existence. The relatively vast intervals of time between the formation of an upper and a lower coal series, separated by 1000 or 2000, or a greater number of feet of unproductive measures, could not be effectively conveyed by words or sections, or represented at all by fossils; but a drawer of sandstones and conglomerates obtained from such an intermediate deposit, and exhibiting undeniable evidence of great wearing down of pre-existing rocks, would strongly impress the beholder with the fact that a long period elapsed during the accumulation of this arenaceous series; and that the production of the materials or component detritus involved many curious, complicated geological phænomena. The important inferences deducible from the coal conglomerate of South Wales can be fully estimated only by actual inspection of specimens.

As respects another point alluded to in the note with which I was favoured—the forming of one general, stratigraphical collection—I beg to state that the principle, laid down long before I had the honour of being connected with the Society, of separating the Foreign collections, has always appeared to have been based on a right view of the state of geological knowledge; and it is conceived that it would be unadvisable now, should the whole collections be maintained, to intermix with the English stratigraphical series, which is almost perfectly determined, foreign suites of doubtful equivalent age.

The Foreign collections, to which attention was particularly called, it is respectfully suggested, could not by any application of the Society's resources be made of equal scientific value with the existing British series, much less of so great importance or benefit to geologists, as that series might be made by inferior exertions. If the Museum were confined to the productions of other countries it would cease to be visited by foreigners, and it would be of comparatively little value to field-workmen in England. Could any collections not connected with these islands be regarded as having direct claims upon the Society, and might be expected to be found in its cabinets, they would clearly be those derived from English colonies. As the resources of the Society, however, are in all respects limited, it is conceived that foreign series ought to yield first. Under the direction of committees appointed in 1841 and 1842, the removal of rock-specimens from that division of the Museum was commenced, and if carried out to the full extent, it is believed an amount of cabinets would be gained more than sufficient to permit the removal to the upper room of the Scottish and Irish collections, and thereby liberate immediately 160 drawers for the extension of the English series. The foreign fossil suites are not extensive, and probably would not occupy a greater number of cabinets than was assigned in 1842 and previous years to the whole American continent. The secondary fossils from Cutch and the Desert to the north-east of it, and those from Southern India, would not perhaps possess the same amount of interest at present in any Museum as in that of the Society, where they can be compared with English analogues.

One other object was alluded to in the note with which I have been honoured, namely the vertebral remains. The Ava bones and some valuable mammalian reliquiæ not exhibited, could, most clearly, be made more available to science in establishments possessed of officers fully competent for their right appreciation than in the Geological Society, whose means necessarily prevent efficient researches in every branch of organic remains.

I beg to apologise for trespassing so far on the Committee, but having been honoured by their request, I have felt it my duty to give the best opinion in my power, however unworthy of attention.

Wm. Lonsdale.

Bath, Dec. 27th, 1845.

From Prof. Forbes.

Considerations respecting the Museum of the Geological Society.

1. The plan of the present collection appears to me too extensive to be followed out by the Society, with the space and means at its disposal.
2. Since that plan is almost identical with the part of the arrangements to be displayed in the Museum of Economic Geology, is it desirable that such should be imperfectly attempted when a better may be adopted?

The following plan appears to me preferable in many respects:—

1. To draw no distinction between British and Foreign collections; but to assemble the organic remains in the lower Museum, and the rock-specimens in the upper (weeding the collections of all unnecessary specimens).
2. The palæontological collection to consist of a *limited* number of well-marked specimens, of as many species as possible, arranged in the following manner:—

   The greater stratigraphical divisions to be maintained (as the three tertiary groups; the cretaceous, oolitic, liassic, and the several palæozoic groups).

   The fossils included in *each* of the divisions to be arranged in Nat. Hist. order.

   The minor stratigraphical divisions not to be maintained separately, as at present, but to be carefully indicated, either by the colour of the card or by some other conspicuous sign.

   The British and Foreign specimens to be placed in contiguous, but not in the same, drawers.

   In the upper room a well-selected series of rock-specimens (sedimentary and volcanic) to be arranged, the former in stratigraphical, the latter in (mineralogical?) order.

   Such a collection would afford great facilities for the study and comparison of fossils, and would oblige those studying it and writing about organic remains to look beyond British forms only, which too few in this country have been in the habit of doing, and which too many will never do till they are obliged.

   I believe there is ample material and space for such a collection, and that the present arrangement can never be satisfactorily carried out.

DESIDERATA

IN THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

February 1848.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDING

OF

THE GEOLOGICAL SOCIETY.

May 26, 1847.

Neil Arnott, M.D., was elected a Fellow of the Society.

The following communication* was read:—

Notice of the Discovery of Coal on one of the Islands on the Coast of the Malay Peninsula. By J. R. Logan, Esq.

[Communicated by Prof. Ansted.]

Mr. Logan states, in a letter to Prof. Ansted, dated 6th March, 1847, that in July 1845 a government steamer was despatched to a place called Gurbie, on the Malay coast near Junk-Ceylon, where, the Governor had been informed, traces of coal existed. Captain Congalton, the Commander of the steamer, proceeded to Temah, which lies on the coast about three miles west of the mouth of the Gurbie. He there found in a low cliff a horizontal layer of black rock only visible at low water, having some resemblance to coal, but found to be incombustible. Mr. Logan then states that on his return from Malacca a piece of rock was shown him by Colonel Butterworth, which he had received a few days previously from the Honourable Mr. Garling, Resident Councillor at Penang. It is a fine clear jet-like mineral,

* Mr. Prestwich's memoir on the Bagshot sands, also read this day, is printed in connection with a previous paper in vol. iii. p. 378 of the Journal.

having a conchoidal fracture, hard, and not soiling the fingers. Its colour is black, velvet-black or brownish black. One portion has a beautiful lustre and high polish. It is described by Mr. Logan as burning with a clear flame, occasionally greenish, and with a slight decrepitation. It was found by a Penang Siamese, on the southern coast of the island of Junk-Ceylon (well-known for its tin). He said he had found a layer of it three feet thick close under the surface, and offered to import it into Penang at the rate of 12*s*. 6*d*. per ton.

On submitting a portion of a specimen of this coal to a rough investigation, it appears to be of very admirable quality. It yields an ash amounting only to 1·32 per cent. The quantity of sulphur, if any, is too small to be appreciated. It is very bituminous, and appears as if it would *coke* well. There can therefore be little doubt that if the specimen is fairly selected, and the quantity be sufficient, this mineral fuel may be applied to many highly important economic purposes.

June 9, 1847.

George Richardson, Esq., and John W. Kershaw, Esq., were elected Fellows of the Society.

The following communications were read:—

1. *Microscopical Observations on the Structure of the Bones of* Pterodactylus giganteus *and other Fossil Animals.* By J. S. Bowerbank, F.R.S., G.S. &c.

On the 14th of May 1845 I had the honour of exhibiting to the Geological Society a portion of the head and other bones of a gigantic Pterodactylus from the lower chalk* near Maidstone, Kent, and subsequently these specimens were engraved and published, accompanied by a short description, in vol. ii. p. 7. Pl. I. of the Quarterly Journal of the Geological Society. In that memoir I expressed an opinion, that the bone represented by fig. 6 in the Plate illustrating my paper was of the same description of animal, and corresponding in position with that figured and described by Prof. Owen in the Transactions of the Geological Society, 2nd Series, vol. vi. Pl. 39, as a portion of the shaft of the humerus of a longipennate bird, and consequently that it was probable that the latter bone would ultimately prove to belong to a Pterodactylus. Since the expression of this opinion, I have had the pleasure of seeing several fine specimens of similar bones to those described by Prof. Owen, in the possession of Mr. Charles of Maidstone, Mrs. Smith of Tunbridge Wells, and Mr. Toulmin Smith, and I have been favoured by the latter two eminent and liberal collectors with the free use for examination and comparison of many beautiful specimens of such remains. Several of these bones, especially those from the rich collection of Mrs. Smith and Mr. Toulmin Smith, agreed so perfectly in all respects

* By an error on my part, the bones are described in the first memoir as being from the Upper Chalk, while in truth the pits from which they came are, I am informed, considered as Lower Chalk.

with the published specimens, as to impress more firmly than before upon my mind, the conviction that the whole would ultimately prove to be the remains of Pterodactyls. With a view of deciding this question if possible, I determined upon a close microscopical examination of the structural peculiarities of the bones, in the hope of eliciting some characters which would, in conjunction with their external forms, point out with some degree of certainty the class of animals to which these interesting remains in reality belonged.

In the first place I removed some small fragments from the jaw of the Pterodactyl from the chalk, in my own possession, and immersing them in water between slips of glass, I submitted them to examination by transmitted light with a power of 500 linear, and I was at once struck by the great difference in the proportions that existed between the bone-cells of the specimen under examination, and those of the human bone with which I was familiar. A measurement of five cells of the latter gave an average of length $\frac{1}{805}$ inch, greatest diameter $\frac{1}{3261}$ inch, while an average of five cells from the lower jaw of the *Pterodactylus giganteus*, represented by fig. 1. Pl. I., gave—length $\frac{1}{552}$ inch, greatest diameter $\frac{1}{6024}$ inch. In the latter also the bone-cells were considerably fewer in number, within the same amount of space, than they were in the human bone, and the canaliculi radiating from them less in number and larger in diameter.

With these striking differences in structure before my eyes, I felt a strong hope that the comparative number and proportions of the cells would afford a sufficient means of discriminating between the remains of the Pterodactyls and those of mammals, and probably birds; and I determined therefore, in the first place, to examine microscopically the whole of the bones from the chalk, and then to compare the results with those which might arise from a similar investigation of the bones of recent reptiles and birds.

Upon submitting to examination minute fragments of all the Pterodactyl bones represented in Pl. I. vol. ii. of the Geological Journal, I found the bone-cells in every case to agree precisely in their proportions and mode of distribution with those from the lower jaw of the *Pterodactylus giganteus* which are represented by fig. 1. Pl. I.

I then called upon Prof. Owen and informed him of my wish to examine the structure of the bones described by him in the Transactions of the Geological Society as those of birds, and he kindly furnished me with some minute fragments from near the centre of the shaft of the bone, represented by fig. 1. Pl. 39. vol. vi. of the New Series of Transactions of the Geological Society. Upon immersing these in Canada balsam, and submitting them to a similar course of microscopical examination to that which I had before adopted, I found the bone-cells to possess the same small diameter and great elongation that characterized those from the jaw of the Pterodactyl and the other remains of the same animal; the average length of five of the cells represented in fig. 2. Pl. I. being $\frac{1}{515}$ inch, and the greatest diameter $\frac{1}{6173}$ inch, so that in reality they are more elongated than those from the jaw of the Pterodactyl; but this it is quite natural should be the case, as I have subsequently found that the bone-cells vary slightly in their proportions in different parts even in the same bone; those of the cancellated portions toward the ends of the bone being somewhat shorter and more irregular in their proportions than those of the shaft, surrounding the Haversian canals, which have proved in all the specimens I have examined to be very nearly uniform in their size and proportions. I have therefore in all cases described in this paper, selected the specimens for examination and figuring as nearly as possible from the central portion of the shaft of the bone.

The result of these examinations strongly impressed upon my mind the conviction, that the bones described as those of birds in truth belonged to Pterodactyls, and it remained only to examine and compare with them the structure of the bone of an Albatros; with the view of procuring which, I called on my friend Mr. John Quekett of the Royal College of Surgeons, and upon mentioning to him the course of investigation which I was pursuing, he at once told me that he had been for some time engaged in an examination of the structural peculiarities of the bones of the four great classes of the animal kingdom, and that he believed that distinctive characters existed which would readily enable an anatomist to decide from a fragment, to which of these classes a bone submitted to his examination might belong. Upon this declaration I immediately submitted to him Camera lucida drawings of the bone-cells from the jaw of the *Pterodactylus giganteus* from the chalk, and those from the bone belonging to the Earl of Enniskillen and described by Prof. Owen (fig. 1. Pl. 39. vol. vi. Geol. Trans. 2nd Series), and he at once declared that they were characteristic of the reptilian tribe.

This confirmation of the opinion I entertained of the reptilian character of the bones under examination was the more valuable, as neither Mr. Quekett nor myself were previously aware of the course of investigation which each had been pursuing.

Having obtained a portion of the shaft of a humerus of an Albatros, I submitted it to examination in the manner pursued with the Pterodactyl bones. I found that the bone-cells were nearly analogous in their proportions to those of the generality of mammals, but somewhat more numerous within the same amount of space, and like the mammalian cells, the canaliculi radiating from them were very much finer and more numerous than those radiating from the reptilian bone-cells, either of the Pterodactylus, or of the common frog or boa-constrictor. The average measurement of five of the bone-cells of the Albatros, represented by fig. 3. Pl. I., was—length $\frac{1}{688}$ inch, greatest diameter $\frac{1}{4274}$ inch; while those from Lord Enniskillen's specimen were—length $\frac{1}{515}$ inch, greatest diameter $\frac{1}{6173}$ inch; thus exhibiting an essential difference in their size and proportions as well as in the number contained within the same amount of space and in the number and proportions of the canaliculi radiating from the cells.

These differences in structure and proportion I found to prevail equally between the bone-cells of the common frog, the boa-constrictor, *Palæophis Toliapicus*, and other recent and fossil reptiles, and those of the bones of the domestic goose, duck, fowls, and several other birds which I examined for the purposes of comparison; and that the latter were in every respect in accordance with those of the Albatros, while the bone-cells of the former exhibited the same small diameter and great elongation as well as the other peculiarities which characterized the bone-cells from the jaw of the Pterodactyl and from the large bone from the collection of the Earl of Enniskillen.

In the same paper by Prof. Owen on the supposed Ornitholites from the chalk, there is a second bone which is described as the "distal extremity of the tibia of probably the same bird," and is represented in the Plate by fig. 2. I did not receive any fragments of this bone for examination; but another specimen of the like description of bone, from I believe the same chalk-pit near Maidstone, has been obtained by Mr. Toulmin Smith, who has kindly allowed me to examine and figure it in illustration of this paper. It has been seen and compared with the figured specimen by Prof. Owen, and I am informed that he considers it as the same description of bone as the one represented by fig. 2 in his paper in the Transactions of the Geological Society.

On examining some small fragments of this bone taken from the broken end of the shaft at the point the farthest removed from the head of the bone, with a power of 500 linear, I found the bone-cells, which are represented at fig. 5. Pl. II., to correspond precisely in all their characters with those from the jaw of the Pterodactyl. The average measurement of five of them, represented at fig. 5. Pl. II., was —length $\frac{1}{519}$ inch, greatest diameter $\frac{1}{5822}$ inch. I have therefore no hesitation in considering this specimen, as well as the long bone from the collection of the Earl of Enniskillen, as truly reptilian, and not as the remains of a bird.

In my former paper on the *Pterodactylus giganteus*, I stated that from a comparison with the figures of Pterodactylus by Goldfuss, I believed that the bone represented by fig. 6 in the illustrations to that paper was an ulna, but unfortunately both that bone and the one in the possession of the Earl of Enniskillen were so imperfect towards their extremities that it was exceedingly difficult to decide that point with any degree of certainty. Fortunately the two fine specimens from the rich collection of Mrs. Smith of Tunbridge Wells, represented by fig. 1. Pl. II., in a great measure justify this conclusion, and in the bone *a*, which is apparently the corresponding bone to the one represented by fig. 1 in Prof. Owen's paper, the head is very nearly in a perfect state of preservation. It presents a simple cupped extremity, as represented by fig. 2, while the extremity of the second bone *b* has suffered so much as to render its form quite indistinct. The animal to which they belonged must have been of enormous dimensions, for there is a further portion of the shaft of the bone *b* imbedded on the mass of chalk, which makes the whole length of the specimen 9½ inches, and the extremity of this part of the shaft does not exhibit any indication of its being near to the opposite end of the bone. There are also two other similar bones imbedded side by side in the collection of Mr. Charles of Maidstone, of still greater dimensions than those from the cabinet of Mrs. Smith. The head of one of these bones, corresponding with fig. 1 *a*, Pl. II. of Mrs. Smith's pair, measures $2\frac{1}{2}$ inches at its greatest diameter, while that of Mrs. Smith's specimen is $1\frac{1}{2}$ inch only. The animal to which such bones belonged could therefore have scarcely measured less than fifteen or sixteen feet from tip to tip of its expanded wings.

In the bone belonging to Mr. Toulmin Smith, represented by fig. 4. Pl. II., there is an orifice at *a* which has every appearance of being a pneumatic foramen. I am not aware that such orifices have hitherto been observed in the bones of Pterodactyls, but I can see no good reason why they should not have been furnished with them. The whole structure of the skeleton, and the extreme thinness of the bones, proclaim them as eminently volant; and as we find among birds that those which are destined to be most continuously upon the wing are furnished to the greatest extent with pneumatic cavities in their bony skeleton, so we may reasonably expect that in a reptile so especially constructed for flight, nature would not fail in contributing organs so essential to the end of their peculiar construction.

The bone described and figured No. 2 by Prof. Owen was in a somewhat mutilated condition, but the head of Mr. Toulmin Smith's specimen is in a remarkably fine state of preservation. From a comparison of this specimen with the plate of *Pterodactylus Macronyx*, described by Dr. Buckland in the Geological Transactions, Feb. 6, 1829, there is every appearance that it is the corresponding bone to that indicated by N′, or the left femur of the animal. I have also compared it with the original in the British Museum, but unfortunately that valuable specimen has suffered so much dilapidation since the plate was engraved that the representation affords a much better reference than the original.

The satisfactory nature of the results of the examinations which I have detailed, led me to believe that I should be rendering an acceptable service to science if I were to extend my researches to other disputed bones beside those from the chalk. I therefore applied to Dr. Buckland for permission to examine in like manner the jaws from the Stonesfield slate, in the hope that their structural peculiarities would assist in deciding the long-mooted question of their mammalian or reptilian nature. To this request Dr. Buckland responded in the readiest and most liberal manner, by removing in my presence small portions of each of these rare and valuable specimens represented by figs. 1 and 3. Pl. 5. vol. vi. Transactions of the Geological Society, 2nd Series. Upon immersing these minute fragments in Canada balsam and examining them by transmitted light with a power of 500 linear, I found the bone-cells were to be seen in the most beautiful manner, and especially those from the jaw represented by fig. 3 in the Plate of the Transactions of the Geological Society. The small fragment removed had fortunately splintered off in the direction of the course of the fibres of the bone, so that the length and proportions of the cells were rendered in the most satisfactory manner, as represented by fig. 6. Pl. I. Upon accurately measuring five of these, their average gave the following dimensions: length $\frac{1}{980}$, greatest diameter $\frac{1}{4032}$. The minute canaliculi were apparent in great abundance, radiating from the cells and presenting all the characters of those of well-known and characteristic mammals. The fragments from the second specimen of *Thylacotherium Prevostii*, represented by fig. 1. Pl. 5. vol. vi. 2nd Series of Transactions of the Geological Society, were not so fortunate in their direction, having splintered off rather obliquely to the axis of the bone, but in other respects they presented precisely the same characters as those from the first specimen. They are represented at fig. 5. Pl. I. Their average measurement was—length $\frac{1}{1214}$ inch, greatest diameter $\frac{1}{4673}$ inch. The canaliculi were equally abundant and quite as much attenuated as in the first specimen, and the abundance of the cells within a given space was in perfect accordance with the other mammalian characters; the difference in their length from the first specimen being accounted for by the oblique position in which they were presented to the eye.

Mr. Morris also kindly furnished me with a third specimen of a small jaw from the Stonesfield slate, which appears to me to be *Thylacotherium Broderipii*, and a similar examination of fragments from this produced precisely the same results as those recorded of the jaws in the possession of Dr. Buckland.

The structural peculiarities therefore appear to place the mammalian character of these long-disputed remains beyond a reasonable doubt, and to confirm the opinion so laboriously and ably worked out by Prof. Owen, of their having belonged to true mammals, and in no respect being allied to the Reptilia.

With the jaw from the Stonesfield slate my friend Mr. Morris sent me a small vertebra from the same formation, which is represented by fig. 6. Pl. II. Small fragments from this bone afforded similar results to those from the jaws. The bone-cells represented at fig. 4. Pl. I. present all the proportions and appearance of those of mammalian remains, and none of the characteristics of the reptilian tribe. The average dimensions of five of these cells were—length $\frac{1}{1087}$ inch, greatest diameter $\frac{1}{4500}$ inch.

The Chalk and the Stonesfield slate are not the only strata that have produced bones which have been the subject of dispute in the geological world. Dr. Mantell, on the 10th of June 1835, read a paper before the Geological Society "On the Bones of Birds discovered in the Strata of Tilgate Forest in Sussex." Doubts had existed previously to the publication of this memoir whether the bones which are the subject of it were not those of Pterodactyls; but on the high authorities, in the first place of Cuvier, and secondly of Professor Owen, they were decided to belong to extinct species of wading birds. Subsequently the latter great comparative anatomist, it appears, mistrusted this decision, and having re-examined the bones which are now deposited in the British Museum, and numbered 453 and 2353, he published the result of this fresh examination in a paper read before the Geological Society on the 17th of December 1845, entitled "On the supposed Fossil Bones of Birds from the Wealden." In this communication Professor Owen enters at length into his reasons for changing his opinion respecting these specimens, and ultimately decides upon designating them as remains of Pterodactyls; that is to say, those represented by figures 1*a*, 1*b* and 3 of Plate 13, illustrating Dr. Mantell's paper, and now numbered 453 in the British Museum. Of the bone represented by figure 6 in Dr. Mantell's paper, there is nothing said in this communication further than a general reference to the nature of the bones treated of in the concluding sentence of the paper, which is thus expressed:—"We have no satisfactory evidence, however, of the existence of birds in the Wealden."

On the 7th of January 1846 Dr. Mantell read a paper to the Geological Society, entitled "On the Fossil Remains of Birds in the Wealden Strata of the South of England," in which he questions the propriety of the conclusions arrived at by Professor Owen; but as neither of the authors of these papers appeared to have examined microscopically the structure of the bones in question, I resolved to endeavour to remedy this omission.

Upon submitting some minute fragments from the fractured end of the shaft of the bone represented by figures 1*a* and 1*b* of Dr. Mantell's paper, and figures 1 and 2 of Professor Owen's communication, published in No. 6 of the Quarterly Journal of the Geological Society, I found the bone-cells, as represented at fig. 8. Pl. I., to coincide in every respect with those of the Pterodactyl remains before described in this communication. An average of five of them gave the following dimensions:—length $\frac{1}{787}$ inch; greatest diameter $\frac{1}{7812}$ inch; and the number, proportion and mode of disposition of the cells, and of the canaliculi radiating from them, were precisely in accordance with those of the recent as well as of the fossil reptilia. We may therefore justly infer that the latter conclusion of Professor Owen regarding this bone is the correct one, and that the specimen is truly Pterodactylian. But not so with regard to the larger bone represented by figure 6 in Dr. Mantell's paper in the Transactions of the Geological Society of June 10, 1835. Fragments from about the middle of the shaft of this bone exhibited the characteristic cells in a very distinct and satisfactory manner, but, unlike the former, they agreed in every respect with those of birds as represented at fig. 9. Pl. I. An average of five afforded the following measurements:—length $\frac{1}{855}$ inch; greatest diameter $\frac{1}{4505}$ inch. The proportional characters of the bone-cells, and the bird-like build of the bone itself, leaves therefore little reasonable doubt of its being truly the remains of a member of the class Aves.

I have examined many other specimens of bones from the Wealden and the Stonesfield slate, as well as from the Chalk, and in every instance the class to which they belonged might, I am of opinion, be readily and correctly determined; but as the specimens I allude to have not been made especial subjects of doubt or discussion, I shall abstain from increasing the length of this communication by describing them. There is one case only to which I shall allude on the present occasion, and that is a specimen described and partly figured in page 22 of the first part of the London Geological Journal as "a reptile or fish" from the chalk of Kent. The possessor of this valuable fossil, Mr. Toulmin Smith, has kindly furnished me with a small fragment of the jaw, which exhibits very distinctly one of the peculiar modifications of the bone-cells which characterize fishes, and is represented by fig. 7. Pl. I. This modification of the bone-cells is perhaps the nearest form among fishes to those of the reptilia. The normal form in fishes is an angular or nearly square cell, with large canals radiating from it in various directions. From these there is a transition of form until they assume the appearance represented by fig. 7, and in some cases the large canals radiating from this form of cell unite, and the whole then forms a plexus of canals of nearly equal diameter.

I cannot conclude this paper without expressing my thanks to my friend Mr. John Quekett for the very liberal manner in which he communicated to me the results of his own laborious and valuable researches on the structure of bone, which were subsequently communicated to the Microscopical Society in a paper read the 18th of March 1846, and which will, I feel convinced, prove a most valuable means of deciding disputed relations of obscure and difficult tribes of recent animals, as well as of pointing out at once to us the true relation of such geological remains of the animal kingdom as it might be otherwise exceedingly difficult, or perhaps impossible, from their dilapidated condition, to refer to their true position among animals.

Average length and greatest diameter of five Bone-cells, from each of the specimens treated of in the above Paper.

Name of Animal.	Length.	Diameter.	Proportion.
	inch.	inch.	
Human	1–805	1–3261	1 to 4
Albatros (Pl. I. fig. 3)	1–688	1–4274	1 to $6\frac{1}{4}$
Pterodactyle Jaw (Pl. I. fig. 1)	1–552	1–6024	1 to 11
Lord Enniskillen's specimen (Pl. I. fig. 2)	1–515	1–6173	1 to 12
Mr. T. Smith's (Pl. II. fig. 5)	1–519	1–5882	1 to $11\frac{1}{4}$
Mrs. Smith's (Pl. II. fig. 3)	1–493	1–5814	1 to $11\frac{3}{4}$
Common Frog	1–392	1–4629	1 to $11\frac{3}{4}$
Boa Constrictor	1–561	1–6097	1 to 11
Thylacotherium Prevostii (Pl. I. fig. 6)	1–980	1–4032	1 to $4\frac{1}{8}$
Vertebra from Stonesfield (Pl. I. fig. 4)	1–1087	1–4500	1 to $4\frac{1}{8}$
Bone from Wealden, No. 453 B.M. (Pl. I. fig. 8)	1–787	1–7812	1 to 10
Do. Do. No. 2353 B.M. (Pl. I. fig. 9)	1–855	1–4505	1 to $5\frac{1}{4}$

DESCRIPTION OF PLATE I.

Fig. 1. A group of bone-cells from the jaw of *Pterodactylus giganteus*.

2. Bone-cells from the specimen represented by fig. 1. Pl. 39. vol. vi. 2nd Series Trans. Geol. Soc., in the possession of the Earl of Enniskillen.

3. Bone-cells from a femur of recent Albatros.

4. Bone-cells of vertebra from Stonesfield slate.

5. Bone-cells of jaw of *Thylacotherium Prevostii*, fig. 1. Pl. 5. vol. vi. Trans. Geol. Soc. 2nd Series.

6. Bone-cells from *Thylacotherium Prevostii*, fig. 3. Pl. 5. vol. vi. Trans. Geol. Soc. 2nd Series.

7. Bone-cells from Mr. Toulmin Smith's fossil fish from the Chalk, figured in the London Geological Journal, vol. i. page 22.

Fig. 8. Bone-cells from a Reptile from the Wealden, described as Bird, fig. 1. Pl. 13. vol. v. Geol. Trans. 2nd Series.
9. Bone-cells from a Bird from the Wealden, fig. 6. Pl. 13. vol. v. Trans. Geol. Soc. 2nd Series.

DESCRIPTION OF PLATE II.

Fig. 1. Radius and ulna of *Pterodactylus giganteus*, in the cabinet of Mrs. Smith of Tunbridge Wells.
2. Head of one of the same bones (*a*), fig. 1.
3. Bone-cells from the bone (*b*), fig. 1.
4. Part of a bone, in the possession of Mr. Toulmin Smith, similar to that described by Professor Owen as from a Bird, and figured in Pl. 39. vol. vi. fig. 2. Trans. Geol. Soc. 2nd Series.
5. Bone-cells from the specimen represented by No. 4.
6. Vertebra of a Mammal from Stonesfield slate, in possession of Mr. Morris.

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2. *On the Geology of some parts of the Alpine and Mediterranean regions of* South-Eastern Europe. By Ami Boué, M.D., F.G.S. &c.

Dr. Boué in this communication states his views in reference to the classification of the nummulitic rocks and the connected strata in various places round the shores of the Mediterranean. He points out especially the great extent of these deposits in European Turkey, as shown in a corrected copy of his Geological Map of that country which he has forwarded to the Society. In this map he also indicates the occurrence of Silurian formations in Carinthia, Styria, and some of the neighbouring regions.

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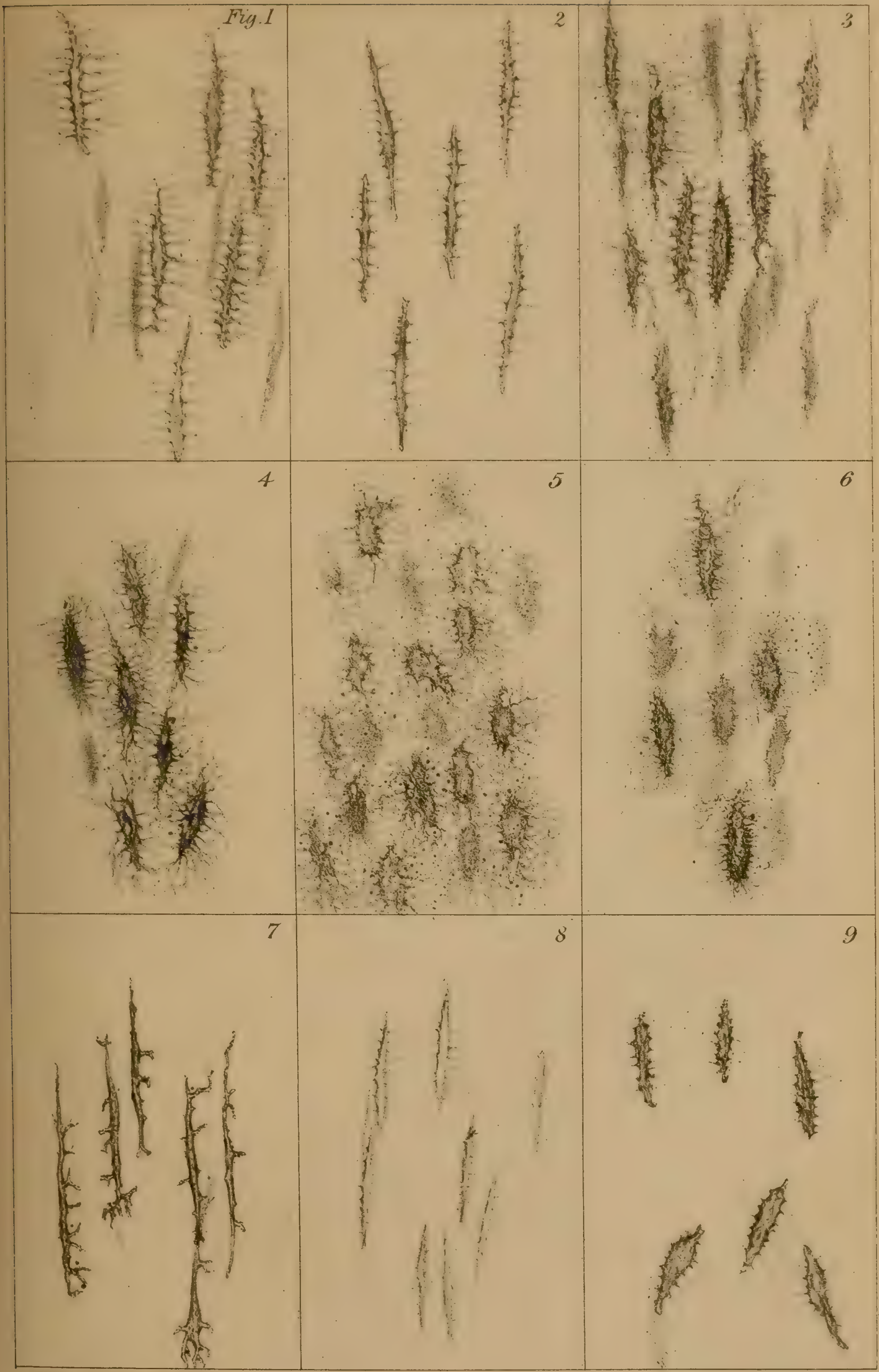
3. *On the relative Age and Position of the so-called Nummulite Limestone of* Alabama. By C. Lyell, F.R.S. and V.P.G.S.

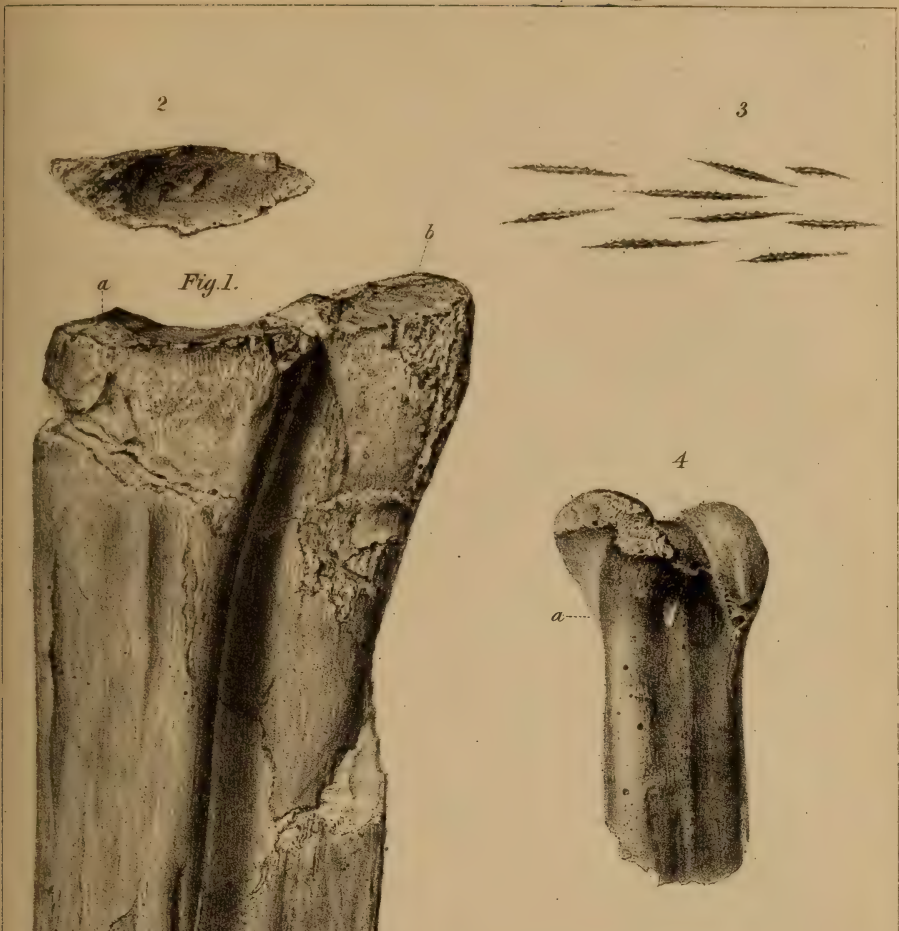
In a former paper published in the Quarterly Journal of the Geological Society of London (vol. ii. p. 405, May 1846), I stated that the limestone containing abundantly the *Nummulites Mantelli*, Morton, which occurs near Suggesville, Clarksville, and other places between the rivers Alabama and Tombecbee, in the State of Alabama, was a member of the Eocene tertiary group, and that so far from constituting any part of the cretaceous formation, as had formerly been imagined, it holds in reality a place high up in the Eocene series of the South. In the same memoir I gave a section extending from Claiborne through Suggesville and Macon to the west of Clarksville, Alabama, in which the position of the so-called nummulitic limestone was explained. It was stated to be newer than all the beds of the well-known Claiborne Bluff, and I mentioned that "the bones of the gigantic cetacean called Zeuglodon by Owen were everywhere found in Clarke County, in a limestone below the level of the nummulitic rock and above the beds which contain the greater number of perfectly preserved eocene shells, such as *Cardita planicosta* and others."



Lens Aldous del et zinc

Day & Son lith^rs to the Queen

M^r. BOWERBANK ON BONE CELLS, P. 2. &c.



Lens Aldous del et zinc. Day & Son lithrs to the Queen

Mr. BOWERBANK ON BONE CELLS. P. 2 &c.

(Quart. Journ. Geol. Soc. vol. ii. p. 409, May 1846.) At the time that my first communication was written, I had not finished my explorings in Alabama, nor visited St. Stephen's Bluff on the Tombecbee river, where I afterwards obtained additional proofs of the order of superposition above indicated; nor had I then compared the Eocene strata at Vicksburg with those of Jackson in the State of Mississippi, which throw light on the same question of relative position. Before adverting to these last-mentioned localities, I will first offer a few observations on the country between Claiborne and Clarksville, for I understand that doubts have been lately thrown on the correctness of the views which I have expressed relatively to the true age and place in the series to be assigned to the "rotten limestone of Alabama," and the associated rock in which the fossil first named *Nummulites Mantelli* by Morton abounds*.

Before restating the grounds of my former opinion and corroborating them with fresh proofs, it may be well to say something of the nature and zoological relations of the *discoid* bodies from Alabama which have passed under the name of Nummulites, and which constitute the chief part in bulk of considerable masses of limestone in certain districts. Having obtained many specimens both from Alabama and from Vicksburg in Mississippi, in which the structure of this fossil was beautifully preserved, I first showed them to Prof. E. Forbes, who at once pronounced them not to be Nummulites, but related to some living plants or zoophytes which Mr. Jukes had brought from Australia. Mr. Lonsdale, who examined them immediately afterwards, said, "They are certainly not Nummulites, but allied to some of the bodies usually termed Orbitolites, and are, I believe, *corals*, in the usual acceptation of that word." Afterwards Mr. Forbes having compared the American fossil with the living species from Australia, and satisfied himself of its near affinity, sent me the following note, dated June 14th, 1847:—

"*On the so-called* NUMMULITES MANTELLI.

"The American '*Nummulites Mantelli*,' judging from Mr. Lyell's specimen, is not a Nummulite, nor is it a foraminiferous shell. It is a species of *Orbitolites*, and consequently a Zoophyte (probably Ascidian). The genus *Orbitolites* was established by Lamarck for the reception of a fossil of the Paris basin, the *Orbitolites complanata*, which may be regarded as the type. Other tertiary species and a Maestricht fossil were associated by Lamarck in the same genus, in which he also placed the '*Orbitolites marginalis*' of the European seas. Respecting the true position of the last-named body, however, there is considerable doubt.

"The *Orbitolites complanata* is very nearly allied to the American

* Sir R. Murchison announced to the Geological Society of London at their meeting May 26th, 1847, that he had just received a letter from M. Agassiz, in which he stated "that M. Desor had clearly shown that the rotten limestone of Alabama was not cretaceous, as Morton and Conrad had supposed, nor Eocene, as Lyell had considered it, but was of the age of the *Terrain Nummulitique* of Biaritz."

fossil. The *Orbitolites elliptica* of Michelin, from near Nice, and that author's *Orbitolites Pratti*, are also closely allied species.

"In British strata, species of *Orbitolites* are recorded from the greensand of Milber Down, from the chalk of Lewes and from the coralline crag of Sutton. It is possible however that bodies belonging to distinct genera have been placed together in our lists.

"Mr. Jukes has collected at Swan River in Australia numerous disciform bodies, apparently Ascidian Zoophytes, which occur there in great numbers upon marine plants resembling Zostera, and when dead are found in great abundance in mud, procured by the dredge from various depths under seventeen fathoms. These discs are usually about half an inch in diameter and are composed of minute cells. They appear to me to belong to the same generic group with the tertiary Orbitolites, and such appears also to have been the opinion of Defrance, for we can scarcely doubt that these are the bodies alluded to by him (in the following passage) as living in the seas of New Holland: 'Cette espèce (i. e. *Orbitolites complanata* of the Paris basin) a les plus grands rapports avec celle que l'on trouve . . . . . . vivant dans les mers de la Nouvelle Hollande.' (Dict. des Sc. Nat. t. 36, Art. Orbitolite.) Marginopora of Quoy and Gaimard seems to be a similar if not identical body.

"As the subject stands at present, then, we have no right to infer from the presence of an Orbitolite, however abundant, that the stratum in which it occurs belongs to one period more than another, between the commencement of the cretaceous epoch and our own times*."

A few days after I had received this communication from Mr. Forbes, a letter reached me from M. D'Orbigny, of which I subjoin a translation:—

"Dear Sir, "Paris, 18th June, 1847.

"I have been long acquainted with the fossil body which you forwarded to me, and at this moment I am printing, in an elementary work, all the mistakes concerning it; it is, in fact, of all genera that perhaps which has been most often misunderstood, and I should call it the greatest culprit in geology. It is a genus nearly allied to *Orbitolina*, and which I have named, in consequence of this analogy, *Orbitoides*. It has always been taken for a nummulite, though it differs from it by the most marked characters. I have known many species, such as the *O. media, papyracea*, and that which you have forwarded to me, and which I had designated by the name of *Americana*. The *Orbitoides* are found in the cretaceous and tertiary formations, the *Nummulina* in the tertiary only. Such at least is the result of my numerous investigations on this subject. The species that you have forwarded to me had been sent me from North America, with a great number of tertiary and cretaceous shells; it came to me without any information respecting it, and I am anxious to know where you found it. "Yours, &c.,

"*To C. Lyell, Esq.*" "Alcide D'Orbigny."

* The *Plagiostoma dumosum* of Morton is decidedly a Spondylus.

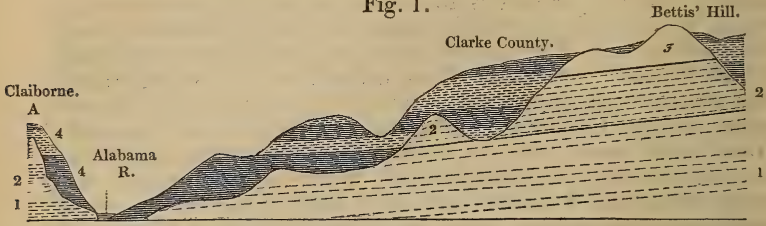
The American fossil therefore now under consideration will henceforth be called *Orbitoides Mantelli*, retaining the specific name first given to it by Dr. Morton.

In my former paper I endeavoured to point out the cause of the obscurity in which the true age of the nummulitic or orbitoidal limestone of Alabama had been involved, it having been considered sometimes as an upper cretaceous group, and at others as intermediate between the cretaceous and the Eocene formations. The accompanying section from Claiborne Bluff to Bettis' Hill near Macon in Alabama may serve to explain the relations which I found to exist between the white limestone group of the south, comprising the successive formations 1. 2. 3, and the overlying group 4, which is perhaps of equal thickness, but which, from the absence of calcareous matter, rarely yields organic remains, and those consisting only of silicified casts of shells and corals. This upper formation (4) is composed of variously coloured red, pink and white sands, and yellow ochreous coloured sands, white quartzose gravel and sand with beds of chert and flint, blood-red and pink clays, and clays of white kaolin or porcelain earth, all horizontally stratified. I could find no fossils in those in Alabama, and only conjectured that they are of Eocene date from the analogy of Georgia, where a deposit of the like aspect and nature and occupying a similar position contains Eocene shells and corals. I formerly explained in 1841–42 the relative position of the upper clays and sands with flint (the Burr-stone formation of Georgia) to the underlying white limestone and marl of the State of South Carolina, in a diagram published in the Journal of the Geol. Soc. vol. i. p. 438, where the newer group is represented as resting on the eocene limestone of Jacksonborough near the Savannah river. It appeared in that case as in Alabama, that the older calcareous strata of limestone and marl had undergone great denudation, and had acquired a very uneven surface, having been shaped into hills and valleys before the incumbent clays and sands were thrown down.

At the bluff on the Alabama river at Claiborne, where so rich a harvest of fossils has been obtained, especially in the beds of No. 2, we see at one spot called "The Old Landing," that nearly the whole precipice in its lower 160 feet, exposes to view the calcareous beds 1. 2. covered with about 20 feet of red clay and sand, whereas at the distance of less than a mile from this spot, the upper formation No. 4 occupies more than 100 feet of the face of the same cliff from its summit, while at the base the lower members of the calcareous series crop out from beneath the horizontal and incumbent beds of sand and clay. This twofold composition of the mass of strata in the bluff at Claiborne is expressed at A in the annexed woodcut, and I verified a similar mode of juxtaposition of the two series of beds in several places in the interior of Clarke County, where the limestone often ends abruptly, and is succeeded sometimes in the same ridge or hill by the newer beds (No. 4), the latter having evidently filled up the inequalities of a previously denuded deposit, after which the whole was again denuded.

I have suppressed several details and repetitions of the same phænomena in the country represented in the annexed diagram, and have

Fig. 1.



1. Sand, marl, &c. with numerous fossils.
2. White or rotten limestone with Zeuglodon.
3. Orbitoidal or so-called nummulitic limestone.
} Eocene.
4. Overlying formation of sand and clay (Eocene ?).

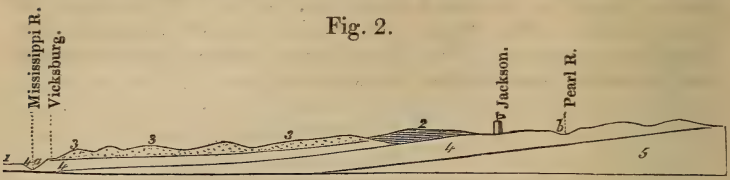
been obliged to give a considerable inclination to the strata, because in the distance of twelve or more miles between Claiborne and Bettis' Hill, although the dip is not perceptible to the eye, the same beds are at the latter place more than twice as high above the Alabama river as at Claiborne. The lowest mass, above 100 feet thick, No. 1, which constitutes the lowest visible member of the Eocene series, comprises marly beds with *Ostrea sellæformis,* seen at the base of the cliff at Claiborne, and an argillaceous stratum with impressions of leaves, and sandy beds with marine shells, among which are found *Cardita alta, C. planicosta, C. parva, Crassatella prætexta, Cytherea æquorea, Oliva Alabamensis, Pleurotoma* (several species), *Solarium canaliculatum, Crepidula lyrata, Endopachys alatum,* Lonsdale, and 200 other species. No. 2, about 50 feet thick, is the white or rotten limestone, which is sometimes soft and argillaceous, but in parts very compact and calcareous, and contains *Flabellum cuneiforme,* Lonsdale, *Scutella Lyelli,* Conrad, *Lunulites,* and several shells, some peculiar, others common, to the formation below. Mr. Conrad has already described this section at Claiborne, and I hope soon to give a fuller notice of it with the observations which I made there in 1846. Of the limestone No. 2, only the lower portion is seen here, for it is cut off at the top of the bluff by the newer series of beds No. 4; but in many parts of Clarke County, as near Bettis' Hill and near Clarksville, the same No. 2 is found more largely developed. It is characterized among other organic remains by a large Nautilus allied to *N. ziczac,* and by the gigantic Zeuglodon of Owen. Near the junction of the mass with the incumbent orbitoidal limestone we find *Spondylus dumosus* (*Plagiostoma dumosum,* Morton), *Pecten Poulsoni, Pecten perplanus,* and *Ostrea cretacea* in abundance.

No. 3 is a pure limestone, sometimes hard and full of *Orbitoides Mantelli.* At Bettis' Hill the formation is about 70 feet thick, and the upper beds are composed of a cream-coloured soft stone which hardens on exposure, is not divided by lines of stratification, and is for the most part made up of orbitoides of various sizes with occasionally a lunulite and other small corals, and specimens of *Pecten Poulsoni.* The origin of this limestone, like that of our white chalk, the softer varieties of which it much resembles, is I believe due to the decomposition of corals, and like our chalk downs, the surface of the country where it prevails is sometimes marked by the absence of wood, by which all the other deposits in this part of Alabama are continuously covered. The spots where few or no trees appear are called "bald Prairies," but in some places, and at Bettis' Hill among others, the orbitolite rock produces what is termed a "cedar knowl," the red cedar, *Juniperus virginiana*, having exclusive possession of the ground. I was much struck with the resemblance of such calcareous tracts, covered with the tree above-mentioned, to certain chalk regions in the south of England, where the only wood which grows on the white rock consists of yew-trees accompanied here and there by shrubs of juniper.

At St. Stephen's, on the left bank of the Tombecbee river in Alabama, a similar limestone with orbitoides forms a perpendicular bluff. The water of the river at the time of my visit was too high to enable me to collect fossils from the beds at the base of the cliff, but I was afterwards furnished with them through the kindness of Prof. Brumby of Tuscaloosa. They are imbedded in a ferruginous ochreous-coloured sand, and consist in part of shells common to Claiborne Bluff, such as *Terebra costata*, Conrad, *Cardita parva*, *Dentalium thalloides*, *Flabellum cuneiforme*, Lonsd., *Scutella Lyelli*, Con., and several more. I shall now conclude by adverting briefly to the result of a comparison which I made of the fossils contained in the eocene strata of Vicksburg on the left bank of the Mississippi river, the position of which is indicated at 4 *a* in the annexed woodcut, with those of other eocene beds forty-five miles farther inland or eastward, at Jackson in the same State (3 *b*). In the former of these at 4 *a*, the *Orbitoides Mantelli* abounds, together with *Pecten Poulsoni*, *Dentalium thalloides*, *Sigaretus arctatus*, Con., *Terebra costata*, Con., and a few others common to Claiborne, but the great bulk of the associated fossils do not agree specifically with those of Claiborne Bluff. I found these distinct species of Vicksburg obtained by me to be referable to the genera *Voluta*, *Conus*, *Terebra*, *Fusus*, *Murex*, *Cassis*, *Pleurotoma*, *Oliva*, *Solarium*, *Natica*, *Turritella*, *Corbula*, *Panopæa*, *Crassatella*, *Lucina*, *Venus*, *Cardium*, *Arca*, *Pinna*, *Pecten* and *Ostrea*, with several corals, the whole having a decidedly tertiary and eocene aspect. The genus *Pleurotoma* for example, which is represented by several species, is one of the forms most characteristic of tertiary as distinguished from secondary formations.

At Jackson, which as before stated is more than forty miles to the eastward, older eocene beds crop out near to the area occupied by cretaceous deposits, as at *b*, woodcut No. 2. Here, on the Pearl river, I found no specimens of *Orbitoides Mantelli*, although some are said to have been met with in the vicinity; but I observed that a larger proportion among the fossils were of species common to Claiborne Bluff than at Vicksburg. Among these may be mentioned *Cardita planicosta*, *Cardita rotunda*, *Cytherea æquorea*, *Natica* like one which I collected at Claiborne, *Flabellum cuneiforme*, Lonsd., and *Endopachys alatum*, Lonsd. (*Turbinolia Maclurii* of Lea); these I found in strata of yellow loam, sand and marl on the Pearl river and in the banks and beds of one of its tributaries. The other shells

Fig. 2.



Length of section 50 miles.

1. Mud of alluvial plain of Mississippi.
2. Superficial drift.
3. Freshwater loam with land shells, &c.
4. Eocene strata.
5. Cretaceous strata.

collected by me at the same place, several of them I believe identical with Claiborne species, belong to the genera *Voluta*, *Oliva*, *Terebra*, *Rostellaria*, *Murex*, *Umbrella*, *Natica*, *Turritella*, *Crepidula*, *Dentalium*, *Corbula*, *Mactra*, *Lucina*, *Cytherea*, *Cardium*, *Cardita*, *Pectunculus*, *Nucula*, *Pinna*, *Pecten* and *Ostrea*. With these are many corals, teeth of fish, &c. I was shown the remains of Zeuglodon procured from the neighbourhood at a place five miles south of Jackson on the right bank of the Pearl river, but as I did not visit the locality, I cannot point out the precise place in the Eocene series in which it occurs. Some of the accompanying corals however were the same specifically as those occurring with the shells above-mentioned at Jackson, and one of my informants stated that this Zeuglodon bed was immediately under "the rotten limestone."

Nov. 5, 1847.—Since the above was read to the Geological Society, I have seen two papers on the Vicksburg deposits by Mr. Conrad, the first in Silliman's Amer. Journ. 2nd Ser. July 1846, No. 4, p. 124, the second in the same Journ. Sept. 1846, No. 5, p. 210, which I had previously overlooked. Mr. Conrad had not visited Jackson, Mississippi, but his results in regard to the fossils of Vicksburg, of which he evidently obtained a larger collection than mine, agree in the main with my own. I cannot however reconcile some of his statements in regard to the want of identity of species at Claiborne and Vicksburg, and suspect some errors of the press and of the dates of his two memoirs, no reference being made from the one to the other. In the first paper, p. 124, he affirms that not one species is common to Vicksburg and Alabama, yet he mentions *Pecten Poulsoni*, a Claiborne shell, as abundant at Vicksburg with a Nummulite. In the second paper, p. 211, he says that ten species will be found on comparison common to Vicksburg and Claiborne, Alabama.

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4. A letter from Grant Dalton, Esq., to the President, was then read, in which he mentioned that he had obtained possession of a considerable part of the fossil tusk of a Mammoth brought up in the

trawl of an Ostend fishing-smack, about ten or fifteen miles off the island of Texel. The tusk, when fished up, was entire, and measured about 11 feet long, but was broken to pieces by the fishermen. The part obtained by Mr. Dalton is 4½ feet in length, and measures about 8 inches in diameter. When found the enamel was hard and sound, but the whole of the interior in a soft state.

June 16, 1847.

Sir James Ramsey, Bart., of Banff, Forfarshire, William B. Carpenter, M.D., Charles Walker, Esq., and J. H. Norton, M.D., were elected Fellows of the Society.

The following communications were then read :—

1. *A Letter to the* President *from* Leonard Horner, Esq., F.R.S. L. & E., *dated Bonn, June* 1847.

In this letter Mr. Horner mentions that he had been informed by M. von Dechen, that some well-preserved remains of Saurian reptiles had recently been discovered in the Saarbruck coal-field, celebrated for containing several species of fossil fish. Mr. Horner gives some details of the structure of these Saurians so far as they were then known, and states that the specimens had been entrusted to Prof. Goldfuss for description.

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2. *On the Fossil remains of* Mammalia *referable to the genus* Palæotherium, *and to two genera,* Paloplotherium *and* Dichodon, *hitherto undefined : from the* Eocene Sand *at* Hordle, Hampshire. By Professor Owen, F.R.S., F.G.S.

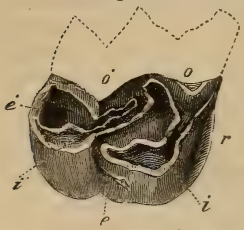
Part I.—*Description of Teeth of a Palæothere, from Eocene sand, Hordle, resembling those of the species called* Palæotherium medium, *figured in* Cuvier's '*Ossemens Fossiles,*' t. iii. pl. 42. fig. 1.*

To Alexander Pytts Falconer, Esq. of Beacon, Christchurch, Hants, and to his brother Thomas Falconer, Esq. of Wootton in the same county, British Palæontology is much indebted for some new and highly interesting fossil remains, which they have obtained at considerable trouble and expense from the Eocene freshwater formation in the cliffs at Hordle, Hants. I beg to express my sincere acknowledgments to those gentlemen for their liberal transmission to me, from time to time, of their valuable acquisitions from this interesting stratum, of which I purpose on the present occasion to describe the specimens of jaws and teeth of the herbivorous or hoofed Mammalia.

* The quarto edition of 1822 is cited throughout this paper.

Amongst the earliest examples received of this order were molar teeth of a true *Palæotherium*.

Fig. 1.



Upper true molar.
Palæotherium medium ?

Fig. 2.

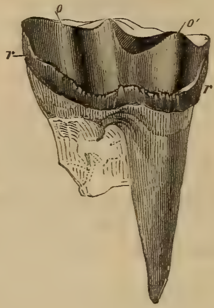
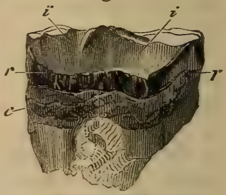


Fig. 3.



Lower molar.
Palæotherium medium ?

A single fragment of an upper molar tooth (fig. 1), with the outer side of the crown broken away at the enamel-line, like the letter W, but including the inner half with the oblique peninsular fold (*e*) and island (*e'*) of enamel, and the two parallel oblique tracts of dentine, *i'*, *i*, presents the typical characters of the upper molars of the genus *Palæotherium*: it was the first evidence of that genus which I had seen from a formation of what, in relation to the Isle of Wight, may be termed continental England. The tooth, when entire, has agreed with the first of the three true molars in fig. 14. pl. 47. and fig. 1. pl. 56. of the 'Ossemens Fossiles,' tom. iii. The ridge *r* at the fore part of the base of the tooth, and the short ridge *e* closing the entry to the oblique fold or valley, are present, as in the true Palæotheres. The tooth is smaller than the upper molar represented in fig. 3. pl. 4. tom. cit., and can only be referred to the *Palæotherium medium* as represented in the other plates above-cited, from the immortal work of Cuvier. Some lower molar teeth (figs. 2 & 3) also exhibited all the typical characters of that part of the genus *Palæotherium*: viz. the two semicylindrical lobes, *o*, *o*, the single point at the reunion of their contiguous angles to form the middle lobe on the inner side of the crown (*i*), and the basal ridge (*r*): this is divided into an external and an internal portion, both of which send their anterior and posterior extremities obliquely upwards to corresponding angles of the two lobes. The crown is supported by two strong and long fangs grooved longitudinally on the sides turned towards each other, and with a thick coat of cement at their base, *c*. The tooth figured was much worn; it is but a millimeter less in antero-posterior extent than the penultimate molar of the *Palæotherium medium*, in the portion of lower jaw, fig. 2. pl. 42. of the 'Ossemens Fossiles,' t. iii. It is three millimeters shorter in the same dimension than the corresponding tooth in the lower jaw figured in pl. 40. fig. 1, t. cit., which is also referred by Cuvier to the *Pal. medium*.

Soon after receiving these, the first evidences of a proper English *Palæotherium*, Mr. Pytts Falconer transmitted to me from the same locality and deposit three portions of the lower jaw of the same species of *Palæotherium*; two of which formed part of the same ramus, the left, and contained three grinders together with the last characteristic three-lobed one (fig. 4, *m* 3), by which the Palæothere differs from the *Rhinoceros*, *Hyrax*, *Macrauchenia*, and other Pachyderms with the lower grinders in two semicylindrical lobes. The other teeth in this fragment were the second (*m* 2) and first (*m* 1) true molars and the last premolar (*p* 4). The antero-posterior extent of the series and of each individual tooth very nearly equalled those in the fig. 2. pl. 42. tom. cit., attributed by Cuvier to the *Palæotherium medium*; in which figure, however, the teeth are somewhat smaller than those in the entire jaw, fig. 1. pl. 40. tom. cit., also attributed by Cuvier to the *Pal. medium*.

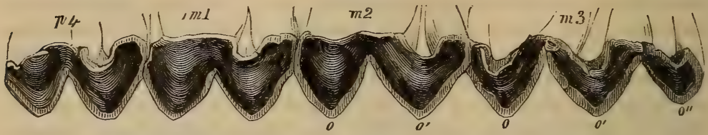
Thus the antero-posterior extent of the series of three true molars in the Hordle Palæothere (fig. 4) is 3 inches 1 line (7 centimeters 11 millimeters), and in fig. 2. pl. 42. tom. cit. it is 3 inches 3 lines (8 centimeters 3 millimeters); whilst in fig. 1. pl. 40. tom. cit. the antero-posterior extent of the corresponding teeth is 3 inches 5 lines (8 centimeters 6 millimeters). The lobes of the molars of the Hordle specimen are also triangular, rather than semicylindrical: the outer convexity, instead of being smoothly rounded presenting a well-marked angle, notwithstanding they are worn nearer to the base than are the teeth attributed to *Pal. medium* in the Cuvierian figures above cited.

The direct view of the grinding surface by which the difference of the Hordle molar teeth in the shape of their lobes could be best tested is not given by Cuvier in regard to the *Palæotherium medium*; those of the *Pal. crassum* figured in pl. 39. fig. 2. most accurately coincide with the semicylindrical form ascribed to the lobes of the lower molars of the Palæothere in the text of the 'Ossemens Fossiles,' and differ in a marked manner from the angular form of the same lobes in the Hordle Palæothere, as well as by their smaller size. Of the accuracy of the Cuvierian figure we have the opportunity of judging by the beautiful casts of the skull of the *Palæotherium crassum* in the British Museum and other collections in London.

I am led, therefore, to suspect that the species of Palæothere represented by the fragments of lower jaw and teeth from Hordle may be distinct from the *Palæotherium medium* represented by the lower jaw from Montmartre, figured in pl. 40, and referred to at p. 67 of the 'Ossemens Fossiles,' tom. iii. as a typical example of that species.

The distinction of the Hordle specimen from the species represented by the portion of lower jaw (pl. 42. fig. 2) is more doubtful: this figure shows, as far as a side-view can, a more angular figure of the molars than in fig. 1. pl. 40. It shows also a smaller size of the molars, though these still slightly surpass those of the *Hordle Palæothere*. Fig. 2. pl. 42. shows a slight difference in the shape of the angle of the jaw as compared with fig. 1. pl. 40; it is however referred to the *Pal. medium* in the description of the plates in the posthumous 8vo edition of the 'Ossemens Fossiles;' and it may have belonged to a female of that species. I purpose, therefore, to register provisionally the Hordle fossils here described under the name of *Palæotherium medium.*

Fig. 4.

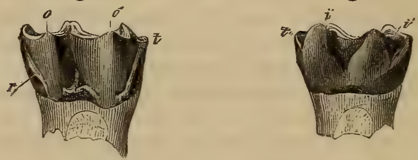


Grinding surface of lower molars. *Palæotherium medium ?*

PART II.—*Description of Lower Molar Teeth from Hordle, indicative of a distinct generic form in the* Palæotherioid *family.*

SOME fragments of inferior molar teeth of a smaller Palæotherioid, among which was an entire crown (figs. 5 & 6), proved most decidedly the former existence of a species of this family of Pachyderms in the Hordle deposits, distinct from any of those previously recorded by Cuvier or other authors.

Fig. 5. Fig. 6.



Lower molar. *Paloplotherium.*

The two semicylindrical lobes *o, o'*, were less angular than in the preceding species of true Palæothere from Hordle; but the basal ridge was absent from the inner side of the crown (fig. 6), and was reduced at the outer side (fig. 5, *r*) to a rising at the bottom of the median fissure, and to two terminal and very oblique ridges, the posterior of which ended by forming a distinct tubercle (*t*) behind the hinder semicylindrical lobe (*o'*).

These characters indicated something more than a distinct species of *Palæotherium.* But as other and more decisive characters of its generic distinction were afforded by more complete specimens of jaws and teeth of the same species from the same formation and locality, subsequently transmitted to me by the Marchioness of Hastings and Mr. Falconer, I shall proceed to the description of these specimens without further dwelling upon the earlier and more fragmentary evidences.

PART III.—*Description of the Lower Jaw with the deciduous and permanent Teeth of a new genus of Palæotherioid, for which the name of* Paloplotherium *is proposed.*

(Pl. III. figs. 3 and 4.)

AN almost entire lower jaw (Pl. III. figs. 3 & 4) obtained from Hordle Cliff, and kindly transmitted to me by Alex. Pytts Falconer, Esq., has an uninterrupted series of six entire grinding teeth on each side, separated by a vacant tract from the series of alveoli of the two canines and six incisor teeth ; which series describes two-thirds of a circle at the slightly expanded anterior extremity of the jaw : an interspace of scarcely two lines extent separates the canine on each side from the incisors. The molar teeth progressively increase in size from the first to the sixth : the last four have the crown composed of two crescentic or semicylindrical lobes corresponding with the type of those of the genera *Rhinoceros, Hyrax, Macrauchenia* and *Palæotherium* : the last (M 2), like the penultimate one, having only a small tubercle (*t*) at its back part, in the place of the third lobe characteristic of the last molar of the true Palæotheres.

The first molar (Pl. III. figs. 3 & 4, D 1) has a conical crown, convex externally, flat and slightly indented internally, with a basal ridge or cingulum, which, instead of completing the circle behind, bends upwards to near the summit of the cone : this tooth is implanted by two diverging fangs. The crown of the second molar (*ib.* D 2) also consists chiefly of one conical lobe with two indentations on its inner side ; the cingulum is interrupted at both the outer and inner sides of the base of the cone ; but its posterior part rises, or sends a strong ridge upwards to the inner part of the apex of the cone, and there is a depression both before and behind this ridge. This tooth is implanted by two fangs, as is each of the other grinders. The crown of the third tooth (*ib.* D 3) assumes the general character of those of the *Palæotherium,* consisting of two semi-conical lobes, which from the attrition of their summits and the deep indentation of their inner sides assume the form of half-cylinders ; their contiguous angles are confluent and form the middle lobe (*i*) of the inner surface of the tooth ; there is no ridge at the base of this surface. On the outer side of the crown a ridge extends from the base of the anterior lobe to its anterior upper angle ; and a second ridge curves from the outer part of the base of the hinder lobe upwards to its hinder summit ; a short ridge closes the base of the outer vertical cleft between the two lobes. The fourth molar (*ib.* D 4) shows, in addition to its superior size, a minute worn tubercle (*t*) behind the hinder angle or summit of the hinder lobe o' ; and the anterior and posterior oblique ridges are more decidedly distinct from the short middle external basal ridge. The fifth molar (M 1) differs from the fourth in the greater depth of the inner excavations or cavities of the lobes, which partly depends on its having been less worn : the hinder angle of the hinder lobe (o') has not been worn down to the level of the small tubercle (*t*) which forms the summit of the posterior ridge ; which ridge, like the anterior one, is now nearly vertical. The sixth grinder (*m* 2) has only come into use at the fore part of the anterior lobe ; the enamelled summit of the hind lobe is intact, and forms a semicircular ridge slightly mammillated ; its anterior angle is below the level of the posterior one of the anterior lobe, from which it is separated by a tubercle (*i*) formed by the obtuse summit of the middle lobe of the inner surface of the crown. The hinder ridge expands at its summit into an obtuse tubercle (*t*), terminating about two lines below the summit of the hinder lobe.

Had all the molars above described belonged to the permanent series, they would have differed from those of the Palæothere not only in their minor number—six instead of seven—but also in the simpler form of the last molar, as well as by the tubercle at the summit of the posterior ridge in the three last molars. A small orifice, however, in the alveolar border (fig. 3, 3), behind the last molar in place, led me to suspect the existence of another molar in a concealed alveolus, and on removing a portion of the outer wall of the jaw, the germ of such a molar was exposed, consisting of the shell of the crown (fig. 4, 3). This seemed to make the number of grinders the same as in the *Palæotherium*, but the hidden grinder resembled the crown of the last one in place, and had not the third lobe which characterizes the last true molar of the *Palæotherium*; whilst the second grinder (D 2) still opposed its small size and unilobate structure to an accordance with the generic dental character of the *Palæotherium*. Observing, next, that the fourth grinder (D 4), in the jaw from Hordle, had been much more worn by mastication than the succeeding tooth (M 1)—now proved to be the first of the three true molars—I was led to suspect that D 4 might be a deciduous tooth, knowing that the permanent one when in this position has its crown less worn in all known *Herbivora* than the first true molar behind it; and that it comes into place either at the same time as the last true molar or a little later. The degree of attrition of the third tooth in place (D 3) indicated that it also might be one of the deciduous series; and the extent to which the fangs of all the four anterior grinders were exposed, together with some minute foramina on the inner border of their sockets, determined me to search for traces of successors beneath them. The search was successful, and the germs of the permanent premolars, not indeed equal in number, but almost co-extensive, with the four anterior grinders which they would have displaced and succeeded, were discovered (fig. 4, P 2, 3, 4). These germs consist of the entire crown widely excavated at the base. The first (*ib.* P 2) is chiefly composed of one semi-conical lobe with a basal ridge interrupted at the outside of the base of the cone, but developed behind into a wing-like appendage, *o'*: the apex of the crown points below the interspace of the first and second deciduous molars, both of which it would have displaced. The second premolar (*ib.* P 3) lies beneath the third milk-molar; it resembles the first premolar in shape, but is of larger size, and has the hinder wing-like process (*o'*) more developed: this process presents a flat and nearly vertical surface outwards, and is convex at the inner and back part of its base. The third premolar (*ib.* P 4) consists of two semicylindrical lobes like the true molars and like the last milk-molar which it would have succeeded: like them, also, it has no basal ridge on the inner side of the crown, and that on the outer side is interrupted and represented by the oblique anterior and posterior ridges, the latter of which terminates in the characteristic tubercle *t*. In all existing hoofed quadrupeds (Proboscidians excepted), the last milk-molar presents and foreshadows, so to speak, the peculiarity in the form of the last true molar, when this tooth differs from the others;

and it might have been inferred, therefore, from the bilobed figure of the tooth now determined to be the last milk-molar, that the last true molar must also have had a bilobed crown, if even the state of the specimen had not permitted the actual demonstration of this generic distinction from the *Palæotherium*, as in fig. 4, M 3.

Thus the specimen in question having belonged to an individual at almost the greatest age compatible with the retention of the deciduous molars, gives the dental formulæ of the lower jaw of both the immature and adult states of the species: *e. g.*—

Deciduous or milk-teeth : $i. \overline{3-3}$; $c. \overline{1-1}$; $m. \overline{4-4}$.

Permanent teeth : $i. \overline{3-3}$; $c. \overline{1-1}$; $p. \overline{3-3}$; $m. \overline{3-3}$.

The animal has perished, in fact, at that age when the jaws contain the greatest number of molar teeth, not less than twenty, for example, being lodged in the lower jaw in question. The teeth in use are the four milk-molars, and the first and second true molars on each side: those still concealed in the jaw are the three premolars and the last true molar. The premolar which is wanting to complete the normal number is that which should have succeeded the first deciduous molar, and which would have answered to the first small premolar in the true *Palæotheria** : I have therefore indicated the three premolars that are developed in *Paloplotherium* by the same signs as those which designate their homologues in the *Palæotherium*†. The non-succession of D 1 by a P 1, and its displacement together with D 2 by P 2, is a modification in which *Paloplotherium* resembles *Equus*‡: and this instance of affinity is extremely interesting in connexion with the approach made by certain Palæotheres (*Pal. Aurelianense*, e. g.) to the monodactyle character of the Horse, by the disproportionate size of the middle of the three toes on each foot.

In the comparison of a detached true molar of the present Palæotherioid with the typical species, since the character of the bifid middle internal lobe would be lost by a moderate amount of wear of the crown, and since the tubercle terminating the hinder ridge would be obliterated by a further extent of abrasion, it may be remarked that lower grinders of the *Paloplotherium* may be distinguished by the absence of the basal ridge along the inner side of the crown, as well as of that which, in the true Palæotheres, unites the anterior and posterior oblique ridges along the outer side of the base of the crown.

A portion of lower jaw from the Hordle Cliff (Pl. IV. fig. 1), of a younger animal than the above-described, having the four milk-molars (D 1–4) and the first true molar (M 1) in place, showed by the character of the crowns of these teeth, and especially by that of the permanent true molar, its distinction from the typical Palæotheres, and its specific identity with the *Paloplotherium* above-described from the same stratum and locality.

The crown of the second true molar was found almost completely

* See my 'Odontography,' pl. 135. fig. 6. *p* 1. † *Ib.*
‡ *Ib.* pp. 572, 580, pl. 136. figs. 4 & 5.

formed in its closed alveolus. The crowns of the last two premolars, and of the last true molar, were represented by the detached, first-formed, enamelled summits of their lobes: of that of the first premolar (*p* 2) I could find no trace, but a smooth round cell indicated that a matrix had been developed, and, by its situation beneath the interspace of the first and second milk-molars in place, that the tooth it was destined to form would have displaced and succeeded both those milk-molars. The comparatively little-worn summits of the milk-molars showed the characters of their crowns better than in the more advanced jaw. The posterior oblique ridge in the third and fourth terminates in a minute tubercle. The slightly abraded summit of the first true molar also showed a similar but better-developed tubercular termination of the posterior ridge.

The detached molar teeth of the above-described species are intermediate in size between those of the *Palæotherium crassum* and *Palæotherium curtum*. The species to which they most nearly approximate in this respect is that represented by Cuvier in pl. 4. fig. 1. of the 'Ossem. Foss.,' tom. iii, and referred to at p. 67, tom. iii, as one of the types of the *Palæotherium medium**. I so strongly suspect an error in the reference to this species, and perceive so much in the figure that requires further elucidation, that I am disposed here to offer a few remarks respecting it. This remarkable fossil was first described and figured by M. Lamanon, in the 'Journal de Physique' for March 1782: he compares its dentition with that of many known living mammals, and arrives at the conclusion that it belongs to a species which no longer existed on the earth†.

* One of the objects of a recent visit to Paris was to examine the original; but M. Laurillard informed me that the specimen was not in the public collections at the Garden of Plants, and that it had been only temporarily entrusted to Baron Cuvier for description.

† "On ne peut enfin rapporter ces ossemens à aucun des animaux terrestres que nous connaissons." (p. 184).—"On est fondé à dire que c'est un animal dont l'espèce est perdue."—"La forme des dents prouve qu'il se nourissait d'herbes et de poissons; et je juge qu'il était Amphibie." (*ib.* p. 185.)

M. Cuvier, in citing this memoir of Lamanon's, in the third volume of the first edition of the 'Ossemens Fossiles,' p. 2, says: "Il décrivit des dents, des vertèbres et une moitié de tête dont nous parlerons dans la suite, qu'il jugea venir d'une espèce perdue d'Amphibie." M. de Blainville blames the brevity of this citation, "sans même expliquer ce qu'en France alors on entendait sous ce nom:" and, after quoting Cuvier as having affirmed that Lamanon meant "un amphibie que se nourissait *de chair* et de poissons," endeavours to fasten a charge of bad faith upon the author of the 'Ossemens Fossiles,' by asserting that Lamanon had determined the fossil in question to be "un herbivore amphibie, comme on appelé alors le Tapir et l'Hippopotame." (Ostéographie, fasc. xxi. p. 13.) What Lamanon understood, or what naturalists generally signified, by the term 'Amphibie' in 1782, it would not be easy to define. In another place, M. de Blainville himself says: "Il faut se rappeler que sous cette dénomination, en France, on comprenait alors les Phoques, les Hippopotames, les Loutres, les Castors." Now, M. Lamanon compares his fossil with the beaver, and concludes by supposing that in addition to herbs, the animal fed, like the seals and otters, on fish. Had Cuvier cited M. Lamanon as affirming his fossil animal to have fed on flesh and fish, he might have been open to the comments in which M. de Blainville indulges. But Cuvier's words are: "Lamanon....conclut que c'était un amphibie que vivait à la fois *d'herbe* et de poisson." (Ossemens Fossiles, 4to, iii. 1822, p. 27.)

But Lamanon imagined it to be an aquatic animal, and calls it an 'amphibiolite sans analogues' (p. 185).

The engraving of the fossil in pl. 2. of the 'Journal de Physique,' Mars 1782, is, as Cuvier rightly observes, reduced one-third; (the original drawing was probably, as Lamanon states, p. 183, of the natural size). The engraving in the 'Ossemens Fossiles' has the superior advantage of both being of the natural size, and of having been drawn by Cuvier's own hand:—"dessinée par moi-même au *compas**." The lower jaw shows four entire bilobed molars, *d*, *e*, *f*, *g*, in place, the roots of another anterior to them (*h*), and the germ of a sixth beneath the base of the coronoid process at *m*; which Cuvier describes as the "germe de molaire postérieure inférieure." He does not appear to have determined its tripartite structure. But assuming that so characteristic a form of the last true molar had not escaped, as it was little likely to do, the notice of Cuvier, and that it had afforded him the true ground for his determination of the tooth, then the molars marked *d* and *e* must be the second and first true molars: and as the next tooth in advance, *f*, has but two semicylindrical lobes, it cannot be the last deciduous molar; since this would show the three divisions in a true *Palæotherium*, like the species figured by Lamanon. The teeth, then, that are present in the specimen must be, according to the description given by Cuvier, the following: *g* is *p* 3, *f* is *p* 4, *e* is *m* 1, and *d* is *m* 2; or the series in place consists of the third premolar and the penultimate molar inclusive. Now the antero-posterior extent of these four teeth is 2 inches 5 lines (6 centimeters); that of the same teeth in the *Palæotherium medium* (pl. 40. fig. 1) being 3 inches 6 lines (9 centimeters). Lamanon says the jaw is 6 inches (French) in length (the admeasurement does not include the condyle); that of *Palæotherium medium* in pl. 40. is 9 inches (French) between the same parts.

The difference in the size of the jaws figured in pl. 4. and pl. 40. tom. iii. of the 'Ossemens Fossiles' might be explained by a difference of age in the original specimens; but as the size of the crowns of the teeth do not alter with age, the great discrepancy in this respect between the two specimens seems to be quite incompatible with their specific agreement.

Both specimens are however called *Palæotherium medium* by Cuvier, in his reference to the typical examples of that species at p. 67, tom. cit. and the editors of the posthumous 8vo edition ascribe the figure 1. pl. 4. (their pl. 83) to the 'young *Palæotherium medium*.' The great discrepancy, however, in the size of the permanent molar teeth, is neither accounted for, nor indeed adverted to. The indications of the canine and incisors may be those of the milk-teeth, since these are not shed in Ruminants until the permanent molars and premolars are in place: the much-worn and broken tooth *h* may be the second milk-molar, also not shed; but the four entire and evidently permanent molars indicate a species of *Palæotherium* intermediate in size between the *Pal. crassum* and the *Pal. curtum*; or one of nearly the dimensions of the *Paloplotherium* of Hordle; but differing from

* Annales du Muséum, iii. p. 292.

that species in having the molar teeth of the typical palæotherian form; and in having the third premolar (P 3) bilobed.

I may add that the coronoid process in fig. 1. pl. 4. tom. iii. 'Ossem. Foss.' is 3 inches 1 line in height, whilst that of fig. 2. pl. 42, *ib.*, with much larger molar teeth, is only 2 inches 1 line in height*. The height of the coronoid process in the Hordle Palæotherioid jaw is 2 inches 10 lines; its proportion to the teeth is therefore much nearer that of the Palæotherium in pl. 4, than that of the older and larger Palæotherium in pl. 42. tom. cit.

The *Palæotherium Aurelianense*, the differential characters of whose upper molars from those of the typical Palæotheres will be noticed in connexion with the fossil upper jaw of the *Paloplotherium* from Hordle, presents corresponding differences, as compared with the Montmartre *Palæotheria*, in the molar teeth of the lower jaw; these differences are regarded as of generic value by M. V. Meyer, but by Cuvier as specific distinctions only; and he thus describes them:—"The meeting (rencontre) of the two arches or crescents forms a double point at the middle of the internal surface (of the crown, fig. 5, *i*); whilst that point is always simple in the Palæotheres of the environs of Paris."—"The last lower molar has its third lobe shaped like a cone rather than a crescent."

The complete lower jaw of the immature Palæotherioid from Hordle presents, as we have seen, the four false molars and the first and second true molars in place. The middle inner lobe (Pl. III. fig. 3, M I) is slightly bifid; but this is due to a cleft in the summit of that lobe, and not to an imperfect or interrupted meeting of the two crescents: the posterior crescent *o'* does not rise so high as the anterior one *o*, but terminates by abutting against the middle bifid internal lobe, without forming a distinct point. The bifid character, therefore, is apparently differently produced, and is certainly much less marked in the lower molars of the *Paloplotherium* than it is described to be and is figured in the lower molars of the *Palæotherium Aurelianense* (*An-*

* I regard this difference as decisive of the specific distinction of the two Palæotheres above compared: both, however, are cited as examples of the *Palæoth. medium* in the 'Palæologica' of V. Meyer, p. 84; the 'Fauna der Vorwelt' (1847) of Siebel, p. 188; and other similar compilations.

M. de Blainville, in the Critique on the Cuvierian species of *Palæotherium*, does not notice any of the differences between the skull and teeth figured in pl. 4, and the specimens figured in pls. 40 and 42, tom. iii. of the 'Ossem. Fossiles': he states, however, that the original of Lamanon's figure had recently been acquired for the Museum of the Jardin des Plantes (Ostéographie, fasc. xxi. p. 26): so that the comparisons which I had hoped to have made in August 1847 may still be carried out. M. de Blainville throws some doubt upon the specific distinction between *Pal. medium* and *Pal. crassum*, and ventures to affirm that all the species "n'ont réellement été définies par M. G. Cuvier que d'après la grandeur rélative," *l. c.* p. 66. But if even the differences of proportion by which Cuvier characterized his *Palæotherium crassum* (t. iii. p. 127) and *Pal. latum* (t. iii. p. 131) were not indicated in the above-cited and other passages of the 'Ossemens Fossiles' with a precision and frequency which makes one astonished at M. de Blainville's assertion to the contrary, the naturalist might cite the Horse, the Zebra, the Ziggetai, and the common Ass, as accepted species, whose teeth and bones would yield less decisive evidence of specific distinction than those which Cuvier has so ably pointed out in the fossil remains of the *Palæotheria.*

chitherium, V. Meyer). The true molars of the lower jaw of the *Paloplotherium* also differ in the absence of the cingulum or basal ridge, and in the presence of the cusp terminating the posterior oblique ridge; at least neither Cuvier nor M. V. Meyer allude to this character in the molars of the Orleans or Madrid Palæotherioid; although something like it is indicated in the lower molars of fig. 17. pl. 67. 'Ossemens Fossiles,' tom. iii.* But the most decisive distinction in the dentition of the lower jaw of the Hordle *Paloplotherium* is the unilobate structure of the second premolar (*p* 3), and its smaller size as compared with the first (*p* 2); a difference which will be at once appreciated by comparing the figure in Pl. III. fig. 4, P 2, with that given by Cuvier in figs. 3 and 13 *b*. of the plate 67, above-cited. This difference would have decided the distinction of the species, if even subsequent discoveries had not proved the generic difference of *Paloplotherium*, by showing that the *Palæotherium Aurelianense* resembled the typical Palæotheres in the number of its inferior grinding teeth.

Another known Palæotherioid pachyderm with which the Hordle species might be confounded, is that to which the left ramus of the fossil lower jaw from the tertiary deposits at Buenos Ayres, now in the British Museum, belongs, and which I have provisionally referred to the genus *Macrauchenia*. This portion of jaw contains six molar teeth, three true and three false; and the last molar differs, like that in the *Paloplotherium*, from the typical Palæotheres by the absence of the third lobe: but it likewise differs from the species under consideration in the absence of the posterior tubercle, which is equally wanting in the other true molars of the *Macrauchenia*: the premolar answering to P 2, in figs. 2 and 4. Pl. III., is more compressed and more extended from before backwards, as is also P 3†, which shows a fold of enamel along its inner side which would not be present in the corresponding tooth of the *Paloplotherium*. Nevertheless this genus resembles the *Macrauchenia* in the more simple form of P 2 and P 3; in which we may discern an approximation to the Anoplotherian type, as in the number of the premolars we discern a character of the Equine and Ruminant dental formulæ. In the figure of the lower jaw of the *Macrauchenia* in my 'Odontography' (pl. 135. fig. 7), the outline of *p* 1 "is hypothetically added to the series" (*ib*. p. 603): but this tooth may have been normally absent, as it is in the *Paloplotherium*, the Horse, and in existing Ruminants‡. The only known species of *Macrauchenia* much surpasses the *Paloplotherium annectens* in size.

* M. de Blainville is equally silent in respect to this character in his recent work on the *Palæotheria*: but I observed it in the specimens of the *Pal. Aurelianense* from Sansans.

† See Odontography, pl. 135. fig. 7.

‡ In an extinct antelope (*Dorcatherium*, Kaup) the first milk-molar was succeeded by *p* 1, and the number of premolars was four.

PART IV.—*Description of a portion of the Skull and Upper Teeth of the same species of* Paloplotherium (*P. annectens*).

(Pl. III. figs. 1 & 2.)

THE *Palæotherium* which Cuvier found to deviate most from the generic characters of those of Montmartre (*Pal. magnum, P. crassum, P. medium, P. curtum*), which may be viewed as the types of the genus, is the species from Orleans already referred to (*l'espèce d'Orléans* of the 'Ossemens Fossiles,' iii. p. 254; *Palæotherium Aurelianense,* Auct. De Bl. Ostéog. fasc. xxi. (1847) p. 43).

The differences specified by Cuvier are those presented by the molar teeth. In the upper (true) molars 'the distinctive character' of the 'Pal. d'Orléans' consists in this, that the lobes or ridges (Pl. III. fig. 6 *i, i'*) (collines) which extend from the external border, at their arrival at the internal border do not come back; and in this, that there is at the posterior border a little insulated 'colline' in the form of a chevron*.

It is assumed in the 'Ossemens Fossiles' that the number of the permanent molars in the *Pal. Aurelianense* is the same as in the other species; in short, that it presents the numerical formula of the genus *Palæotherium*: and Cuvier, therefore, interprets the modifications of the grinding surface of the upper molar as a specific difference.

M. Hermann V. Meyer, on the other hand, has founded a genus† on a few fossil teeth, from the tertiary deposits near Madrid, which present the same modifications of the grinding surface, and belong apparently to the same species as the *Palæotherium Aurelianense.*

Not any of the fossils, however, described and figured by Cuvier, Guettard, or M. V. Meyer, and which are referred in the systematic Palæontological Treatises‡ to the *Palæotherium Aurelianense,* exhibit the whole series of molars in either upper or lower jaw. The question of the generic distinction of this Palæotherioid must therefore remain in abeyance until further evidence, and especially the important character of the dental formula is determined; for few anatomists or naturalists, I apprehend, will be found to regard as generic the distinctive characters of the Orleans Palæothere, specified by Cuvier.

Ample grounds, however, for so interpreting the fossil cranium under consideration (Pl. III. figs. 1 & 2) are furnished by the entire series of molar teeth in the upper jaw, which consist on each side of three molars (M 1, 2 & 3) and of but three premolars (P 2, 3 & 4), instead of four premolars as in the typical *Palæotheria*: the sockets

* Tom. cit. p. 255, pl. 67. figs. 11 and 12. Cuvier also cites a figure by Guettard of one of these molars, in the 'Mémoires sur les Arts et les Sciences,' tom. v. pl. 7. fig. 1;—a work which I have not had the opportunity of consulting.

† *Anchitherium Equerræ*; Jahrbuch für Mineralogie, 1844, p. 298.

‡ PICTET, 'Traité Elémentaire de Paléontologie,' t. i. (1844) p. 274. GIEBEL, 'Die Säugethiere der Vorwelt,' 8vo. (1847) p. 189.

of the canines and incisors are also preserved, showing the dental formula of the upper jaw of the present genus to be—

$$i\,\frac{3-3}{\quad},\ c\,\frac{1-1}{\quad},\ p\,\frac{3-3}{\quad},\ m\,\frac{3-3}{\quad}.$$

The grinding surface of the true molars differs from that of the same teeth in the *Palæotherium Aurelianense* : the penultimate molar M 2 in the specimen (fig. 2) has the enamelled summits of the ridges abraded to the same extent as in the (apparently) penultimate molar of the *Palæotherium Aurelianense* figured by Cuvier * (fig. 6) ; and shows the following distinctions :—there is no small insulated chevron-shaped lobe like that marked *c*, fig. 6, in the depression at the posterior borders between the ridges *o*′ and *i*′: the anterior ridge (fig. 2, M 2, *i*) is divided by a notch, and its inner lobate termination (*p*) presents on its summit a distinct island of dentine surrounded by enamel: the anterior and external angle is not produced forwards, as represented in Cuvier's figure, which gives a peculiar character to that tooth not alluded to by Cuvier, but which I have not observed in any specimens or figures of the corresponding molar in any known species of *Palæotherium*. The Palæotherioid from Hordle is also smaller than the Orleans species.

Nothing, therefore, can be inferred as to the true dental formula of the *Palæotherium Aurelianense*, or of its claims to the generic appellation of *Anchitherium*, from the ascertained dental formula of the upper jaw of the *Paloplotherium* from Hordle †.

That this formula accurately gives the number and kind of the teeth of the upper jaw is proved by the following facts. The edentulous border of the jaw between the first premolar and the canine is entire on both sides, is sharp until its expansion to form the socket of the canine, and shows no trace of the socket of a shed or abortive false molar. The alveolar tract or 'process' is also entire and terminates behind the last molar ; it does not bulge out backwards, as it would do if the germ of another molar had there been present. The fourth grinder (M 1, figs. 1 & 2) counting backwards is more worn than the three which precede it, showing that they had come later into place ; and, to determine whether the worn fourth grinder was the last of four milk-molars, or the first of the three true molars, I

* Annales du Muséum, iii. (1804) pl. 35. fig. 10. Ossemens Fossiles, pl. 67. fig. 11.

† Since this paper was read at the Meeting of the Geological Society, I have had the opportunity of inspecting at Paris, through the kindness of M. Laurillard, the series of fossils of the *Palæotherium Aurelianense*, which has been enriched, since the time of Cuvier, by the discoveries of the zealous and learned M. Lartet of remains of the same or a very closely allied species in the Eocene deposits at Sansans. These remains, some of which M. de Blainville has recently described and figured in the last published (21st) fasciculus of his 'Ostéographie' (pp. 51, 75, pl. 3.), prove the number of premolars to be the same in both jaws as in the typical Palæotheres, viz. $\frac{4-4}{4-4}$. The indefatigable author of that beautiful work, though recognising the specific identity of the *Palæotherium equinum* of Lartet with the *Palæotherium Aurelianense*, Cuvier, proposes nevertheless another synonym—*Palæotherium hippoïdes*—for the species.—*December* 1847.

excavated the upper jaw, above it, but found no trace of a successional tooth; the air-cavities of the maxillary sinus were exposed.

The animal to which this cranium belonged was not quite of mature age when it perished. The last true molar M 3, though through the gum, has had the summits of the outer crescents very slightly abraded; and the first (P 2) and second (P 3) premolars in place are but little worn. The characters of the grinding surfaces are, therefore, beautifully manifested, and in degrees of attrition that almost correspond with those of the upper molars of the *Palæotherium crassum* figured by Cuvier in the 'Ossemens Fossiles,' t. iii. pl. 48. fig. 2; with which, therefore, I shall proceed to compare the molars of the *Paloplotherium*. The antero-posterior extent of the six molars of *Palæotherium crassum* (the first being wanting) is 4 inches 5½ lines (11 centimeters 3 millimeters, Fr.), that of the six molars (the entire series) in *Paloplotherium* (Pl. III. figs. 1 & 2, M 3 to P 2) is 3 inches 1 line (7 centimeters 7 millimeters, Fr.). The first grinder in *Paloplotherium* answers to the second premolar in *Palæotherium*: its antero-posterior extent is 9 millimeters, that of the second premolar in *Pal. crassum* is 16 millimeters.

This tooth P 2, in *Paloplotherium* (*ib.* figs. 1 & 2), presents, like P 1 in *Palæotherium*, one conical lobe externally: there is a second smaller compressed lobe *p* at the fore-part of the inner side of the tooth, and the crown is surrounded by a strong basal ridge, interrupted only at the anterior angle of the inner lobe and at the back part of the tooth in contact with the next. The form of the grinding surface is triangular, broad, and excavated behind; it is implanted by three fangs: but in its general character P 2 in *Paloplotherium* corresponds with P 1 in *Palæotherium magnum**; with this difference, that there is an inner lobe near the back part of the grinding surface in *Pal. magnum*.

The second premolar in the upper jaw of *Paloplotherium* differs from both P 2 in *Palæotherium*† and its proper homologue P 3 in *Palæotherium*, in having, like the tooth before it, but one external conical lobe; it presents, however, a third lobule at the fore-part of the crown, wedged between the outer lobe *o* and inner tubercle *p*: this tubercle is relatively thicker than in *p* 2, but is still at the fore-part of the inner half of the grinding surface: the back part being widely excavated; but showing a rudimental oblique tubercle (*i*). The basal ridge is interrupted at the inner side of the base of the inner lobe. This tooth is implanted by three fangs.

The last upper premolar (P 4) in *Paloplotherium* resembles each of the three posterior premolars of *Palæotherium* in having, like the true molars, two exterior conical crescentic lobes *o*, *o'*, divided by a vertical ridge extending from the external basal ridge, but not quite reaching the summit of the grinding surface; a second parallel ridge bounds the fore-part of the outer surface of this premolar, as in *Palæo-*

* Cuv. *l. c.* pl. 43. fig. 1, *b*.

† See my 'Odontography,' pl. 135. figs. 5 & 6, where the homologies of the individual molars are determined, and expressed by the letters and numbers used throughout the present memoir.

therium. The oblique tubercle, *ï*, is now developed into a compressed lobe or ridge; in other respects P 4 resembles P 3, but is larger. It is implanted by four fangs.

The first true molar (M 1) deviates least from the Palæotherian type; the worn summits of the two conical and subcrescentic outer lobes present the two zigzag lines of enamel which Cuvier compares to a double W, and the vertical ridge dividing them on the outer surface of the tooth reaches the margin of the grinding surface: the concavities in the outer surface bounded by the above-described ridge, and the anterior vertical ridge, show a slight median rising. The oblique ridge of the lobe *ï* on the grinding surface, being worn, presents a narrow tract of dentine, extending from the posterior and internal angle of the crown to near the interspace of the two outer lobes *o*, *o'*: it answers to "l'autre ligne pareille qui part du milieu de la ligne en W," &c. in the Palæotheres*.

The summits of the tubercle *p* and of the antero-internal lobe (*i*) are blended together by attrition, and show a tract of dentine parallel with *ï*, but thicker and of a bilobed form; extending from the anterior and external angle to the middle of the internal border of the crown. The oblique peninsular fold of enamel (*e*), penetrating from the inner side of the crown and dividing the before-named tracts, doubles the extremity of the posterior tract (*ï*) and communicates with the posterior depression or fold of enamel: in equally worn molars of *Palæotherium* that fold (*a*) is cut off, and forms an island. There is a ridge at the fore-part of the base of the inner lobe *p*; and also a slight remnant of the cingulum at the entry of the fold *e*.

The molar fig. 2. M 2 has had merely the summits of the highest lobes and ridges of the grinding surface abraded; the tubercle *p* and the antero-internal lobe *i* continue distinct. The posterior boundary of the posterior depression is unworn.

The last grinder, M 3, has just cut the gum, and almost corresponds in growth with the last upper molar of the *Palæotherium medium*, figured in the 'Ossemens Fossiles,' pl. 47. fig. 14; and with that of the *Palæotherium crassum*, figured in my 'Brit. Foss. Mamm.,' fig. 112. p. 319. The generic distinctions are accordingly well-displayed in the comparison of the germ of the last molar of the Paloplothere with those in the true Palæotheres above-cited. The antero-internal lobe (*i*) rises quite independently between the crescentic lobe *o* and the large inner tubercle *p*. The posterior inner lobe *ï* extends forwards and outwards as an oblique ridge to the entering angle of the anterior and external crescent. The remnant of the cingulum at the base of the fissure *e* does not rise above that part, and its communication with the basal ridge at the fore-part of the lobe *p* is interrupted. The two outer vertical channels are less deep than in the Palæotheres, and the bottom of each is gently convex in both directions.

Each of the true molars is implanted by four fangs, the two inner ones appearing to be connate, and the two posterior ones in the last

* Ossem. Foss. iii. p. 9.

molar being closely approximated, in conformity with the contracted breadth of that part of the crown.

The enamel which invests the crown is almost a millimeter in thickness: the fine striæ indicative of its successive formation are obvious; but otherwise its surface is smooth and polished. The cement covering the fangs is thinner; the coronal cement does not fill up any of the cavities of the crown. The molar teeth in relation to each other hold the same slightly oblique position and zigzag outer contour as in *Palæotherium*; the anterior and external angle of the hinder molar projecting outwards beyond the crown of the next molar in advance, and so with the rest. The six grinders progressively increase in antero-posterior extent as they recede in position, from P 2 to M 3.

The chief distinctive character of the true molars, as compared with those of the genus *Palæotherium*, is the detachment of the inner portion of the antero-internal oblique ridge (' colline transversale antérieure,' Cuv.) as a distinct lobe or tubercle *p*, and its superior thickness to the other part of the ridge *i*. It is not so thick and round as the homologous lobe in the *Anoplotherium* (fig. 5, *p*), and it forms an oval instead of a rounded disc of dentine when moderately worn, as in *m* 2, fig. 2; but it then gives the crown of the tooth a character which brings it very close to that in the *Anoplotherium*: for which indeed it might, if insulated, be mistaken, according to the differential character laid down by Cuvier*. The entire molar series in the upper jaw resembles that of the *Anoplotherium* in the progressive increase of the size of the crown from the foremost to the hindmost tooth: the molars are more equal in *Palæotherium*. The premolars differ in their smaller number from both *Palæotherium* and *Anoplotherium*; but those answering to *p* 2 and *p* 3 (Odontography, pl. 135. fig. 2) resemble in their smaller size and comparatively simple structure the corresponding teeth of the *Anoplotherium* more than they do those of the *Palæotherium*.

The true molars not only differ from those of the *Anoplotherium* (Pl. III. fig. 5) in the comparatively smaller size and more compressed form of the conical tubercle *p*, but in the more open angles of the outer lobes *o*, *o'*, and in the less curved form of the ridge *i*, which is separated from the posterior outer crescent by the deep fissure (*a*). In these latter differences the *Paloplotherium* resembles the *Palæotherium*, to which genus it approximates in the development of the canine teeth, and their separation, in the upper jaw, by a diastema from the premolars. But in the characters above specified, by which the Paloplothere differs from the Palæothere, it approaches the Anoplothere; it differs, however, from both genera in the absence of the first premolar (P 1): of which not a rudiment or trace is present, although the last molar has not come into use.

One may associate with the absence of this premolar the relatively longer interspace which divides the first of these teeth (P 2) from the canine in the upper jaw of *Paloplotherium*: in the specimen under description this space measures 9 lines (2 centimeters), which

* Tom. cit. p. 21.

is equal to the antero-posterior extent of the last two premolars. In *Palæotherium crassum* (Cuv. *l. c.* pl. 53. fig. 1) the same space measures $4\frac{1}{2}$ lines (1 centimeter), or little more than half the antero-posterior extent of the last premolar: and the proportions of the diastema are nearly the same in the other known species of typical Palæotheres.

The antero-posterior extent of the oval outlet of the socket of the canine (fig. 1, *c*) is $4\frac{1}{2}$ lines (9 millimeters). This socket is separated from the outer incisor (*i* 3) by a diastema of $2\frac{1}{3}$ lines (5 millimeters). The three subequal incisors are juxtaposed, and the inner one (*i*) is close to the premaxillary symphysis.

The canines seem to have been rather smaller proportionally than in the typical *Palæotheres*, but there is no specimen either of these or of the incisive teeth by which the characters of their crowns can be given; their relative size and position are indicated only by the sockets.

If we compare now the characters of the dentition of the upper jaw with those of the under jaw of the Hordle Palæotherioid previously described, we shall find that they agree with each other both in the antero-posterior extent of the molar series and in that of each individual tooth. They further exhibit the more important concordance in the number and kinds of those teeth, viz. $p\,\frac{3-3}{3-3}$, $m\,\frac{3-3}{3-3}$: the two first teeth (P 2 & 3, fig. 1) show the same comparative simplicity of structure, and consequently the same deviation from the character of those teeth in the *Palæotherium*; and if the other grinders of the lower jaw differ less from their homologues in *Palæotherium* and less resemble those in *Anoplotherium* than do those of the upper jaw, we shall not find that this opposes any real difficulty to their association with such upper jaw, when we observe that the differential characters between *Palæotherium* and *Anoplotherium* are much less marked in the lower than in the upper grinders; just as the difference between *Chæropotamus* and *Dicotyles* is less marked in the dentition of the lower than in that of the upper jaw. The extent of deviation therefore, though small, in the true molars of the lower jaw of the Hordle Palæotherioid from those of the true *Palæotherium*, accords with or is proportional to those greater differences which we observe in the true molars of the upper jaw*. When however we find superadded to the degree of concordance between the true molars of the upper and lower jaws of the Hordle Palæotherioid, and to their differences from those teeth in the Palæotheres and Anoplotheres, a common manifestation of the more striking and important differences in the minor number and simpler structure of the premolars, no reasonable doubt can be enter-

* The bony arch supporting the upper molars being more remote from the centre of life than that supporting the lower molars, being in fact the anterior terminal arch of the hæmal series, is the seat of a greater amount of adaptive variation than the succeeding arch, and the teeth which it supports are in like manner more varied. This principle is well-illustrated by comparing the upper molars of the odd-toed Ungulates generally with the lower molars of the same natural group.

tained that both the upper and the lower jaws above described belong to the same genus and the same species. For the genus I propose the name of *Paloplotherium*; its dental formula is $i\frac{3-3}{3-3}$; $c\frac{1-1}{1-1}$; $p\frac{3-3}{3-3}$; $m\frac{3-3}{3-3}=40$; with the specific name *annectens* for the present known representative, as indicative of the transitional characters which to a certain degree connect the *Palæotherium* with its eocene contemporary the *Anoplotherium*. The *Paloplotherium* has however several characters by which it differs from both; amongst which may be mentioned, besides the absence of *p* 1 in both jaws, the reduction of the third lobe in the last molar of the lower jaw to the tubercle *t*, in which simplification of *m* 3, the Paloplothere resembles the Macrauchenia and Rhinoceros.

The bones which contain the perfect series of the upper molar teeth form the middle and anterior thirds of the skull. Only the rhinencephalic compartment of the cranial cavity is preserved with the facial division: but the bones, though crushed and fractured, permit of many instructive comparisons being made with the Anoplothere and Palæothere, in regard to this part of their osteology. The orbits are relatively larger than in the *Palæoth. crassum*; and owing to the flattening of the frontals at the interorbital region, they have not so low a position as that which peculiarly characterises the Palæothere. In this respect, as well as in the minor convexity of the interfrontal region, the Paloplothere resembles the Anoplothere. The postorbital process of the frontal descends lower than in the Palæothere, and in this character the skull resembles that of the Anoplothere.

The curvature of the moderately strong malar bone forming the lower boundary of the orbit is convex downwards; it is relatively less deep anteriorly than in the Anoplothere. The orbit is on the same vertical parallel as the last two molar teeth. The ridges continued backwards from the postorbital processes, curving and converging upon the frontal bone, are strongly marked by the sudden sinking of the temporal fossa which they define, but they do not rise above the level of the frontals: they converge at a less acute angle than in the *Palæotherium crassum*.

The lachrymal bone is perforated by two foramina, defended externally by a small projecting tubercle. The rhinencephalic depressions* of the cranial cavity are vertically oblong, divided from the prosencephalic chamber by descending superior ridges, and from each other by a sharp vertical ridge (*crista galli*) formed by the hinder margin of the coalesced prefrontals (*lamina media æthmoidei*). The posterior parts of the ossified olfactory capsules close the anterior outlets of the rhinencephalic depressions, and were perforated, as usual, by the numerous filaments of the olfactory nerves, forming

* I restrict the term 'olfactory' to the chambers of the face containing the turbinal and other parts of the olfactory capsules.

the *lamina cribriformis æthmoidei*. The frontal sinuses do not extend further backwards in this cranium than above the rhinencephalic chamber.

The frontonasal suture runs, with a very slight bend backwards, across the cranium, parallel with the fore-part of the orbits. The nasal bones are as broad at their origin as the frontals, and are bent down externally to join the lachrymals: their apices are broken off. The anterior border of the maxillaries is entire, and so much of the premaxillaries is preserved as demonstrates that they were separated from the nasals by about an inch of the maxillaries, and that these concurred with the premaxillaries and nasals to form the contour of the anterior bony nostrils, which were thus surrounded by six bones, as in the Palæotheres, instead of by four, as in the Anoplotheres. The maxillaries ascend more rapidly, or with a nearer approach to verticality, in joining the nasals than in the Palæotheres: so that with regard to the osseous walls of the face anterior to the orbits and to the shape of the anterior nostril, the Paloplothere manifests again a character intermediate between the Palæothere and Anoplothere. The facial plate of the maxillary is perforated by a single antorbital foramen 5 millimeters in diameter, situated 1 inch ($2\frac{1}{2}$ centimeters) anterior to the orbit, and 14 lines (3 centimeters) behind the nasal border, and 7 lines ($1\frac{1}{2}$ centimeter) above the alveolar border of the maxillary. The bony palate is much crushed, but seems to have terminated by a concave border opposite the interspace between the penultimate and last molar.

The premaxillaries are long, slender, destined almost exclusively to the support of the six incisors, and to give passage to the incisive or prepalatine nerves and vessels, which impressed their mesial sides with an oblique channel. The symphysis of the premaxillaries had not been obliterated, as it becomes in the Tapir; and the premaxillaries had been divaricated by external pressure or violence before the surrounding matrix had hardened and fixed them in that position. There are other marks of violence which have evidently been left upon this skull before it became enveloped by the matrix, which fills the cracks and crevices of the crushed parts. Over the left frontonasal suture there is a depression and comminuted fracture of the skull, inflicted as it seems by the blow or pressure of a conical instrument of the size of a large tooth of a crocodile: a similarly comminuted fracture exists on the bony palate a little behind the vertical parallel of the upper one. The opposite sides of the facial bones have been partially crushed and similarly driven in, just in front of the orbits; and this latter compression seems to have started asunder and opened the symphysis of the premaxillary bones. I strongly suspect that these injuries were inflicted on the recent head by the jaws and teeth of a crocodile. The great inferior canine tusk, penetrating the interspace of the rami of the lower jaw, would crush the palate in the attempt to meet the upper canine, which would drive in the opposing upper part of the skull by the same bite. Before or after this the head has been turned half round, and the same teeth have left the traces of another bite at the opposite sides of the face. At all events it is plain that the violence inflicted upon the head of this young Pachyderm has been received before the skull became imbedded in the eocene mud, and that the matrix hardening around it has preserved the evidence of the nature of the injuries received to this day. The points of the great canine teeth of old crocodiles not unfrequently become so blunted as would produce such crushed and depressed fractures without penetrating more deeply. The remains of an extinct species of *Crocodile* are common in the same formation as that in which the debris of their prey have been buried. I have received many detached teeth and bones through the kindness of the Messrs. Falconer, and Lady Hastings has generously confided to me for description the unique and almost perfect skull of a crocodile from the Hordle sands, which demonstrates, by the exterior position of the lower canines in the grooves on the outer border of the upper jaw, its true crocodilian character. The Sheppey crocodile also belongs to the subgenus *Crocodilus*, but approximates closely to the Bornean species, whilst the Hordle crocodile much more closely resembles the crocodile of the Nile. As Dr. Buckland has given the name of *Crocodilus Spenceri* to the Sheppey species, I propose to call the coeval species from the Hordle eocene *Crocodilus Hastingsiæ*, in honour of its accomplished possessor, whose zeal in the collection of the fossils in her Ladyship's vicinity has contributed so much to advance our scientific knowledge of them.

DESCRIPTION OF PLATE III.

Fig. 1. Side view of mutilated cranium with permanent series of grinders; and those of the lower jaw, of *Paloplotherium annectens*, nat. size.

Fig. 2. Grinding surface of upper premolars and molars and alveoli of canine and incisors, left side, of ditto.

Fig. 3. Horizontal rami of lower jaw, showing symphysis and sockets of incisors and canines, and grinding surface, deciduous and persistent molars, of ditto.

Fig. 4. Side view of left ramus of lower jaw with deciduous molars and two permanent molars in place, and with the premolars and last molar exposed in the formative cells, of ditto.

Fig. 5. Grinding surface of an upper true molar of *Anoplotherium commune*: after Cuvier.

Fig. 6. Grinding surface of an upper true molar of *Palæotherium Aurelianense*: after Cuvier.

In the figures of the *Paloplotherium* I 1, 2, 3 indicates the first, second and third incisive sockets; C, the socket of the canine; P 2, 3, 4, the premolars; M 1, 2, 3, the molars; D 1, 2, 3, 4, the deciduous molars. The letters of the lobes and ridges are explained in the text.

Part V.—*Description of the Teeth and the Lower Jaw of an extinct species of Mammal belonging to the section of Hoofed Quadrupeds* (Ungulata) *having molar teeth with the principal lobes in symmetrical pairs, and forming the type of a new genus* (Dichodon) *in that section.*

The existing *Ungulata*, which have the principal lobes of the true molar teeth arranged in symmetrical or subsymmetrical pairs, are the *Ruminantia* and the genera *Sus, Dicotyles* and *Hippopotamus*, with

From Nature on Zinc by J. Erxleben. Day & Son Lithog^rs to the Queen.

Figs. 1.–4. Paloplotherium. Fig. 5. Anoplotherium. Fig. 6. Paleotherium.

which I have associated, as members of the same great natural group of mammals*, the extinct genera *Hippohyus, Hyracotherium, Chæropotamus, Anthracotherium, Merycopotamus, Dichobunes* and *Anoplotherium,* although the symmetrical or parial character of the crown of the tooth, as shown by the normal lobes *o i*, and *o' i'* (Pl. III. fig. 5), in *Anoplotherium* is disturbed by the excessive development of the accessory tubercle *p*.

The fossils about to be described give evidence of the former existence of another of these interesting annectent links that once filled up the interval that now almost insulates the Ruminants from the few remaining members of the Ungulates with the lobes of the grinders and the toes of the feet in symmetrical pairs. These fossils, discovered by Alexander Pytts Falconer, Esq., in the eocene sand-bed at Hordle, consist of a portion of the upper jaw, with the three true molars, the third and fourth premolars, the canine and three incisors; and a nearly entire under jaw, with the whole dental series of one side and a large proportion of it on the opposite side (Pl. IV. figs. 2, 3, 4, 5). The genus established by the peculiarities of this dentition, and which I propose to call *Dichodon*†, makes the nearest approach by its upper true molars to the *Merycopotamus* of Messrs. Cautley and Falconer (Pl. IV. fig. 7), and to that smaller allied extinct Indian quadruped called '*Anthracotherium silistrense*' in the second volume of the Second Series of the Geological Transactions (p. 392, pl. 45. figs. 2 & 3).

In the true molars of the lower jaw the genus *Dichodon* closely resembles the genus *Dichobune*; and it manifests a striking affinity to the Anoplotherioids in the low development of the canine teeth and in the number and uninterrupted contiguity of the entire dental series. But *Dichodon* presents peculiar modifications of the molar and especially of the premolar teeth, which distinguish it from all known genera of fossil and recent Mammalia.

The crowns of the upper true molars of *Dichodon* (Pl. IV. fig. 3. M 1, 2 & 3) are subquadrate and four-lobed, and the antero-posterior cleft describes two strong curves, concave outwards, as in fig. 3. pl. 45. of the 'Geol. Trans.' above-cited, and as in *Merycopotamus*‡ (Pl. IV. fig. 7) and *Dichobunes*§; but there is no depression or fold of enamel that would mark off in the abraded crown a lobe of dentine answering to that marked *p* in fig. 1. p. 420 of the 'Geol. Proceedings' above-cited; and by this difference, as well as other characters, the molars of *Dichodon* more resemble those of *Merycopotamus* and of the little so-called *Anthracotherium silistrense*.

The outer sides of the outer lobes (fig. 2. *o'*, *o*) of *Dichodon* are

* Odontography, pp. 523, 571.

† The numerous sharp and well-defined divisions of the crowns of both upper and lower molar teeth suggested the term 'Dichodon' (διχάω, *divido*; ὀδοὺς, *dens*), expressive of this character, and of the sharp incisive nature of most of the teeth; the human cutting-teeth were called διχαστῆρες ὀδόντες, *incisivi dentes*, by the Greek anatomists.

‡ Odontography, p. 566, pl. 140. fig. 8.

§ Proceedings of Geol. Society, May 1846, p. 420, fig. 1.

less deeply indented than in *Merycopotamus*, but show a trace of a longitudinal rising at their middle part. The inner sides of both outer and inner lobes (fig. 5. *i, ï*) are strongly convex, and more angular than in *Merycopotamus*. Attrition of the summits of these semiconical lobes would, however, produce the same double crescentic islands of enamel which characterize the upper molars of *Merycopotamus* and *Dichobunes*, and were once supposed to be a peculiar characteristic of the *Ruminantia**.

In the young animal under consideration the lobes of all the molars terminate in sharp enamelled points; those of the first true molar (*m* 1) being slightly abraded at their summits and anterior angles. The upper true molars differ from those of *Merycopotamus* in the absence of the "strong rugged ridge" (fig. 7. *r*) "along the inner side of the base of the crown†," and in the presence of the series of five small but sharp accessory cusps (*a, b, c, d, e*, M 2, fig. 3, Pl. IV.) along the outer side of the base: one of these cusps (*a*) terminates externally the sharp ridge continued from the anterior angle of the base of the inner and interior lobe (*i*) along the anterior side of the base of the crown: the other four cusps are placed at the angles of the bases of the outer sides of the two external lobes, and answer to the corresponding angles of the outer lobes in *Merycopotamus*, which angles are, as it were, pinched up and pulled outwards in that genus.

A sharp ridge is continued from the posterior angle of the base of the posterior and inner lobe, along the posterior part of the base of the crown, to the corresponding angle of the posterior and external lobe; but there is no ridge beneath this, as in *Merycopotamus*. The contiguous angles of the bases of the two inner lobes (*i, ï*, M 2, fig. 3) are prolonged outwards far into the interspace between the two outer lobes. A small tubercle (*p*) is situated at the inner entry to the fissure between the two inner lobes: a ridge penetrates this fissure in *Merycopotamus*.

The three upper true molars progressively increase in size from the first (M 1) to the last (M 3) in *Dichodon*; they are equal-sized in *Merycopotamus*. All the lobes and ridges are remarkably sharp, and the fissures are deep and neatly defined in the molars of *Dichodon*; and the enamel is smooth, not rugous as in *Merycopotamus*. Each true molar is implanted by four fangs. The first true molar (M 1) has its outer side relatively longer than the others, by reason of the larger size of the anterior basal cusp. The characteristic modification of the last premolar (P 4, fig. 3) may be understood by supposing the homologue of the anterior and external basal cusp (*a*) to have been

* "Order RUMINANTIA:—

"The molars, almost always six in number on each side of both jaws, have their crowns marked by two double crescents, the convexity of which is turned inwards in the upper jaw and outwards in the lower jaw." (Règne Animal, ed. 1829, vol. i. p. 254.) And again, defining the supposed peculiarities of the Ruminantia, "Les trois arrière-molaires supérieures des ruminans semblent être des inférieures retournées; elles sont de même formées de deux demi-cylindres, présentant chacun un double croissant, mais dont la convexité regarde en dedans." (Cuvier, Ossemens Fossiles, t. iv. p. 7.)

† Odontography, 4to, p. 566.

developed at the expense of the anterior and internal lobe (*i*, M 1) which has disappeared: the crown of the tooth is thereby extended from behind forwards and diminished in breadth: it presents also a trilobed character externally, but has a fourth lobe, *ï*, at the inner side of the posterior and external one, answering to the hinder and inner lobe *ï* of the true molars. The base of the outer side of the hinder and outer lobe (o') has its two tubercles like those of the true molars, and its inner convex base is similarly girt by the outwardly prolonged angles of the base of the inner lobe *ï*. From the inner side of the base of this lobe a ridge is continued forwards along the inner sides of the middle (*o*) and anterior (*a*) lobes. This tooth is implanted by one anterior and two posterior long fangs: there was no cavity of reserve, or germ of a successor, in the substance of the jaw above it.

The upper penultimate premolar (P 3) has also a long and narrow crown, three-lobed externally, but with the fourth posterior and inner lobe (*ï*) reduced to a simple cusp: a ridge is continued from the hind part of its base to the hinder angle of that of the lobe (o') external to it, and a second ridge extends from the fore-part of its base forwards to the anterior lobe (*a*). The middle of the three outer lobes (*o*) is the largest; they are all conical and pointed: there is a rudiment of the cusp answering to *e* in the true molars; the others are suppressed. This tooth is implanted by two long and divergent fangs.

The premolars corresponding to the first and second below have not been obtained; but a single-fanged tooth (fig. 2, C) with a simple trenchant crown appears to be the canine of this species, and it will be shown to belong to the upper jaw. The antero-posterior diameter of the crown of this tooth, C, is more than double its vertical extent; its chief summit is followed by a lower rising of a trenchant edge: the fang is grooved longitudinally on the outer side, indicating it to consist of two connate fangs, one for each division or rising of the crown.

The left premaxillary bone supports three incisors; their crowns, like the canine, are low but long, with a slight obtuse point near their fore-part, trenchant behind; convex outwardly, concave and with a basal ridge on the inside; the three teeth are set close together, the second slightly overlapping the third.

Thus of the dentition of the upper jaw of *Dichodon* we have the three true molars and last premolar *in situ* with a portion of the upper jaw, the penultimate premolar and the canine detached, and the three incisors with the premaxillary bone. The true molars manifest the type of crown most allied to that of the *Merycopotamus*, *Anthracotherium*, and other genera closely approximating to the Ruminant type; while the premolars have peculiarities of form and structure quite different from those in any known recent or extinct Herbivorous Mammal. In *Merycopotamus* the canines and incisors closely accord with the hippopotamic type of those teeth: in *Dichodon* they offer a nearer resemblance to the anoplotherian type.

The dentition of the lower jaw corresponds as closely with that of the upper jaw as it does in *Merycopotamus* or *Dichobunes*, and the true molar teeth present a strong resemblance to those of the latter Anoplotherioid subgenus. The inferior teeth are beautifully displayed in an entire right ramus and in a nearly entire left ramus of the same lower jaw (Pl. IV. figs. 2 & 3).

The first and second true molars (fig. 4, M 1 & 2) consist each of four semiconical high and sharp-pointed lobes, in two transverse pairs, with the convex sides turned outwards. The inner sides of the outer lobes *o*, *o'*, are smooth and nearly flat; the basal angles extend inwards, embracing the base of the inner lobes *i*, *i'*; and the ridge from the hind angle of the base of the hinder and outer lobe terminates by expanding into a small cusp behind the base of the hinder and inner lobe; from this cusp a sharp ridge extends not quite across the hind part of the base of the crown. The inner surface of the inner lobes is sinuous, convex in the middle, concave before and behind this part: each angle of the base is produced into a small ear-like lobule or cusp: thus there are five basal cusps along the inner side of the base of the crown, besides the two lofty pointed conical lobes (M 1, *i* and *i'*).

As the number of the restored annectent links increases in the Ungulate series of *Mammalia*, the marks of distinction become less salient, and the necessity for more minute attention to them is entailed upon the describer. The anterior margin of the outer and anterior lobe is slightly raised and swollen at its termination upon the fore-part of the base of the inner lobe: below this margin the fore-part of the base of the crown is traversed by a thin but sharp ridge (Pl. IV. fig. 6). There is a mere rudiment of a tubercle at the outer entry of the great median transverse cleft dividing the two pairs of lobes. The outer convexities (*o*, *o'*) of the principal lobes are subangular. Each lower true molar is implanted by two long fangs. The distinction between the four-lobed lower molars of *Dichodon* and those of *Dichobunes* is shown by the fifth inner basal cusp (fig. 5, M 1) posterior to the one at the back part of the base of the second inner lobe, and in the anterior and posterior basal ridges.

The premolars of *Dichodon* deviate still further from those of *Dichobunes*. I at first thought that the tooth (P 4) must be the last of the deciduous series, and that it indicated, as in the *Anoplotherium* and Ruminants, a third posterior division of the last molar tooth; but on excavating the jaw beneath it (as shown at P 4, fig. 2), not the slightest trace of either the germ of a successor or of the cavity for its matrix appeared, and it was evident from the length of the fangs and the small depth of the jaw,—only half that of the same part in the young Paloplothere,—that the tooth in place was destined to have no successor. This tooth agrees moreover in the antero-posterior extent of the crown and its three chief divisions with the last premolar above; the slightly-worn summits of which concurred, with the absence of any trace of a successor, in showing that it likewise could not have been in use during the period of the milk-dentition.

The last premolar (fig. 4. P 4) in the lower jaw has six semiconical lobes in three transverse pairs, slightly decreasing in size as they advance forwards, but repeating the characters of those of the true molars; the inner side of the base of each of the three inner lobes having the ear-like cusp on each side, and the posterior basal ridge terminating on the inner side in a smaller seventh cusp. There is a mere rudiment of the anterior basal ridge. The summits and sharp borders of each of the six lobes have been slightly abraded, and the dentine exposed, but along a mere linear tract in each lobe.

The penultimate premolar (P 3) retains only the hinder transverse pair of lobes; the middle and anterior lobes are single, subcompressed, convex on both inner and outer sides, which meet at trenchant and slightly-worn edges, trending away from before and behind the summit. The posterior cusp is present at the back part of the base of the inner and posterior lobe, but not at the fore part; the cusp behind the preceding is also wanting; there is a trace of the posterior basal ridge, and an obtuse belt at the inner side of the base of the anterior lobe which terminates in a feeble prominence anteriorly. This tooth has two long slightly diverging fangs.

The antepenultimate or second premolar (P 2) is three-lobed, the mid-lobe being the longest, the hind-lobe the thickest: this has a well-defined vertical ridge, with a notch behind it on its inner side; it is simply convex externally: the mid-lobe is less deeply indented on the back part of its inner side, is convex on the rest of that side, and on the outer side; the fore and hind sloping borders are trenchant: the front lobe is concave on the inner side, which has an obtuse border at its base: the antero-posterior extent of the crown of this tooth is thrice the vertical extent. It is implanted by two fangs.

The anterior premolar (P 1) is situated directly above the back part of the symphysis of the jaw: its crown is more compressed and trenchant than the second, and the anterior and posterior lobes are reduced to accessory basal cusps of the middle lobe: they are all so compressed as to produce an undulating trenchant summit, rising to a higher point at the middle: there is no indent dividing the anterior from the posterior lobe on the outer side; but their distinction is indicated by a depression on the inner side. This tooth is implanted by two fangs.

The left ramus of the lower jaw of the *Dichodon* includes a great portion of the symphysis, with the sockets of the canine and of two incisors, with a part of that of the anterior incisor, I 1. A detached single-fanged tooth which fits the socket of the canine (C), and one of the incisors equally fitting the vacant socket of the third of this series (I 3), accompanied this specimen. In both rami the canine precedes the premolar without any interval, and is as directly preceded by the third incisor, so that the whole series of teeth is uninterrupted, as in the extinct genera *Dichobunes*, *Anoplotherium*, and *Nesodon*.

The canine has a low but long trenchant crown, not rising into a point, resembling in its harmless character that of the *Anoplotheriidæ*: its outer side is gently convex; its inner side has two indentations.

The incisor has a smaller but more quadrate and truncate trenchant crown; it is also gently convex externally, and with two concavities internally.

A gubernacular orifice behind the rising crown of the second true molar indicated the concealed alveolus of the third molar, which I exposed in the ramus of the jaw (fig. 2, M 3). The matrix had either not begun to be calcified, or in such detached portions of the summits of the lobes that they had been lost: the chamber was filled with the fine eocene sand, and by its size indicated a rather larger development of the tubercle *e* than the first and second molars.

Thus the dental formula of the lower jaw of the present Mammal is proved to consist of three incisors, one canine, four premolars, and three true molars, in a continuous series in each ramus; and we must conclude that they were opposed by the same number of teeth in the upper jaw. The detached premaxillary demonstrates in fact the number and shape of the incisors of that jaw; the crowns of these incisors being, as in the Anoplothere, somewhat larger than those below. The single-fanged tooth which I have described as the upper canine shows the same proportional superiority of size over that of the lower jaw, with a correspondence of form which leaves no doubt in my mind of its being the opposing tooth of such lower canine. There are wanting, therefore, to establish *ex visu* the entire dental series, only the first and second premolars of the upper jaw and the last true molar of the lower jaw, the germ of which had not been sufficiently calcified at the time of the animal's death to yield satisfactory evidence of its true form.

The dental formula therefore of the genus *Dichodon* is:—

$$i\,\frac{3-3}{3-3};\ c\,\frac{1-1}{1-1};\ p\,\frac{4-4}{4-4};\ m\,\frac{3-3}{3-3}=44.$$

From the trenchant character of the ridges and the sharp points of the lobes of all the teeth, which in the molar series are bristled with cusps like those of some Insectivores, the food of the *Dichodon* would seem to have been of a peculiar character, perhaps not exclusively of a vegetable nature, but different from that of any of the small Ruminants or Pachyderms of the existing creation. From the number and sharpness of the pointed cusps of the teeth in the present species, I propose to call it *Dichodon cuspidatus*.

DESCRIPTION OF PLATE IV.

Fig. 1. Portion of lower jaw of *Paloplotherium*, with the four deciduous molars and first permanent molar, one canine and one incisor.

Fig. 2. Outside view of the lower jaw and teeth and parts of the upper jaw and teeth of *Dichodon cuspidatus*, nat. size.

Fig. 3. Grinding surface of most of the teeth of the upper jaw of ditto.

Fig. 4. Grinding surface of the teeth (M 3 excepted) of the under jaw of ditto.

Fig. 5. Inside view of the lower jaw and teeth and parts of the upper jaw and teeth of ditto.

Fig. 6. Hind view of the crown of the second upper molar of ditto.

Fig. 7. Grinding surface of second upper molar of *Merycopotamus*.

In each figure, I 1, 2, 3, indicates the first, second and third incisors; C the canine; P 1, 2, 3, 4, the premolars; M 1, 2 & 3, the molars. The letters of the lobes and cusps are explained in the text.

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3. *Notice of the occurrence of Fossil Remains of the* MEGACEROS HIBERNICUS *and of* CASTOR EUROPÆUS *in the Pleistocene deposits forming the Brick-fields at* ILFORD *and* GRAYS-THURROCK, ESSEX. By PROF. OWEN, F.R.S., F.G.S.

SINCE the publication of my 'British Fossil Mammalia,' two of the conclusions touching the so-called 'Irish Elk,'—viz. first, that its re-

From Nature on Zinc by J. Erxleben.

Day & Son Lith. to the Queen.

Fig. 1 Paloplotherium. Figs. 2. 6. Dichodon. Fig. 7. Merycopotamus.

mains had been found in different parts of England, in caves and stratified deposits, showing its equal antiquity with the extinct Mammals of the newer pliocene period; and, secondly, that there was no good evidence of its having ever existed in England or in Ireland contemporaneously with Man,—have been called in question in a pamphlet by H. D. Richardson, Esq., entitled 'Facts concerning the Natural History, &c. of the Gigantic Irish Deer,' 8vo, 1846; and in letters by Messrs. Nolan and Glennon published in the 'Dublin Evening Post,' Nov. 14, 1846, and by the editor of the 'Dublin Farmers' Gazette' of November 28th, 1846.

Mr. Richardson affirms that the specimens described (Phil. Trans. 1746, vol. xliv. pt. i.) and in my 'British Fossil Mammalia,' pp. 466, 467, as having been found in England, had been previously "*sent* over from Ireland" (p. 41). He makes the same statement with regard to those described by Cuvier as having been found in diluvian deposits on the continent of Europe, and he affirms "that the 'skeleton found in the Isle of Man,' and now in the Edinburgh University, was not originally found in the Isle of Man," but "was brought from Ireland." (*ib.* p. 38.)

Leaving to those who have more immediate interest in the continental and Manx specimens to verify the current and accepted history of the place of their discovery, if they deem the counter-assertions in the pamphlet quoted to call for further investigation, I may be excused for repeating, with regard to the specimens cited in my work as having been discovered at Walton in Essex, at Hilgay in Norfolk, and in Kent's Hole, Devon, that they presented the same degree of fossilization, the same specific gravity, colour and other physical characters, as those of the bones and teeth of the Mammoths, Rhinoceroses, and other extinct Mammals found in the same formations and localities, although the concurrent affirmations of our esteemed fellow-members John Brown, Esq. and Whickham Flower, Esq., with that of the late Rev. Mr. McEnery, stand in no need of such corroborative testimony from the fossils themselves. I have since received additional evidence of the coexistence of the fossil remains of the *Megaceros* with the extinct Mammals in the pleistocene brick-earth of Essex.

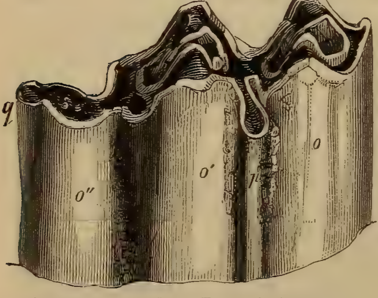
Mr. Ball, a diligent and successful collector from those deposits, has from time to time submitted to my inspection series of fossils obtained from the brick-fields at Grays-Thurrock and Ilford, including remains of *Elephas, Rhinoceros, Ursus, Hyæna, Equus, Bos, Sus,* &c. In one of these collections was the os frontis and the bases of the great antlers of the *Megaceros,* showing the beginning of their characteristic expansion or 'palm,' the origin of the brow-antler, and every mark of agreement with the corresponding parts in specimens of *Megaceros hibernicus* from the subturbary marls of Ireland, with which it also agreed in size. The fragment of skull showed the characteristic transverse bar or rising between the origins of the antlers. The physical characters of the specimens, resulting from change of original texture through long interment, were precisely those of the associated fossils of other pleistocene Mammals. The specimen is now in the Museum of the Royal College of Surgeons, London.

Since I examined these remains, Dr. Cotton, of Bolton-street, Piccadilly, has kindly submitted to my inspection the entire ramus of the under jaw of the *Megaceros hibernicus* from the brick-earth at Ilford, Essex, obtained by himself upon the spot. This specimen, like Mr. Ball's, has undergone the same amount of change as the other mammalian fossils from that pleistocene deposit. With the *Megaceros* Dr. Cotton also obtained a considerable portion of the lower jaw of the *Castor europæus*; a circumstance which is interesting in so far as remains of the *Megaceros* have been found similarly associated with the Beaver, now extinct in England, though still existing on the continent, by Mr. Whickham Flower, in a subturbary deposit at Hilgay, Norfolk.

I have not seen any authentic Irish specimen of the *Megaceros* so much fossilized, or of the colour of those from the Essex pleistocene strata and from the Devonshire cavern. The specimens submitted to me by Mr. Brown of Stanway from the till at Walton, by Dr. Cotton and Mr. Ball from the brick-earth at Ilford and Grays, and by Mr. McEnery from Kent's Hole, were severally obtained by those gentlemen in person at the localities mentioned. Instances have also occurred of English collectors having discovered fossil remains of the *Megaceros* in England without being aware of their nature and rarity. In making a list of the fossils in the collection of the late Mr. Gibson of Stratford, Essex, chiefly obtained from the pleistocene deposits in that county, and which since his decease have been liberally presented by his son, the Rev. R. Gibson, M.A., to the Royal College of Surgeons, I found that a considerable portion of the ramus of the lower jaw, with the molar teeth of the *Megaceros hibernicus*, had been labelled *Bos*. It was in the same fossilized condition as the true Bovine remains from the brick-earth, and as the ramus of the jaw of the *Megaceros* from Ilford, in Dr. Cotton's collection.

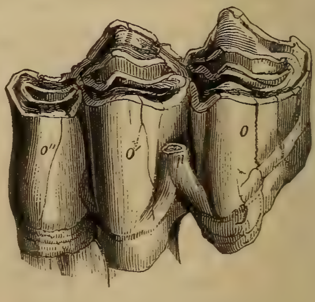
I have pointed out the distinctions between the upper molars of *Megaceros* and those of *Bos* in my 'British Fossil Mammalia,' p. 450: those of the lower molars are as easily recognizable. In the great Bovines, where the size of the teeth is nearly the same as in *Mega-*

Fig. 1.



Last lower molar. *Bos primigenius.*

Fig. 2.



Last lower molar. *Megaceros.*

ceros, the anterior outer interspace of the last molar (fig. 1), and the outer interspace between the two lobes of the first and second molars, are occupied by a slender but long accessory column of enamelled dentine (*p*); in *Megaceros* this column is represented in those teeth by a pyramidal tubercle at the bottom of the interspace (fig. 2. *p*).

In molars, therefore, which have been worn down to the same extent as in those of the fossil Bovine and the Megaceros represented in

Fig. 3. *Bos primigenius.*

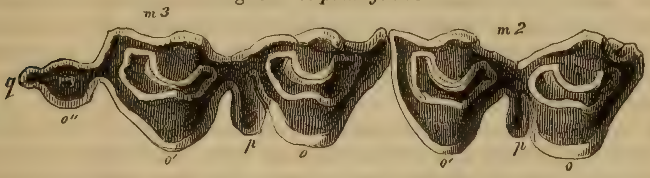


Fig. 4. *Megaceros.*

figs. 3 & 4, the column, *p*, increases the complexity of the grinding surface in the one, but not in the other. The third lobe, *o″*, in the last molar, M 3, of Bovines is terminated by a similar enamelled column or 'columella,' *q*, fig. 1, which is not present in the Megaceros. The minor differences of the grinding surface are sufficiently illustrated by the figures, which may aid future collectors in determining similar evidences of additional examples of *Megaceros* in British pleistocene strata.

The teeth of the *Bos longifrons* are readily distinguished by their smaller size. This species of *Bos* co-existed with *Megaceros* in Ireland, and in England with *Megaceros, Rhinoceros, Elephas, Hyæna,* &c.

Remains of *Bos longifrons* have, however, also been found in the bog itself, as well as in the subjacent marl, in Ireland; but I have not, as yet, had any trustworthy and authentic evidence of the discovery of undisturbed remains of *Megaceros* in the peat-bog above the shell-marl in any part of Ireland.

Remains of *Bos longifrons* have been found in ancient places of sepulture, and so associated with British and Roman remains, as to leave little doubt of its having survived, as a species, many of the mammals with which it was associated during the pleistocene period in geology. Whether the *Megaceros,* likewise, continued to exist until the 'Human period,' is a question on which I have never entertained or expressed a decided opinion, knowing the uncertainty of negative evidence. But, as yet, I am bound to state that no good evidence to the contrary, *i. e.* no evidence demonstrating the co-existence of remains of *Megaceros* with those of *Man*, or in any shape proving it to have come down to the traditional or historical period, has been adduced.

I have personally and carefully examined the skulls of the *Megaceros* affirmed by the correspondents of the 'Dublin Evening Post' and the 'Farmers' Journal' to have been slaughtered for human food, at Lough Gar near Limerick; and have explained the nature of the mutilations of the fossil skull, which have been interpreted as proof that the animals "had been knocked on the head when alive." The breaking-away of the antlers from the skull during or after exhumation both led to that fallacy and to the mistake of the skulls of the male for those of the female *Megaceros**.

The unequivocal and well-established facts made known since the publication of my 'British Fossil Mammalia,' have served to confirm the fact of the former existence in England of the gigantic extinct broad-antlered deer, '*Megaceros hibernicus*'; and this evidence, though it be still less abundant than that of the former existence of the same species in Ireland, is equally conclusive and of greater value, inasmuch as it establishes the contemporaneity of the *Megaceros* with the Mammoth, Rhinoceros, and other extinct Mammalia of the period of the formation of the newest tertiary freshwater fossiliferous strata.

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4. *Description of an upright* LEPIDODENDRON *with* STIGMARIA ROOTS, *in the roof of the* SYDNEY MAIN COAL, *in the* ISLAND OF CAPE BRETON. By RICHARD BROWN, Esq.

[Communicated by Charles J. F. Bunbury, Esq., F.G.S.]

MANY eminent geologists have long entertained the opinion, that Stigmariæ are nothing more than the roots of Sigillariæ, and this opinion has been supported by so many recorded cases during the last two or three years, amongst which I may include one from the Sydney coal-measures, an account of which appeared in the 8th Number of the Journal of the Geological Society, that I think no further doubts can remain concerning the real nature of those fossils.

Since I forwarded to the Society a description of the Sydney Sigillaria about twelve months ago, I have discovered several upright trees in the coal-measures, evidently *not* Sigillariæ, with roots of Stigmariæ united to them. These trees exhibited so many of the peculiar characteristics of Lepidodendron, that I at once concluded they belonged to that genus; but having never even seen it hinted that Lepidodendron possessed Stigmaria roots, and distrusting my own skill in fossil botany, I determined to wait until I could collect more decisive evidence in confirmation of my opinion. This evidence I have now obtained in another example, fortunately most complete in all its parts, a description of which I hasten to lay before the Society, accompanied with sketches, which I hope will clearly prove

* See my Letter to the Editor of the 'Dublin Evening Post,' Dec. 19th, 1846.

that the stem in question is a genuine Lepidodendron united to roots of Stigmaria.

The main coal, six feet in thickness, is overlaid by a shale roof abounding in plants. Occasionally when the coal is worked out, large masses of shale fall down, leaving hollow spaces known to the miners by the name of "Pot Holes"; the fallen masses being in fact the roots and truncated stems of Sigillariæ and other trees, which separate at the parting formed by the coaly bark covering the roots, when the supporting coal is taken away. The pit overman having brought me several pieces of the root of a tree from one of these pot-holes, showing the areolæ of Stigmaria scattered amongst rhomboidal markings peculiar to Lepidodendron, I caused the timber props to be taken out, which allowed the shale roof to fall and bring down with it the remaining roots and a piece of the stem of the tree.

Fig. 1.

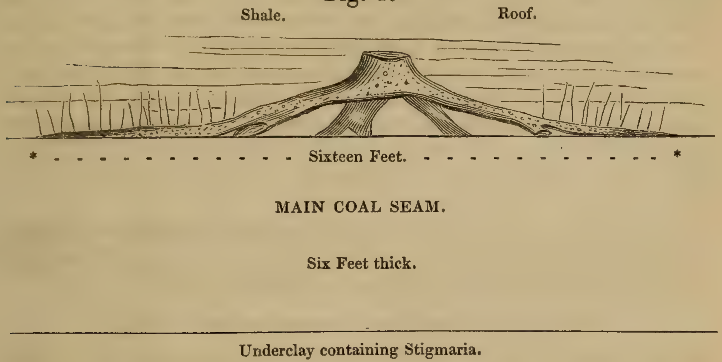


Fig. 1. Section showing the position of the tree above the coal seam, with the inclination and lengths of two of the principal roots so far as they could be distinctly traced.

Fig. 2.

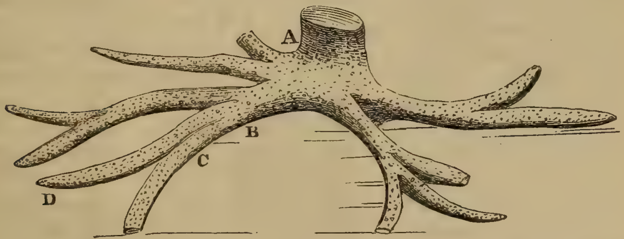
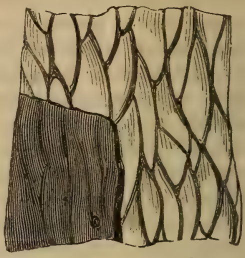


Fig. 2. Sketch of the trunk with its branching roots, constructed from careful measurements of the dimensions and position of each root, taken on the spot.

The stem being composed of friable shale arranged in horizontal layers, separated and fell away from the bark when the props were removed, leaving a hollow cylinder of coaly matter one-third of an inch thick adhering to the surrounding shale. Part of the inner surface of this coaly bark fell down with the stem, but its scaly structure was distinctly visible. The impression of the outer surface of the bark (*b*) upon the enveloping shale is undoubtedly that of Lepidodendron, as will be seen by referring to fig. 3, which is a sketch of a piece taken from the part marked A in fig. 2, (*a*) being the inner surface. The stem is not quite cylindrical, its longest diameter, which lies in the direction of the strike of the coal seam, being 15 inches, and that at right angles thereto only 12 inches.

Fig. 3.



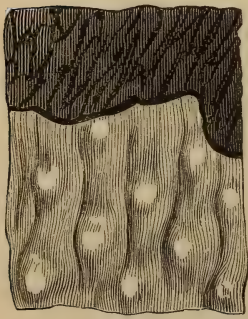
Half nat. size.

Four main roots spread out nearly at equal distances from one another, which fork at about 30 inches from the centre of the stem, where their width is 12 inches, and depth from 2 to 3 inches. Two of these branches fork again, as shown in fig. 2; their width at the second forking being 7, and depth $1\frac{1}{2}$ inches. Beyond this they gradually taper off to about 2 inches in width by $\frac{3}{4}$ in depth. I followed one of these small roots two feet further, where it appeared to terminate in contact with the coal seam, in a flat obtuse point; but I have only represented in fig. 2 such parts as were plainly visible and could be correctly measured.

All the roots are enveloped in a coaly bark one-tenth of an inch thick near the first forking, which thins off to a mere film at their extremities. At 12 inches from the stem, the rhomboidal structure of the external surface of this bark is quite distinct; it grows fainter, but is still visible, as far down as the first forking at C, fig. 2. This bark is closely marked with fine parallel transverse striæ.

Decorticated pieces of root taken from the spots marked B, C &

Fig. 4.



Half nat. size.

Fig. 5.

Half nat. size.

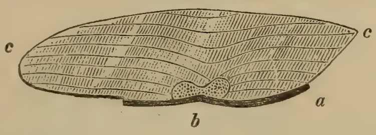
Fig. 6.

Half nat. size.

D, fig. 2, are represented at (*b*) in figs. 4, 5 & 6 respectively, (*a*) being the bark. At B, the areolæ (in which the black ring and central dot commonly observed in Stigmaria are absent) consist of small oval-shaped knobs or eminences arranged in spiral lines; the surface is also marked with waving longitudinal striæ. At C, the decorticated root is distinctly imbricated like the stem, but the areolæ, although very perfect, do not appear to be arranged in any regular order. Near the extremity of the root at D, the surface is marked "in quincuncial order with depressed areolæ, with a rising in the middle, in the centre of which rising a minute speck is observable*." The surface of this part of the root is also marked by longitudinal sinuous lines alternately approaching and receding, which cause a strong resemblance to the waving rhomboidal spaces exhibited by *Lepidodendron obovatum*. I observed rootlets spreading upwards from the areolæ into the shale between the first forkings and the extremities, but none near the stem. There are no visible traces of rootlets in the coal, although there can be no doubt that they penetrated deeply into the underlying mass of vegetable matter from which the tree derived its chief nutriment, the areolæ being much larger and more distinct upon the under than the upper sides of the roots.

The roots are filled with a hard dark bluish shale arranged in nearly horizontal layers, inclining a little towards the core or pith, which is impregnated with iron pyrites and lies on the under side of the roots, sometimes in contact with the coaly bark, as shown in fig. 7, which is a transverse section of a piece at 6 feet from the stem; (*a*) being the bark, (*b*) the core or pith, and (*c*, *c*) the lines of bedding in the shale. Nearer to the stem, the core, which is much flattened, has almost maintained its original position in the centre of the roots; in some places no traces whatever of the core could be found. These roots must have been perfectly hollow before the deposition of mud within began, fern-leaves being interposed between the layers of shale, which could only have obtained access thereto by settling down through the trunk from above. It must be observed, the preceding description of the roots refers only to the most perfect branch I could select; many of the others have been so much crushed and distorted, that it is impossible to make out either any rhomboidal structure or regular order in the arrangement of the areolæ.

Fig. 7.



Since it has been shown that Lepidodendra possessed roots and rootlets of Stigmariæ, bearing a strong resemblance to those which have so often been found united to Sigillariæ, we certainly have good reason to conclude that all the large trees, which flourished during the carboniferous period, were furnished with roots of a similar character, especially adapted to the soft muddy soil which universally prevailed over those areas upon which coal strata were accumulating, none of a different description having yet been found in the roofs or underclays of the coal seams.

* I quote from Steinhauer's description of Stigmaria, which applies precisely to this part of our fossil.

In conclusion, I may observe that this instance affords strong additional proof, if any were required, that coal seams were formed from plants which grew upon the spot; since we here find not only the roots of the ancient forest which flourished upon the under-clay of the main coal, but also, so soon as the materials for that coal had accumulated, whether in the shape of a peat-bog or otherwise, and, in consequence of a slight submergence under water, had been covered with a few feet of mud, that another forest of Sigillariæ*, Lepidodendra, &c. immediately sprang up, which in its turn, owing to a further subsidence of larger amount, was submerged, and buried by a deposit of coarse sand 24 feet in depth, forming the succeeding bed to the shale in the ascending series.

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5. *On the Discovery of* Coal *on the* Island of Labuan, Borneo. By Thomas Bellot, Esq., Surgeon R.N.

Coal has been discovered near the river Gooty, on the east coast of Borneo. It resembles the best cannel coal, and burns readily, leaving a little ferruginous ash. The bed is about three feet thick, and is covered by grey shale and red sandstone. The island of Labuan consists of reefs of coral and beds of soft white sandstone with layers of blue clay. Near the north-east point of the island a bed of coal, six feet or more in thickness, has been discovered in several places. Some of this coal has been used on board the ship, and it is found to burn well and leave very little ash.

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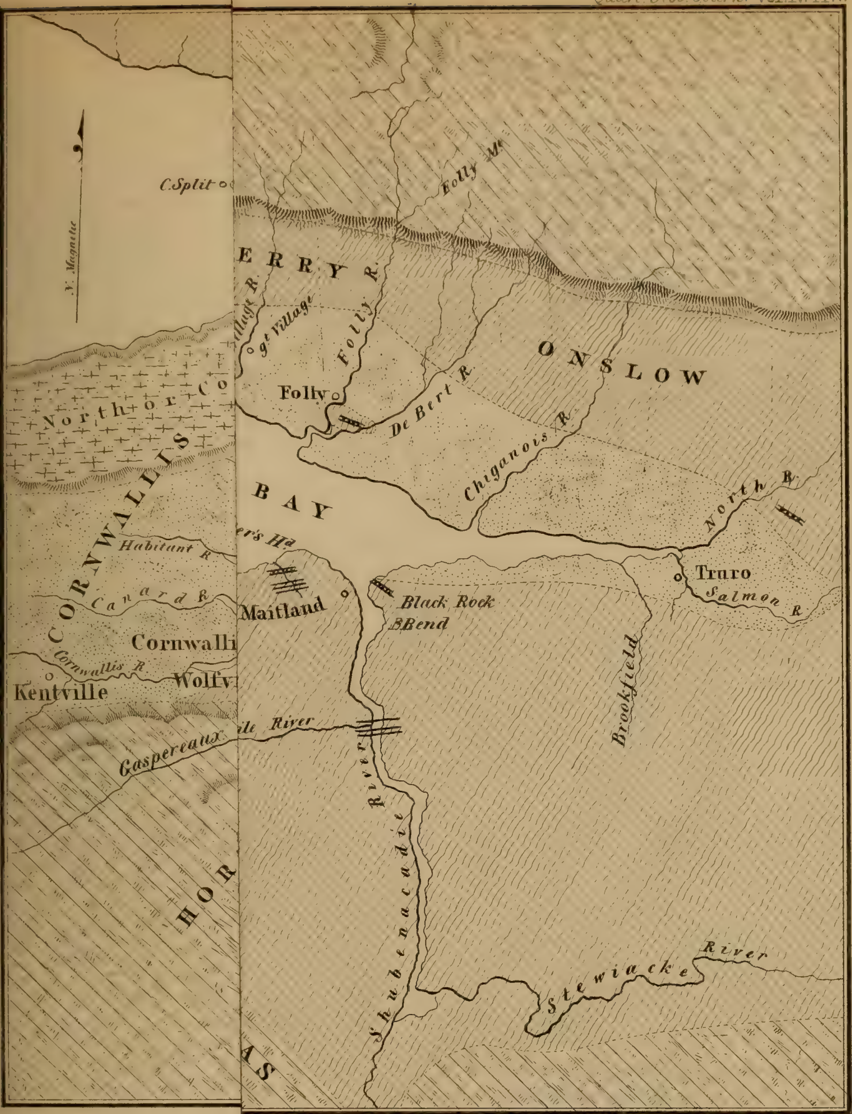
6. *On the* New Red Sandstone *of* Nova Scotia. By J. W. Dawson, Esq.

In several late papers on the carboniferous rocks of Nova Scotia, reference has been made to a deposit of red sandstone skirting the shores of Cobequid Bay, and resting unconformably on strata of the carboniferous system. I propose in the present paper, to describe this formation as it occurs in the above-named locality, and in other parts of the country bordering the southern arm of the Bay of Fundy, retaining provisionally the name of New Red Sandstone, which is at least locally appropriate.

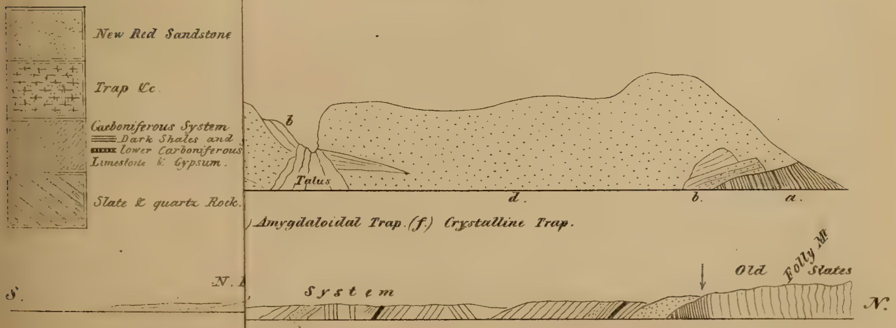
The new red sandstone of Nova Scotia has already been described by Messrs. Jackson and Alger, and by Dr. Gesner. The attention of these geologists was however directed rather to the structure of the trap, and to the numerous crystallized minerals which it contains, than to the geological relations of the deposit; and they did not distinguish it from a group of sandstones, with beds of limestone and gypsum, occurring in its vicinity, which has since been shown by Mr. Lyell to belong to the carboniferous system.

* Sigillariæ with roots of Stigmariæ attached to them are very abundant in the roof of the main coal, often occurring at intervals of a few yards.



on stone by Reeve Benham & Reeve.

VA SCOTIA.



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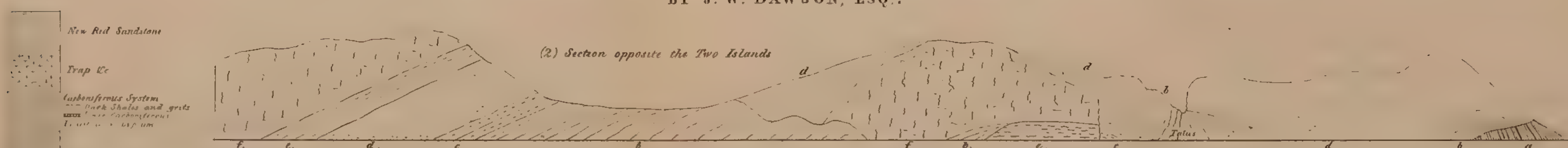
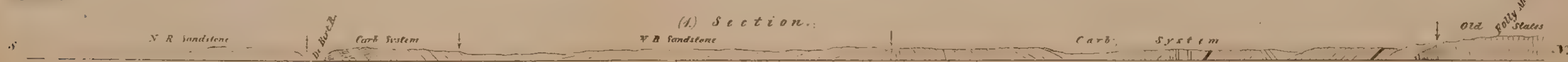
MAP AND SECTIONS OF NEW RED SANDSTONE OF NOVA SCOTIA.

BY J. W. DAWSON, ESQR.



(a) Black shales and hard grey & brown Sandstones of Carboniferous System (b) Soft red Sandstones with greenish bands (c) Do with fragments of Trap. (d) Trap Conglomerate & Breccia. (e) Amygdaloidal Trap (f) Crystalline Trap.



1. *Truro and south side of Cobequid Bay.*

In the valley of the Salmon River, four and a half miles eastward of the village of Truro, the eastern extremity of the new red sandstone is seen to rest unconformably on hard reddish brown sandstones and shales, belonging to the lower part of the carboniferous system, and dipping N. 80° E. at an angle of 40°. At this place the overlying formation is nearly horizontal, and consists of soft and rather coarse bright red siliceous sandstones. Southward of Truro, at the distance of less than a mile, the horizontal soft red sandstone is seen, in the banks of a brook, to run against hard brownish grits and shales, dipping to the eastward at angles varying from 45° to 50°. Westward of this place, the red sandstones extend in a narrow band, about a mile in width, to the mouth of the Shubenacadie, ten miles distant. This band is bounded on the north by Cobequid Bay, and on the south by highly inclined sandstone, shale, and limestone of the lower carboniferous series. In the coast section, between Truro and the Shubenacadie, the red sandstone presents the same characters as at the former place, except that, near the Shubenacadie, some of the beds, which like most of the red sandstones of Truro have a calcareous cement, show a tendency to arrangement in large concretionary balls.

West of the mouth of the Shubenacadie, the country as far as the estuary of the Avon is occupied by lower carboniferous rocks, similar to those seen in the banks of the former river; perhaps with the exception of Salter's Head, and a few other projecting points which appear to consist of nearly horizontal red sandstone resembling that of Truro.

2. *North side of Cobequid Bay and Mines Basin from Truro to the Five Islands.*

Northward of Truro the red sandstone meets and overlies unconformably the carboniferous grits, shales, limestone and gypsum, of the North River and Onslow Mountain, its boundary in this direction being about three miles distant from the bay. From the North River it extends in a belt about three miles wide to the De Bert River, where an apparently insulated patch of rocks with characteristic lower carboniferous fossils projects through it. This island of carboniferous strata shows general high north-east dips, while the surrounding red sandstones dip at small angles at the south-west. I have represented this arrangement in sect. 1. Pl. V., which extends from the metamorphic slates and quartzite of the Cobequid range to the shore, and shows the strata as observed along the Folly River and part of the De Bert River.

It may be proper here to remark, in reference to the position of the new red sandstone and carboniferous system as seen in this section, that the latter forms a long belt, extending along the foot of the Cobequid hills, parallel to the red sandstone; and that in this belt the carboniferous rocks, though often much fractured and disturbed, have a prevailing trough-shaped arrangement. On the north side of this trough, near the base of the hills, the carboniferous rocks consist of hard grey conglomerates, grey and reddish grits and dark shales, with fossil plants; but marine limestones and gypsum appear only on the southern side of the synclinal axis, or where the beds again dip toward the hills. It results from this arrangement, that in the district now under consideration, the new red sandstone, with general southerly dips, meets and overlies lower carboniferous rocks, usually dipping to the northward; and that those portions of the carboniferous system which contain limestones with marine shells, gypsum and the largest proportion of reddish sandstones, usually occur very near the junction of that system with the new red sandstone.

In the section of the Folly River, the new red sandstone meets the main body of the carboniferous rocks about five miles from the shore. At this place it is coarse and sometimes pebbly; and near its junction with the older formation its dip increases till it amounts to 50°. Westward of the Folly River, the belt of red sandstone gradually decreases in width, and begins to contain in its lower part thick beds of red conglomerate, made up of fragments of the neighbouring older rocks united by red sandstone.

In the banks of Economy River, seventeen miles westward of Folly River, the red sandstone and conglomerate, which near the shore dip to the southward at a low angle, assume an undulating arrangement as they approach vertical, hard, brown and grey grits, and shales of the carboniferous system. After passing these vertical rocks, red conglomerate and soft red sandstone, with a south-west dip, again appear in the section for a short distance, and are again succeeded by vertical carboniferous grits and shales, which continue to the base of the hills. At a short distance eastward of the Economy river, the carboniferous rocks contain a bed of limestone, with *Producta Martini* and other fossil shells.

In Gerrish's Mountain, six miles west of Economy River, the red sandstone and conglomerate are overlaid by amygdaloidal trap, and having been protected by it from denudation, rise into an eminence nearly 400 feet high. At Indian Point, the southern extremity of Gerrish's Mountain, the trap and red sandstone form a bold precipitous cliff, and are continued along the picturesque rocky chain of the Five Islands, in two of which the red sandstone is seen to underlie the trap.

3. *North shore of Mines Basin, from Five Islands to Cape Sharp.*

Between Five Islands and Swan Creek, ten miles distant, an excellent coast section, often rising into lofty cliffs, shows the new red sandstone and trap as well as the underlying carboniferous strata.

At the mouth of Harrington River, opposite the Five Islands, the carboniferous rocks approach the shore very closely; and as seen in the west side of the river, consist of black shales and dark-coloured sandstones with *Flabellaria* and other fossil plants. They dip at high angles to the south, and are met by the new red sandstone dipping gently to the southward. The sandstones of the newer formation here contain little conglomerate, and are variegated by numerous greenish bands and blotches. They occupy the shore for some distance, and then contain a thick bed of trap conglomerate, consisting of large partially rounded fragments of amygdaloidal and compact trap, united by a hard brownish argillaceous cement. At a short distance westward, another bed of trap conglomerate of the same kind appears in the cliff. It is overlaid by a bed of dark clay, filled with angular fragments of black shale constituting a kind of breccia. The sandstone underlying this bed of trap contains small nodules of selenite and narrow veins of reddish fibrous gypsum. No other volcanic rocks occur in the coast section near these trap conglomerates. Westward of this place, the section is occupied for about three miles by soft red sandstones with greenish bands, dipping generally to the south-west: some of them are divisible into very thin layers, whilst others are compact and form beds several feet in thickness.

Near Moose River the red sandstones meet black shales and hard grey sandstones of the carboniferous system, containing *Flabellaria*, *Ferns* and *Lepidodendra*. At this place the junction of the two groups of rocks was not, at the time of my visit, well-exposed in the cliff, and had the appearance of a fault; but as seen in the horizontal section on the beach, the red sandstone with a south-west dip seems to overlie unconformably the carboniferous strata, dipping at a high angle to the E.N.E. On the west side of Moose River the carboniferous strata include three large masses of trap which have altered the grits and shales in contact with them, causing them to assume reddish colours. Beyond the last of these masses of trap, the shales and grits, there dipping to the north and north-east, have some red sandstone resting on their edges, and are succeeded by another great mass of trap forming a lofty cliff, and in part at least resting on soft red sandstone which it must have overflowed when in a fluid state. At the western side of this mass, or rather bed of trap, its upper surface is seen to dip to the W.S.W., and is conformably overlaid by red sandstones similar to those already described. These continue with various dips to a cove where there is a break in the section, westward of which the coast exhibits the interesting and complicated appearances which I have endeavoured to represent in section 2. Pl. V.

The lower part of the cliff, on the western side of the cove abovementioned, consists of hard, black and reddish shales and grits, like some of those seen near Moose River, with a steep dip to the E.N.E. Resting on the edges of these are a few beds of red conglomerate and sandstone with greenish bands, dipping to the south-west and apparently a remnant of more extensive beds. An enormous mass of trap conglomerate forms a high cliff towering above this little patch of sandstone, and is seen a little further on to contain a wedge-shaped bed of red sandstone, and at its western extremity rests on red sandstone mixed with fragments of trap. Here the trap conglomerate seems to be cut off by a fault, and abuts against a great trappean mass, composed in ascending order of amygdaloidal trap, a wedge of red sandstone extending over part of the surface of the amygdaloid, a great bed of crystalline trap, and a bed of trap conglomerate. The western side of this mass rests on an apparently denuded surface of soft red sandstones, with S.S.W. dip. These are overlaid by another trappean mass, consisting of beds which appear to dip conformably with the underlying sandstones. At its western side it abuts against greatly disturbed red sandstones succeeded by other red sandstones dipping to the southward, and extending as far as Swan Creek.

On the west side of Swan Creek, the soft red and variegated sandstones are seen to dip to the north at an angle of 30°, and are underlaid by a bed of trap conglomerate, which rests against disturbed strata of a composition different from any previously occurring in this section. They consist of laminated, compact and brecciated grey limestone, a bed of white gypsum, hard reddish purple and grey marls and sandstones, some of them with disseminated crystals of specular iron ore. I saw no fossils in these beds, but as they are identical in mineral character with some parts of the gypsiferous member of the carboniferous group, and have evidently been disturbed and altered before the deposition of the overlying trap conglomerate and red sandstone, I have no doubt that they belong to the carboniferous system, the sandstones and shales of which, with some trappean rocks, occupy the cliff between this place and Partridge Island five and a half miles distant. The new red sandstone in the vicinity of Swan Creek appears to form a small synclinal trough, occupying an indentation in the carboniferous rocks, and probably extending only a short distance westward of the mouth of the creek. The two islands near Swan Creek are detached masses of trap, resting on or rising through red sandstones, which at low tide are seen to extend between them and the shore. The red sandstone and trap, occurring in the section between Five Islands and Swan Creek, appears to be a very narrow band, extending parallel to the coast; and as the section is nearly in the general direction of the strike of the formation, it is probable that some of the trappean masses above-described are portions of beds disconnected by faults and denudation.

Partridge Island consists above of black crystalline trap, with a vertical columnar structure. On the western side, this is seen to rest on a thick mass of amygdaloid and earthy and arenaceous tufa. Underlying these, at the north-western extremity of the island, are a few beds of soft red sandstone with greenish bands, dipping to the southward. The mainland opposite consists of vertical and hardened dark-coloured sandstones and shales of the carboniferous system, containing Flabellaria, Ferns, and shells of a species of Modiola and of Unio. Vertical and contorted carboniferous strata occupy the coast section as far as Cape Sharp, three miles distant. This promontory consists of trap and underlying red sandstone, as at Partridge Island, except that trap conglomerate and breccia take the place of the finer tufaceous matter seen at the latter place. Westward of Cape Sharp, the coast consists chiefly of carboniferous rocks, with some isolated masses of trap, associated with red sandstone, in small patches. These I have not been able to examine.

The compact trap occurring in the sections above-described, is a fine-grained crystalline augitic rock of a dark grey or blackish colour, and often with a rude columnar structure. The amygdaloid is of a grey colour, and its vesicles are usually filled with zeolitic matter.

Many beautiful crystallized minerals occur in the trap rocks of the sections described. The masses near Moose River contain cavities coated with opake white varieties of quartz, in stalactitic and other imperfectly crystalline forms. Opposite the Two Islands, the fissures of the trap are lined with fine crystals of analcime and natrolite; and the fissures and vacant spaces of the trap conglomerate in the same neighbourhood contain a reddish variety of chabasie in rhombohedrons, often of large size. At Partridge Island, stilbite, calcareous spar and quartz, in various states, are the prevailing minerals; they occur chiefly in the amygdaloid and tufa, in fissures which also contain chabasie, heulandite and other zeolites, though in smaller quantity than the minerals above-named.

4. *Blomidon and the Valley of Cornwallis, on the south side of the Bay of Fundy.*

Blomidon is the eastern termination of a long band of trappean rocks, forming an elevated ridge, named in the greater part of its length the North Mountains. This ridge is about 123 miles in length, including two insular portions at its western extremity, and does not exceed five miles in breadth, except near Cape Blomidon, where a narrow promontory, terminating in Cape Split, extends to the northward. The trap of the North Mountains presents to the Bay of Fundy a range of high cliffs, and is bounded on the inland side by soft red sandstones, which form a long valley separating the trappean rocks from another and more extensive hilly district occupied principally by metamorphic slates and granite. The trap has protected the softer sandstones from the waves and tides of the Bay, and probably also from older denuding agents; and where it terminates, the shore at once recedes to the southward, forming the western side of Mines Basin, and affording a cross section of the North Mountains and the valley of Cornwallis.

At Cape Blomidon, the cliff, which in some parts is 400 feet in height, is composed of red sandstone surmounted by trap. The sandstone is soft, arranged in beds of various degrees of coarseness, and is variegated by greenish bands and blotches. It contains veins of selenite and fibrous gypsum, the latter usually parallel to the containing beds, but sometimes crossing them obliquely. I found no fossils in it: it dips to the north-west at an angle of 16°. Resting on the sandstone, and appearing to dip with it to the north-west, is a thick bed of amygdaloidal trap, varying in colour from grey to dull red, but in general of greyish tints. It is full of cavities and fissures; and these, as well as its vesicles, are filled or coated with quartz, in different states, and with various zeolites, especially heulandite, analcime, natrolite, stilbite and apophyllite, often in large and beautiful masses of crystals. In its lower part there are some portions which are scarcely vesicular, and often appear to contain quartz sand like that of the subjacent sandstone. Above the bed of amygdaloid is a still thicker stratum of crystalline trap, precisely similar to that of Partridge Island, and like it having a rude columnar structure.

The columnar trap of Blomidon, in consequence of its hardness and vertical joints, presents a perpendicular wall extending along the top of the precipice. The amygdaloid beneath, being friable and much fissured, falls away in a slope from the base of this wall, and the sandstone in some places forms a continuation of this slope, or is altogether concealed by the fallen fragments of trap. In other places the sandstone has been cut into a nearly vertical cliff, above which is a terrace of fragments of amygdaloid.

Northward of Cape Blomidon, the north-westerly dips of the sandstone and trap cause the base of the former to descend to the sea level, the columnar trap, which here appears to be of increased thickness, still presenting a lofty cliff. Southward of the Cape, on the other hand, the amygdaloid and basalt thin out, until the red sandstones occupy the whole of the cliff. It thus appears that the trap at Blomidon is a conformable bed, resting on the sandstone, exactly as in some places already described on the opposite shore.

The coast section between Blomidon and Horton, as seen near Perean River and Bass Creek, and at Star's Point, Long Island and Bout Island, exhibits red sandstones, with north-west dips at angles of about 15°, and precisely similar in mineral character to those of Blornidon, except that near Bass Creek some of them contain layers of small pebbles of quartz, slate, granite, and trap. The whole of these sandstones underlie those of Blomidon, and resemble those which occupy the long valley of Cornwallis and the Annapolis River, westward of this section. In this valley, the red sandstone, in consequence of its soft and friable nature, is rarely well-exposed; but in a few places in Cornwallis where I observed it, it has the same dip as on the coast. The comparatively high level of the sandstone, where it underlies the trap, shows that the present form of this valley is in great part due to denudation; and the trap itself must have suffered from this cause, since fragments of it and of the quartzose minerals which it contains, are frequent in the valley of Cornwallis, and along the base of the slate hills to the southward.

We may now consider the relations of the red sandstone of Cornwallis to the other formations bounding it on the south. Near Kentville, seven miles westward of the direct line of section from Blomidon to Horton, the red sandstone with its usual north-west dip, rests against clay-slate having a high dip to the N.N.E., and belonging to a series of similar rocks apparently equivalents of the Silurian system. In tracing the boundary of the slate eastward of this place, along the south side of Cornwallis River, its junction with the red sandstone is not again observed; and at Wolfville the slates support hard grey sandstones, composed of the materials of granite, with some beds of brownish sandstone. These rocks were observed in one place to dip to the north-east, and in another to the N.N.W. They are separated from the red sandstones of Bout and Long Island, and Star's Point, by a wide expanse of marsh, and by the estuary of the Cornwallis River. In Lower Horton, and between that place and Halfway River, grey sandstones, similar to those of Wolfville, are seen to support black shales and dark sandstones, with *Lepidodendra* and other fossil plants of carboniferous forms, and dipping to the N.E. N. & N.W.

At Horton Bluff, at the mouth of the estuary of the Avon River, these dark shales and sandstones, with grey and reddish sandstones like those of Wolfville, and containing Lepidodendron, Flabellaria, and scales of fish, are well-exposed, and have been described by Mr. Lyell. Some additional facts respecting them will be found in the Appendix to this paper. At the north end of the section at Horton Bluff the dark shales dip to the southward. They are then concealed by boulder clay, which with a marsh occupies the shore for nearly a mile. Beyond this, in a small point named Oak Island, are seen a few beds of coarse red sandstone, with some finer red beds and grayish bands. These beds dip to the N.N.W., and form a continuation, and the eastern termination of the red sandstones of the Horton Islands and of Cornwallis.

It appears from the facts above-stated, that the red sandstones of Cornwallis and Horton, though not seen in contact with the carboniferous rocks, extend parallel to their disturbed strata with uniform north-west dips, and passing beyond them with the same dip, rest unconformably on the older slaty series. This arrangement I think, satisfactorily proves that these red sandstones and the overlying trap are really newer than the carboniferous shales of Horton, and unconformable to them.

Eastward of the estuary of the Avon, the country as far as the Shubenacadie River is occupied by a deposit of reddish, grey and purple sandstones and marls, with large beds of gypsum and limestones abounding in marine shells. This gypsiferous series is much fractured and disturbed, and is in many places associated with dark shales containing fossil plants, like those of Horton Bluff, and thin seams of coal. This association of the gypsiferous series with dark fossiliferous shales, occurs at Halfway River, where coarse brown and grey sandstones, with imperfect casts of fossil trunks of trees, and a thick bed of anhydrite and common gypsum, rest conformably on the continuation of the dark beds of Horton Bluff. The carboniferous date of this gypsiferous series has been fully established by Mr. Lyell; and though it contains red sandstones with veins of gypsum like those of Blomidon, these never extend to so great a thickness as that of the Cornwallis sandstones, without alternating with fossiliferous shales, or limestones, or with beds of gypsum. For this reason, in connection with the undisturbed condition of the Cornwallis sandstones, their apparent unconformability to the carboniferous shales of Horton, and their identity in mineral character and association with trappean rocks, with the red sandstones of Swan Creek and Five Islands, I have no hesitation in separating them from the gypsiferous series and including them in the new red sandstone formation.

I am not aware that any rocks equivalent in age to the new red sandstones which have been described, occur in any other part of Nova Scotia. Red sandstones not unlike those of Cornwallis and Truro, occur in some parts of the newer coal formation, as seen on the shores of the Gulf of St. Lawrence; but they alternate with beds of shale and grey sandstone, containing fossil plants of carboniferous species. Prince Edward Island, in the Gulf of St. Lawrence, is chiefly composed of soft red sandstones, little disturbed, and similar in mineral character to the new red sandstone of Nova Scotia; but they contain in their lower part silicified wood and other vegetable fossils, which I have not been able to distinguish from some found in the newer coal formation. It is however possible that these red sandstones of Prince Edward Island may be post-carboniferous. It is not improbable that the new red sandstone of Connecticut, and some other parts of the United States, which is believed to be a Triassic deposit, may be of the same age with the formation above described. At present however, from the want of fossils in the new red sandstone of Nova Scotia, it must be regarded as a post-carboniferous deposit of uncertain age.

The new red sandstones now described appear to have been deposited in an arm of the sea, somewhat resembling in its general form the southern part of the present Bay of Fundy, but rather longer and wider. This ancient bay was bounded by disturbed carboniferous and Silurian strata; and the detritus which it received was probably chiefly derived from the softer strata of the carboniferous system. The arenaceous nature of the new red sandstone, as compared with the character of these older deposits, indicates that the ancient bay must have been traversed by currents, probably tidal like those of the modern bay, which washed away the argillaceous matter so as to prevent the accumulation of muddy sediment. When we consider the large amount of land in the vicinity of the waters in which the new red sandstone was deposited, the deficiency of organic remains in its beds is somewhat surprising, though this is perhaps to be attributed rather to the materials of the deposit and the mode of its accumulation, than to any deficiency of vegetable or animal life at the period in question.

The volcanic action which manifested itself in the bed and on the margin of the bay of the new red sandstone, is one of the most remarkable features of the period. It has brought to the surface great quantities of melted rock, without disturbing or altering the soft arenaceous beds through which it has been poured, and whose surface it has overflowed. The masses thus accumulated on the surface have greatly modified the features of the districts in which they occur; especially the great ridge extending westward from Cape Blomidon. It is worthy of note, that this ridge, probably marking the site of a line of vents of the new red sandstone period, and occurring in a depression between two ancient hilly districts, so nearly coincides in direction with these older lines of disturbance. The trap rocks associated with the new red sandstone do not precisely coincide in mineral character with any that I have observed in other parts of Nova Scotia, though it is possible that some of the igneous rocks which have penetrated and disturbed the carboniferous rocks of various parts of this province, may belong to the new red sandstone period, or are of a date not long anterior to it.

The new red sandstone of Nova Scotia contains no valuable mineral deposits, unless the agates and jaspers of the associated trap deserve that designation. It generally supports fertile soils.

Appendix.

On the Lower Carboniferous Rocks of Windsor and Horton.

The true age of these rocks was first determined by Mr. Lyell, and the facts now stated may be considered as supplementary to those contained in his paper on the coal formation of Nova Scotia.

The lower carboniferous rocks of Horton and Windsor consist of two groups of beds, very distinct from each other in mineral character and fossils; these are in descending order.

1. A marine formation, composed of red and grey sandstones with red and purple marls, and large beds of gypsum and limestone, the latter with numerous fossil shells.

2. A lacustrine or estuary deposit, consisting of dark shales and sandstones with some white and reddish sandstone, containing fossil plants and scales of fish.

The *first* group is seen at the mouth of the Halfway River, and south of this place along both sides of the Avon. It occupies the greater part of the country between the estuaries of the Avon and the Shubenacadie, and eastward of the latter river. The lowest bed of gypsum in the group, as seen in the Avon estuary, is of great thickness and contains a large quantity of anhydrous gypsum. This bed is well-exposed near the mouth of Halfway River, and it is probably the same bed which forms the high cliff of gypsum extending for a considerable distance along the east side of the St. Croix River. Under this bed, at Halfway River, are coarse brownish and grey sandstones which appear to rest on the upper beds of the second group.

The *second* group is seen at Wolfville, and at several places on the road between that place and Windsor, at Horton Bluff, at Sneid's Mills south of Windsor, on the St. Croix River near the road from Windsor to Halifax; and similar rocks, with some of the same fossils, are associated with the gypsiferous series on the upper part of Kennetcook River, at Five Mile River, on the Shubenacadie, and at Salmon Creek and Noel Bay.

Near Horton Bluff is a bed containing numerous stumps of small trees, apparently in the place where they grew. The stumps are casts in clay and only a few inches high, and are marked only by transverse wrinkles, apparently caused by compression. The bed underlying them is filled with small branching roots, and that above contains numerous prostrate trunks of Lepidodendron, probably the upper portions of the stumps below. These fossil trees must have formed a thick grove as the stumps are very close together, and they had probably not attained their full growth when broken down and buried; the largest which I saw being only eleven inches in diameter. This fossil forest is lower in the carboniferous system than any hitherto discovered in Nova Scotia.

The dark shales of Horton and Windsor, though in some places containing small seams of coal, are not equivalents of the productive coal measures of Pictou and Cumberland, but rather correspond to some similar beds seen to underlie the gypsiferous series on the shores of the Gulf of St. Lawrence, noticed in the Geological Journal, vol. i. pp. 31 and 34.

7. *On the Genera and Distribution of Plants in the Carboniferous System of* New South Wales. By the Rev. W. B. Clarke, M.A., F.G.S.

In Count Strzelecki's work on New South Wales, it is stated that the Australian coal-fields are entirely deficient in the genera *Sigillaria, Lepidodendron, Calamites,* and *Coniferæ.* This view Mr. Clarke considers as erroneous, and endeavours in this paper to remove. After some general remarks on the supposed similarity of the plants found in the Australian coal beds to those in India, he gives the following list:—

Genera of Coal Plants found by Mr. Clarke in the carboniferous deposits of New South Wales.

1. Pecopteris.
2. Neuropteris.
3. Odontopteris.
4. Cyclopteris.
5. Sphenopteris.
6. Glossopteris.
7. Genus intermediate between Tæniopteris and Glossopteris.
8. Halonia.
9. Cannæform plants.
10. Reed-like stems.
11. Calamites.
12. Phyllotheca.
13. Zeugophyllites.
14. Equisetum.
15. Lycopodites.
16. New genus of plants with wedge-formed stems.
17. Lepidodendron, sometimes Lepidostrobi.
18. Ulodendron.
19. Sigillaria and Stigmaria.
20. Coniferæ.

In all about sixty species.

On the above list it may be useful to make a few observations.

The existence of coniferous wood in the Australian coal beds has long been known. The Rev. C. P. N. Wilton of Newcastle (N. S. W.) sent specimens to Professor Jameson in the year 1832, and on these Mr. Nicol reported in the Edinburgh Philosophical Journal. I have also forwarded two specimens of trees, now in the museum of the Society, from Awaaba Lake, accompanied by an account of a fossil forest of coniferous trees, of which the two in question were examples, which was published in the Proceedings*.

Dr. Leichhardt, in his recent expedition to Port Essington, found masses of fossil coniferous wood in a soil, and under circumstances, similar to those which distinguish the occurrence of much of the fossil Coniferæ of the colony, in 23° S. lat. on the Mackenzie River, more than 600 miles northward from Newcastle, and in the vicinity of beds of coal undistinguishable from those of the Hunter at Newcastle, affording evidence of the existence of coal deposits along the flanks of the Cordillera of Australia and Tasmania, through a distance, in latitude, of not less than 1200 miles.

In the part of the country now under review, coniferous plants are not only found *in situ* imbedded horizontally or standing vertically in the various deposits, but are also found lying upon the surface in the shape of local drift; whole trees, some of them 50 or 100, or even 150 feet in length, completely changed into silex or hydrated iron, existing in this state uninjured, or broken up into clean sections,

* Vol. iv. p. 161.

which may be joined together; or forming a conglomerate of silky fragments and chips*.

In December 1845, my friend Mr. J. B. Jukes, F.G.S. (late of H.M.S. Fly), examined with me a portion of the Illawarra coast, north of Wallongong; and he there saw coniferous trees and a true *Stigmaria* imbedded in the beach rock of Ballambai. He will also, doubtless, remember my pointing out to him sections of fossilized coniferous trees, amidst the basaltic blocks and disturbed coal strata of Towrudgi Point. Further to the south, as at Munniwarree, fragments of these coniferous trees are imbedded in the low cliffs, amidst a multitude of *Spirifers*, *Producti*, *Goniatites*, and *Pleurotomariæ*; a fact incidentally mentioned to justify the opinion I have formed as to the comparative age of our Australian Coal-fields; which will be further illustrated hereafter by a still more striking reference.

There is, indeed, scarcely a tract of the region in question in which coniferous wood has not been found. I have observed branches and stems of trees, washed out of the strata, lying, as mere surface-drift, upon the mountains at the height of at least 3000 feet above the sea; and if we calculate from such a point downwards through the probable thickness of all the carboniferous strata, the Coniferæ will be found to lie at all elevations throughout a vertical range of not less than 6000 feet.

I have already mentioned the occurrence of *Stigmaria* at Ballambai. At Awaaba, *Sigillariæ* of various species are crowded together in the white fire-clays of the coal seams; and at Muswellbrook on the Upper Hunter the remains of *Sigillariæ* of gigantic size distinguish the sandstones. They have been also found at Mulubimba near Newcastle, and in some other localities, especially in the soft grits and sandstones along the Paterson and Allyn rivers, which there overlie fossiliferous beds that in mineralogical and conchological conditions have a great resemblance to rocks of the Silurian epoch.

Lepidodendra occur in the shales of the Manila River, about 30° S., and on the Namoi and Gwydir rivers, on the western flanks of the Cordillera.

On Pini Ridge, also to the westward near Wellington Valley, a fine specimen of *Ulodendron*, named by me after its finder, A. Templer, Esq., *U. Templeri*, was discovered in 1842.

Lepidodendra also occur in the grits and mudstones of the Paterson, and in the hard siliceous metamorphic rocks of Colocalo on the Allyn, with a multitude of *Orthidæ*, *Atrypæ*, *Trilobites*, *Strophomenæ*, &c., proving that the coal plants are found imbedded in true marine deposits, and far lower in the geological scale than even the Productus beds of Munniwarree or Wollongong.

Passing upwards again, in geological order, *far above* the great sandstone (the variegated sandstone of Strzelecki, assumed by him to be the highest beds in the geological series in the two colonies)†, and which, by way of distinguishing it, I will call the Hawkesbury

* Similar fossilized wood occurs in Tasmania (see Tasm. Journ. vol. i. p. 24).

† Phys. Des. p. 129.

Rocks, we come to a mass of shales and calcareous grits and sandstones, which pass into coal beds at Camden, Cabramatta, George's River, &c., and occupy the whole of the interesting basin along the South Creek of Wianamatta, in the county of Cumberland, incidentally alluded to by Strzelecki*. This basin, which I have long distinguished by the name of the *Wianamatta Basin*, is bounded on all sides by the Hawkesbury Rocks of the coast ranges and the Blue Mountains, and consists of a series of sloping, rounded, water-worn shale-beds, capped by summits of nearly horizontal beds of calcareous sandstone, which attain, in the Bulbunmatta ranges, and on Mocaragil (or Menangle Sugar Loaf), an elevation of from 600 to 1000 feet above the sea, and are at least 800 feet thick.

At Clarke's Hill, near Cobbitee, and elsewhere, various species of *Pecopteris* occur in a fine sandstone; on Badjalla Hill, *Stigmariæ* and *Sigillariæ*.

At Wiriouil, near Campbelltown, in the blue shale, immediately over the variegated sandstone, I have found casts of heterocercal ganoidal fishes, coniferous wood, and a new coral of singular aspect; whilst at Paramatta, at the north-eastern edge of the basin, in the same shale, I have found three species of fish, coniferous wood, and fragments of ferns, together with casts of the intestines of sauroidal or other fishes.

A ganoidal heterocercal fish, apparently similar to one I detected at Campbelltown in ironstone, was also found at Newcastle †, 70 feet below the sea-level, in a greyish-blue grit; and Mr. Wilton also discovered at Newcastle a coralite, named after him by Leichhardt, *C. Wiltoni*.

A specimen of *Halonia* was found by me at Bolborook near Paramatta, in a soft micaceous shaly sandstone of the Wianamatta Basin, together with numerous casts of species belonging to the genera 9 and 10, in the list above, which are characteristic, to a great degree, of the Wianamatta ironstones and shales.

Lycopodites I found in soft blue fire-clay at Mulubimba, near Newcastle; and at Wollon Hills; also in the Page River at the back of Mount Wingen; at Foy Brook, on the Hunter; and at Burwood Range, near Newcastle, I have found a peculiar species of *Cyclopteris*, which has no resemblance, in the thickness of its leaves, to any yet figured.

Equisetaceæ and *Calamites* abound not only at Newcastle, but all over the Hunter district, and in the Illawarra region. Some of the latter, with an elegant *Neuropteris*, occur in an altered sandstone, at Arowa near Arrawang on William's River, where the carboniferous series rests upon porphyry, and has been intruded into by greenstone and trachytic basalt, which must have partially flowed subaërially. Casts of Producti and Spirifers occur there also, at a lower level than the metamorphosed coal beds, a continuation of which may be traced as far as the left bank of the Paterson River.

As my object in this communication has been merely to announce

* Phys. Des. p. 58.

† See Phys. Des. p. 125.

the above facts, and not to discuss them, with reference to various topics suggested, I shall conclude with a few general remarks.

It is certain the same genera of plants that were characteristic of the carboniferous epoch of Europe, prevail in the Australian formations; and though the species are different, they are not more so than might be expected at the antipodes of Europe.

It is also certain that the greater part of the matrix of these Australian plants is derived from granite, and that one of the most prominent genera still delights in the lofty summits of granite rocks.

We also find, in the undoubted traces of gigantic forests, and the profuse vegetation of fern-bearing soils, interpolated beds full of marine mollusca, conchifera, and zoophytes; the latter imbedded in mud and shingly grits, which bear undoubted evidence of their igneous character.

We find also, that there is a gradual passage from a fauna, usually supposed to belong to the lowest carboniferous beds of Europe, to one still lower in the geological scale, in which, in Europe, no true coal beds have been discovered.

And if we adopt the view long ago presented to my mind, that the Australian system is the equivalent of the Devonian, or embraces that and the European carboniferous formation together*, we shall still be met with the fact only incidentally mentioned in this paper, that Silurian forms are mingled in abundance with a flora supposed to be younger; and therefore it is impossible to class the Australian series exactly in a parallel with any of the European formations, but only to consider it with Mr. Jukes†, as the representative "of the Silurian and Devonian rocks, including the carboniferous system of England, in one uninterrupted and conformable series of deposits."

Whatever conclusion we adopt, this is undoubted, that the Australian carboniferous deposits have nothing in common, save one or two rare species of plants, with the jurassic system, but have an antiquity in part greater than that of the European coal-fields.

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8. *On the occurrence of* TRILOBITES *in* NEW SOUTH WALES, *with remarks on the probable age of the formation in which they occur.* By the Rev. W. B. CLARKE, M.A., F.G.S.

THE only notices hitherto published respecting the occurrence of Trilobites in New South Wales are those given in Strzelecki's 'Physical Description' of that colony and Van Diemen's Land, and a brief mention made by myself in the 'Sydney Herald' long previous to the publication of that work.

The announcement made in the 'Physical Description' has reference to "small oblong impressions *resembling Trilobites,* not exceeding half an inch, and which are to be met with in Yass plains and the Boree country, New South Wales, associated with *Favosites*

* Physical Description, &c., p. 296. † Tasmanian Journal, vol. i. p. 11.

Gothlandica, Orthoceras, and stems of *Encrinites**." In another place†, another species of "*Favosites* and *Amplexus arundinaceus,* and *remains of Trilobites,*" are mentioned as having been only at present noticed.

In the year 1842 I discovered numerous casts of Trilobites on the right bank of the River Paterson, in a sandy micaceous mudstone at a spot called Burragood; and in a concretionary limestone associated with brownish sandy shale, also concretionary, on the left bank of Binjaberri Creek, a feeder of the River Allyn. Since then I have found Trilobites in a rock of the same age, partly a pure limestone, partly a slaty clay, on the bank of the Allyn, at Colocolo near Camyrallyn, as well as near Trevallyn on the Paterson.

In 1846 I received from T. A. Murray, Esq., M.L.C., some fragments of a fossiliferous rock found at Yarralumla near Queanbeyan, and at Mount Murray, in the county of Murray; on breaking up which I detected several species of Trilobites, which can be referred to well-known Silurian genera.

The Yarralumla rock resembles, in all respects, the Burragood mudstone, and, like it, contains concretionary lumps of a ferruginous limestone surrounding fossils which are generally Trilobites. The fossils there, as well as at Burragood, are thickly coated with a powder of yellow oxide of iron.

The direct distance between these localities is 230 miles. The site of the former is to the east, of the latter to the west of the great dividing range or Cordillera; the former to the north-east of the latter.

As the associated fossils in both places correspond, these discoveries serve to point out the fact that the same formations occur in similar geological order on both flanks of the older rocks comprising the Cordillera, at great distances. Yass Plains, where Strzelecki found traces of Trilobites, lie thirty-two miles N. by W. of Yarralumla; and the ridge near Booral, north of Port Stephens, where he also found minute fragments of crustaceans belonging either to Cythere or Bairdia, in a calcareo-argillaceous flag-stone, is situated about thirty-two miles E.S.E. from Burragood. In these flagstones I found *true Orthidæ* in March 1842. M. Leichhardt has also remarked that he found the same sequence of geological formations in descending to the shores of the Gulf of Carpentaria that he had observed in ascending the ranges of the Cordillera along the Rivers Burdekin and Clarke. Little doubt, therefore, remains as to the persistency of the geological phænomena throughout the course of the Cordillera. From Yarralumla to the junction of the Burdekin and Clarke cannot be less than 960 miles of direct distance. A limestone was observed on the Burdekin containing small Spirifers resembling those of Yass Plains, and *Cyathophyllidæ.*

At Burragood the genera of Trilobites are chiefly *Trinucleus* and *Asaphus.* Mr. MacLeay has done me the honour of calling one of the former after its finder, *T. Clarkei.*

Mr. Clarke then enumerates forty genera, with 240 species of fossils associated with Trilobites at Burragood.

* P. 268. † P. 296.

The characteristic fossils of the mudstone are encrinital stems of every variety of form and ornament; whole masses of the rock are made up of these, as if they had been crushed *in situ*, the longest portions seldom exceeding an inch. Next to these are minute *Atrypæ* and fragments of Polypiaria, the Spirifers being the largest fossils.

At Binjaberri, and for several miles along the ranges dividing the Allyn and William's River, are well-developed expansions of limestone; and at the head of these rivers, and of the others, such as Carrow Creek, Fall Brook, Goorangoola, and the Rouchel, which radiate from between the southern spires of the Mount Royal ranges, fossiliferous bands and occasional masses of limestone are found inclined around the porphyritic and other igneous rocks that there attain an elevation of from 2000 to 3000 feet above the sea. These masses, at the head of the Williams, are associated with a great development of basaltic rocks which have produced a perfectly prismatic arrangement of some of the fossiliferous beds.

At Lewin's Brook, at a spot called the Wells, not far from Binjaberri, a dark schistose and flaggy mudstone is found, at a lower level than the beds at Burragood, much-jointed and iron-stained, and charged with a variety of very long-winged Spirifers, Productæ, and other fossils.

At Colocolo, near Camyrallyn, one of the Spirifers found at Lewin's Brook is also common. The limestone there, as well as at Binjaberri, is frequently made up of an infinite number of small globular bodies, which do not appear to be distinctly oolitic, but rather resemble some new form of encrinital remains. Amidst these well-developed encrinital stems occur, with a vast quantity of *Turbinolopsis bina*, large Fenestellæ, Cyathophyllidæ, Turbinoliæ, Atrypæ, Orthides (one of which is identical with *O. semicircularis*), Strophomenæ, Pectens and Trilobites, chiefly Asaphi. These fossils are partly coloured by yellow and brown oxide of iron, and partly by red. With them I found a Fucoid, nearly resembling one figured by Brongniart, and some fragments of charred and otherwise metamorphosed vegetable matter.

Passing now to the southern district of Murray, we find at Yarralumla rocks of a description similar to those of the Paterson and Allyn. The principal fossils in the blocks I have examined are the Trilobites mentioned at the beginning of this memoir. Of these I have six species. Their remains are as frequent as those of encrinites at Burragood. Associated with them is an Orthis, which can hardly, if at all, be distinguished from *O. orbicularis*, and another greatly resembling *O. semicircularis*, the former being Devonian as well as Silurian. Besides these are species of Fenestellæ and Reteporæ, and extremely minute Atrypæ. *Leptæna sericea* also occurs.

Now at Yass Plains, the limestones of which are connected with the limestones and mudstones of Yarralumla, not only are *Favosites Gothlandica*, *Amplexus arundinaceus*, and an Orthoceratite mentioned by Strzelecki, but I have seen *Strombodes plicatum* amongst the Yass fossils.

No doubt, I think, can exist that if the rocks of Yass Plains are not Silurian, they are at the very base of the Devonian system; and the occurrence of the Yarralumla Trilobites leads to the same conclusion. The existence of Trinuclei at Yarralumla, and especially of one species, which I cannot separate from *T. Caractaci,* is an important fact which must not be lost sight of.

Although but few of the fossils at Burragood, Colocolo and Yarralumla are identified, yet I cannot but express my opinion that if facilities of comparison (possessed by geologists in Europe) were afforded to inquirers here, by the existence of cabinets, to the contents of which reference could be made, numerous other identifications would probably be made out, and the existence of new species and genera be determined out of 1500 or 1600 species which I have collected from various deposits in New South Wales, many of which (owing to the brittle character of the matrix, in which they occur as mere casts) are perishable.

On comparing together the preceding observations, it will be found that the preponderating evidence is in favour of the conclusion that the beds furnishing the Trilobites of the Paterson and the Murrumbidgee are related more nearly to the Silurian than to the Devonian rocks of Europe.

Notwithstanding my admiration of the intelligence and perseverance exhibited in the geological portion of the 'Physical Description,' it appears to me that a great modification of the "epochs" there assumed must take place before we shall thoroughly understand the true history of the Australian system. Should any actual division into "Epochs" be determined, it appears to me that such division would more accurately be fixed by a separation of the Burragood, Colocolo and Yarralumla beds from those of Wollongong, Raymond Terrace, Harpur's Hill and Mulberring Creek. Yet, as before mentioned, all these betray an insensible gradation into the beds charged with Orthides, Atrypæ and Trilobites; the Wollongong beds, in the cliffs of Munniwarree, passing in the southern part of Illawarra, as on the coast near Wallamboola and Wagamee, into others charged with fossils more nearly allied to those of Yarralumla and Burragood.

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9. *On* Trematis, *a new genus belonging to the family of* Brachiopodous Mollusca. By Daniel Sharpe, Esq., F.G.S.

In looking over the valuable collection of Palæozoic fossils brought from the United States by Mr. Lyell, I was struck by a small Brachiopod possessing a combination of structure hitherto unobserved, which entitles it to be placed in a separate genus.

The general appearance of the shell is similar to *Orbicula,* in which genus it has hitherto been placed. It is nearly circular, but slightly broader than long and with an irregular outline. The shell is attached by a ligament which passes through an oblong slit in the lower valve, as in the *Orbiculæ*; this slit reaches from about the centre of the shell to near the posterior margin. Both the valves are slightly and irregularly convex, giving a depressed form to the shell.

The valves are united by a hinge, of which the details cannot be seen in the specimens; but it is probably formed of two diverging lamellar processes in the dorsal valve, for where the shell of that valve has been worn away, we can trace three calcareous plates diverging from the hinge of the dorsal valve, as in the Leptænoid species of *Orthis* and in many of the Spirifers. Wherever these plates are found in the Brachiopoda, the outer pair appear to be continuations of the teeth or lamellar processes of the hinge; so that the presence of such plates is sufficient to show that the valves played upon a hinge. The third or mesial plate separates the two great adductor muscles.

The beak of the dorsal valve is slightly produced, but the specimens are too imperfect to show whether there was any opening in it for the passage of a ligament. As the shell was attached by a ligament passing through the ventral valve, it is not probable that it should have had a second mode of attachment at the hinge, for we know no Brachiopod which has two modes of fixing itself.

The shell consists of layers of two distinct structures: the outer layer is punctated; the punctations are so large as to be clearly visible to the naked eye, and are arranged quincuncially with great regularity. The inner layers of shell are not punctated, and have a fibrous and slightly striated appearance and pearly lustre; these impunctate layers are thickest towards the middle of the shell and do not quite reach the margin*.

It thus appears that the genus *Trematis* differs from *Orbicula* in the punctated structure of its shell and in having the valves united by a hinge, while it is distinguished from *Terebratula* and the other hinged forms of Brachiopods by the ligament passing through the ventral valve. It thus forms a connecting link of great interest be-

* An inner layer of unpunctated shell lining an outer punctated layer is of common occurrence among the Brachiopoda; it may be especially observed in the flat species of *Orthis* and in many *Leptænæ*, covering all the central parts of the shell and leaving the punctations open only round the margin. Among the *Productæ* and some species of *Chonetes*, the punctations are closed up everywhere, except at the edge, by a gradual deposit of shelly matter in the interior. In *Crania*, *Thecidea*, and some recent *Terebratulæ*, the punctations can only be seen in the interior round the edge of the shell; but in the majority of the recent species of *Terebratula*, they are equally visible over the whole shell.

Taking a general view of these punctated shells, it appears that in a very large majority of cases the punctations only remain open round the margins of the valves, so that it is probable that whatever function was served by these minute perforations, its operation was confined to the margin of the shell. As the respiratory process is carried on in this family by organs placed round the edges of the mantle, it seems probable that the punctations must be connected with that process.

The present communication shows the necessity of attending to the distinction between the punctated and nonpunctated forms of Brachiopoda, of which Mr. Morris has pointed out the importance in the *Terebratulæ*. It was the study of his paper on that subject that led me to observe the characters of the genus *Trematis*, and I am also indebted to Mr. Morris for further assistance in working them out.

tween several genera. Several species of *Trematis* have been already published under the name of *Orbiculæ*, all of which are found in Lower Silurian beds.

The genus may be defined as follows :—

Trematis ; a suborbicular, inequivalve Brachiopod attached by a ligament passing through a longitudinal fissure in the posterior part of the ventral valve. Valves united by a hinge which is supposed to resemble that of *Terebratula*, and is accompanied in the dorsal valve by three diverging internal plates. Shell regularly punctated externally ; pearly, fibrous, and slightly striated internally.

1. Trematis terminalis.

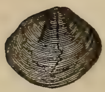
Orbicula terminalis, Emmons, Report on the Geology of New York, pt. 2. p. 395. f. 4 ; Hall, Palæontology of New York, pl. 30. f. 11.

Shell subquadrate, rounded, broader than long, depressed ; both the valves are slightly convex, but the convexity of the lower valve is interrupted by a large depression sloping towards the fissure, which reaches from the centre of the shell to near the hinge ; surface smooth, marked with regular punctations distinctly visible to the naked eye. Breadth half an inch, length $\frac{7}{16}$ths of an inch.

Found in the "Trenton limestone" of New York and in the "Blue limestone" of Ohio : the specimen figured was sent to Mr. Lyell by Mr. Clark, who found it in the "Blue limestone" at Cincinnati.

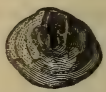
Fig. 3.

Fig. 1.



Upper valve.

Fig. 2.



Lower valve.

Trematis terminalis. Lower valve magnified.

2. Trematis cancellata.

Orbicula cancellata, G. B. Sowerby, Zoological Journal, vol. ii. pl. 11. f. 6.

Shell orbicular, very flat, being more gibbous near the posterior extremity : surface covered with close-set elevated lines radiating from the apex, which are crossed by the elevated lines of growth, so that the entire surface has a finely reticulated appearance: the fissure in the ventral valve is small and close to the hinge: shell very thin. Length and breadth ¾ths of an inch.

Found by Dr. Bigsby in limestone one mile north of Montreal in Lower Canada.

The above description is compiled from Mr. Sowerby's description and figure. The next species, called by Mr. Hall *Orbicula ? filosa*, is probably the same as this, but not having seen either shell, I have not ventured to throw them together.

3. Trematis filosa.

Orbicula ? filosa, Hall, Palæontology of New York, p. 99.

"Orbicular; one valve more or less convex; apex marginal; surface radiated with numerous fine elevated thread-like striæ, which are more or less prominent, depending on exfoliation of the shell; intermediate striæ coming in between the others as they recede from the beak, but the striæ are not bifurcate."—*Hall.*

Found in the "Trenton limestone" at Middleville, New York.

This species is given on Mr. Hall's authority; I have not seen it, nor the figure which will accompany the description in his forthcoming work. From the description I suspect it to be the same as the *T. cancellata* last described. Mr. Hall refers it to *Orbicula* with great hesitation, and appears to consider it intermediate between that genus and *Crania*.

4. Trematis punctata.

Orbicula ? punctata, Sowerby, Silurian System, pl. 20. f. 5.

Ovate, depressed, surface smooth, punctations very large. Length ⅝ths, breadth ½ an inch.

Found in the Caradoc sandstone at Chatwell, on the east flank of the Caradoc.

The specimens described by Mr. Sowerby are now in the Society's collection; they are very imperfect, and do not show the principal characters of the genus. Mr. Sowerby placed it in *Orbicula* with a mark of doubt.

Note, 26*th November* 1847.—M. Barrande has described two shells, which probably belong to the genus *Trematis*, under the names of *Terebratula hamifera* and *Terebratula scrobiculosa*: they are found at Beraun, in Bohemia, in a quartzite supposed to belong to the Silurian formation: vide Haidinger's 'Naturwissenschaftliche Abhandlungen,' vol. i. plate 20. figs. 9 and 10. They may perhaps be the old and the young shells of one species.

PROCEEDINGS,

ETC.

POSTPONED PAPERS.

On the Elevation and Denudation of the District of the Lakes of CUMBERLAND *and* WESTMORELAND. By W. HOPKINS, Esq., M.A. and F.R.S.

[Read June 6th, 1842.]

[An abstract of this paper was given in the Proceedings of the Geological Society, vol. iii. p. 757.]

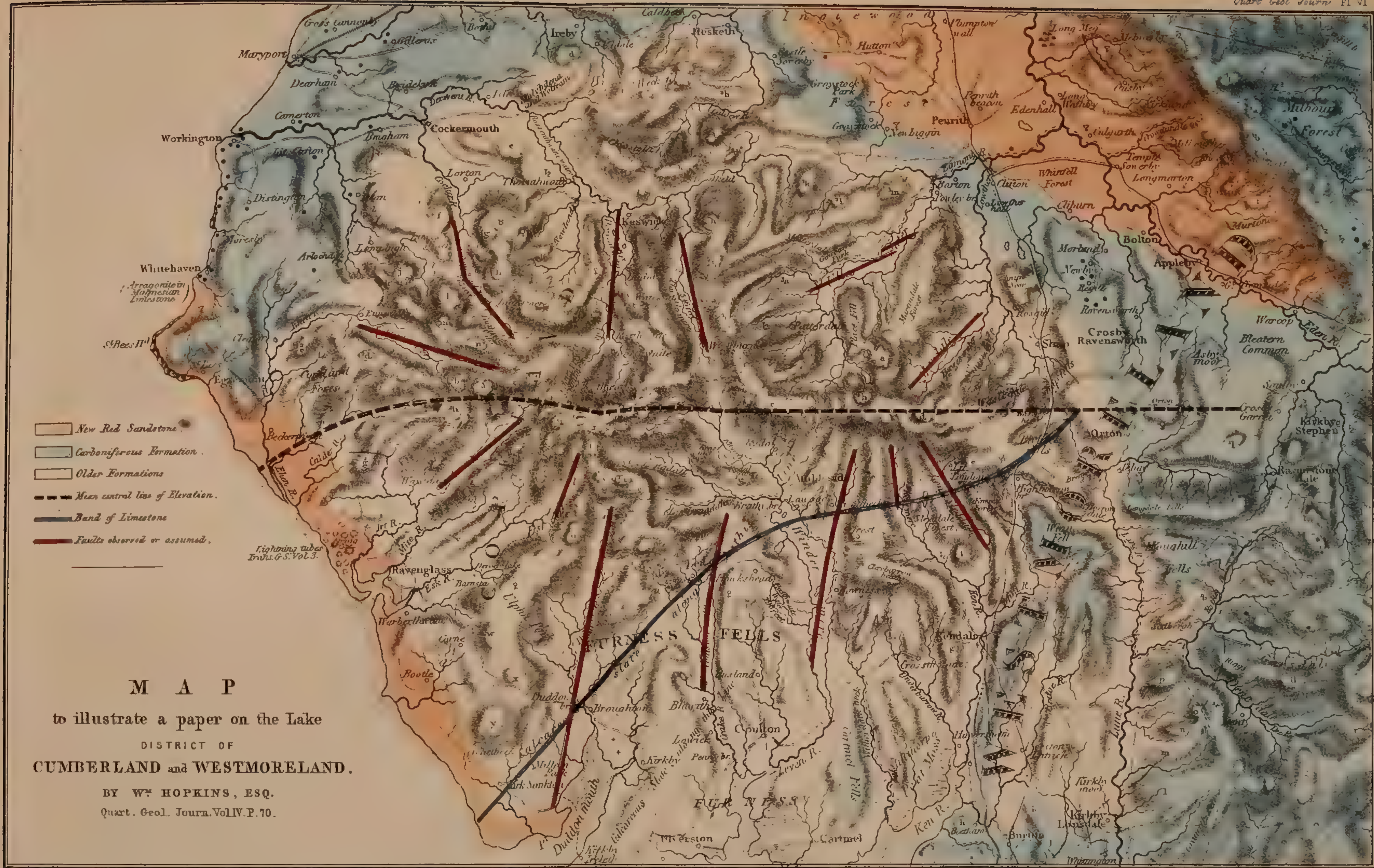
PART I.

§ *Structure of the District.*

THE general structure of the district of the lakes of Cumberland and Westmoreland is well known to geologists, more particularly by the labours of Professor Sedgwick. My own task, in the general examination which I have recently made of the district, has been one of inspection and not of discovery; and the object of the present communication is not the description of phænomena, but the theoretical discussion of the causes to which they are to be referred. I shall enter into descriptive details only so far as may be necessary for this purpose. In the first part of the memoir I shall consider the *structure* and *elevation* of the district, and in the second part the phænomena of its *denudation*.

1. *Boundary of the District.*—In descriptive geology we may apply the term *district* to a portion of country comprised within any arbitrary boundary to which our researches may have extended; but in considering the theory of its elevation, a district must include the whole of that space throughout which we recognize a character of continuity in the external configuration and the observed phænomena. Thus in the case before us, we must not limit ourselves to the group of mountains immediately associated with the lakes, but must extend the district eastward to the great Penine fault, which will thus form its eastern boundary. On the north, from Kirkby Stephen by Hesket round to Egremont and thence to Morcambe Bay, its boundary will be sufficiently marked by that of the New Red Sandstone, except for some distance north of Whitehaven, where it is marked by the coal-field. From Morcambe Bay it turns eastward, and is sufficiently marked by the discontinuous portions of mountain limestone, by which it is carried on to meet the Craven fault south of Kirkby Lonsdale.

Reeve Benham & Reeve, lithogrs.



MAP
to illustrate a paper on the Lake
DISTRICT OF
CUMBERLAND and WESTMORELAND.
BY Wm HOPKINS, ESQ.
Quart. Geol. Journ. Vol. IV. P. 70.

Reeve Benham & Reeve Lithog.

2. *Structure.*—The *general strike* of the beds of red sandstone as well as of the limestone coincides with the direction of the above boundary at each point of it, and the general dip is consequently perpendicular to that boundary. On the southern side, however, this observation must be taken with reference to the *mean* strike and dip, which are both locally affected by north and south faults. Above Kirkby Stephen the limestone dips rapidly N.E. by N. under the red sandstone of the vale of Eden; and the same dip is strongly marked along the limestone fells to Orton. As the boundary approaches Penrith it recedes further from the axis of movement, and the dip is proportionally less, as it continues to be generally along the northern boundary. On the west the dip is again more rapid, being frequently 20° or upwards, both in the limestone and new red sandstone, a circumstance which would scarcely have been anticipated on account of the unconformability of the two formations and general greater horizontality of the latter in the vale of Eden. On the southern side, the general dip, as dependent on the general elevation of the district, and independent of the local effects of faults, must be smaller than in most other parts of the boundary, as indicated by the greater width of the irregular limestone band.

3. The space within the band of mountain limestone is occupied by the older formations, which (as I have here no concern with their distinctive mineralogical or zoological characters) it will be convenient to designate by one appellation—the grauwacké group*. Their stratification, though in some places perfectly distinct, is frequently very obscure. Professor Sedgwick states the dip to be in general nearly S.E. In some places it is more nearly E., as in the valley between Kendal Fell and Whitbarrow, and from thence to the lake of Windermere, in which places the stratification is extremely well marked. The dip is there not less in general than 50° or 60°. On the north of Kendal, as we approach Shap Fell, the stratification in some places is well-marked; but the best proof of continuous stratification is afforded by a band of limestone interstratified with the grauwacké beds, and extending from the mouth of the Duddon to Shap Fell, a distance of nearly forty miles. Its general strike (independent of dislocations) is very nearly N.E. and S.W., dipping rapidly towards the S.E. It is described in detail in a memoir of Professor Sedgwick's, where the author has also described the curious cases of discontinuity which it presents to us. I shall shortly recur to them as indications of the prodigious faults by which this country has been dislocated.

4. *Junction of the Mountain Limestone and the Older Formations.*—This junction may be distinctly seen in many places, and always indicates that the limestone must have been deposited on a plain and even surface, formed by the perfect wearing down of the upturned edges of the older strata, and thus free, not only from the greater inequalities of hill and valley, but also from the minor inequalities which now characterize, in many places, the exposed grauwacké

* The detached masses of red conglomerate, found in several parts of the district, may be here considered as included in this group.

surface, arising from the protrusion of the harder beds. In fact, the junction may be made out along nearly the whole boundary of the district with sufficient accuracy to justify, I think, this conclusion. This perfect evenness of the grauwacké surface is also beautifully exhibited along the north side of Ingleborough and round the western flank of Whernside. There can be little doubt, I conceive, of the bottom of the sea on which the mountain limestone was deposited having been very approximately a *plain* surface. Moreover, if the surface on which the general mass of this limestone was deposited was very nearly plain, it must also have been very nearly *horizontal*. The truth of this proposition depends on the conclusion that, whatever be the depth at which organic beings of any proposed class may exist in the ocean, it cannot be a matter of indifference whether the individuals of that class exist at the depth of a few feet, or at that of several thousands. For, assuming this, if a stratum be characterized throughout by similar organic remains, it follows that the different parts of the stratum could not have been deposited at very unequal depths, and consequently, if the surface was nearly plain and even and of sufficient extent, it must have been also very nearly horizontal. Such, therefore, I conclude to have been the case with the surface on which the lower beds of the mountain limestone were deposited.

5. This reasoning applies directly only to those portions of the district in which the surface of junction has been preserved by the superincumbent limestone. There still remains the question—whether the limestone originally extended over the central part of the district. That it extended over a considerable portion of it is proved (as shown by the most cursory inspection) by the height which it now occupies at several points of its present boundary, as for instance on Kendal Fell on the south-east, between Penrith and Keswick on the north-east, and on the west near Egremont. To form an opinion on this point, let us conceive an imaginary surface as a continuation of the general surface of junction (independently I mean of merely local irregularities) to be carried over the central area from the present basset of the mountain limestone, and so as just to touch the summits of the highest mountains.

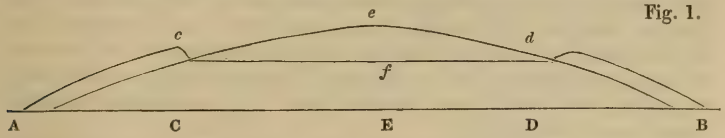
The inclination of this imaginary surface in many places would not exceed 2°, would rarely amount to 3° (about one in twenty), and would never, I think, exceed 5°*. This greatest inclination would take place only on the north of the Skiddaw group. Now the inclination of the limestone beds near the boundary of our district is generally considerably greater than 2° or 3°, sometimes amounting (on the west) to 20° or 30°. Hence it seems highly probable that

* There are few points on which an observer is more likely to receive erroneous impressions than the angular elevation of the sides of mountains. A good model, on a true scale of heights and distances, is the surest safeguard against such impressions. At Keswick there is an excellent model of this kind, which I cannot too strongly recommend to every one who wishes to gain an accurate conception of the geography and physical structure of the district of the Lakes. It is the work of Mr. Flintoft, by whom it is now exhibited to visitors at Keswick. It originated, I believe, with himself, and has been completed by his unaided exertions.

when these beds, and therefore the surface of junction and our imaginary continuation of it, were all in their original horizontal position, below the surface of the sea, those portions of the grauwacké group which now constitute the highest summits of the mountains were at a lower level than the surface of junction, in which case we should necessarily conclude that the deposition of limestone originally extended over the whole central area of the district.

It appears to me extremely difficult to avoid this conclusion, unless we adopt some arbitrary and improbable hypothesis respecting that elevation of the central portion of the district which must necessarily have accompanied that of the mountain limestone now surrounding it, or deny the general truth of the conclusion respecting the original horizontality of sedimentary beds. Assuming this horizontality, let A B represent a stratum before its elevation. The portions A C, B D have been elevated into the positions A *c*, B *d* respectively, as shown

Fig. 1.



by the present position of the limestone beds, and the question is, whether the central portion C E D was raised into the position *c e d* or *c f d*. Of this we can obtain no direct evidence from observation, because the beds occupying the central portion of the district have not derived their actual positions from the movement of which we are now speaking. We are obliged, therefore, to have recourse to the analogy of similar cases of elevation in which the evidence is complete. Arguments deduced from such analogy must, I conceive, be almost entirely in favour of the view which would represent A *c e d* B, and not A *c f d* B, as the disturbed position of the line of which A B was the undisturbed position. In such case, though the inclination from *c* to *e* and from *d* to *e* be allowed to be considerably less than that of the limestone from A to *c* and from B to *d* respectively, still the whole district must necessarily have been beneath the surface of the ocean at the time of the commencement of the deposition of the mountain limestone.

6. It might be contended perhaps that these limestone beds were not, in the proper sense of the term, *sedimentary*, but originally formed like coral reefs. Supposing such to be the case, the argument above adduced in favour of the original horizontality of sedimentary beds is equally applicable. I regard that argument as one of the highest importance in the fundamental reasonings of Physical Geology. The exact point to which it may be urged cannot yet be asserted, from our want of more accurate knowledge of the power of animals inhabiting the ocean to accommodate themselves to different degrees of fluid pressure. It should be recollected, however, that the truth of the argument does not depend on any impossibility of the more profound depths of the ocean being inhabited, but on the improbability that

animals of the same species should be able to exist at the greatest or the smallest depths indifferently,—so far at least indifferently, that the full and free performance of the animal functions should not in either case be impeded. It appears to me extremely improbable that any species of animals should possess that power of adaptation to external circumstances differing so widely as light and darkness, and the fluid pressure of a few feet and that of several thousands. If this improbability be admitted, then is it easily seen that the validity of our argument is unquestionable*.

7. *Faults.*—I have already spoken (Art. 3) of the band of limestone interstratified with the grauwacké rocks. The dislocations of this band furnish the principal direct evidence respecting the faults of the district. Beginning with its south-western extremity, there is evidence of two faults, one in the valley of the Duddon about Duddon Bridge, and the other a little to the west, passing along the valley of Hallthwaite. It is probably to the combined effects of these faults that the valley of the Duddon (a striking feature in this part of the district) is to be referred. Taking the mean direction of the river Duddon as indicating that of the fault (independently of minor irregularities), we observe that it ranges about N. by E., tending to a point a little east of Scaw Fell.

Another enormous dislocation is seen just above Coniston Water, producing a horizontal displacement of about a mile. The direction of the fault, as determined by a line joining the extremities of the dislocated portions of the limestone band, passes exactly down the lake. It is very nearly parallel to the Duddon fault, a little to the east of N. by E. Several other dislocations in this neighbourhood, described by Professor Sedgwick, are also indicative of so many faults similar and parallel to the above, but not attended by any marked external features.

Another fault ranges down the valley of Troutbeck, as indicated by a dislocation of the limestone band and a great horizontal displacement. It ranges accurately with that part of the lake of Winandermere which lies south of the embouchure of the valley. An enormous dislocation is also described by Professor Sedgwick between Coniston and Winandermere, by which the limestone band on its eastern side has been apparently moved towards the north to the distance of a mile and a half. It is not in this instance again indicated by the external configuration of the district, but there is doubtless here also a great fault parallel to those already described. On the east of Troutbeck also there are dislocations which cannot be doubted to have been connected with the formation of the two striking valleys of Troutbeck and Kentmere. The line of dislocation would seem to pass exactly along that part of the latter valley in which the mere is situated.

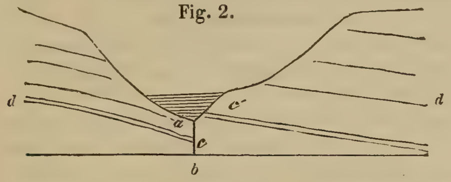
We have further evidence of a line of dislocation along the valley

* The reader is here requested to bear in mind that a period of more than five years has elapsed since the reading of this paper to the present time, December 1847. The late researches of Prof. E. Forbes in the Ægean Sea and on our own coasts have completely established the argument in the text.

between Whitbarrow Scar (a mountain limestone hill) and the great limestone fell immediately on the west of Kendal. This dislocation must have been posterior to the mountain limestone, since it affects the beds of that formation.

8. *Formation of the Lakes.*—From the preceding descriptions it would appear impossible not to ascribe the origin of the lakes of Coniston and Winandermere to the dislocations with which they are so immediately associated; nor does it indeed seem possible to account for the existence of any of the larger lakes independently of similar dislocations. Taking Wastwater, for instance, its depth is found to be forty-five fathoms, so that its bottom is probably almost a hundred feet lower than the surface of the sea. It is evident that such a basin could not be scooped out by the action of water; nor is its depth increased by an accumulation of detritus at the mouth of the valley, for the river by which its surplus water is discharged cuts into the solid rock. The lake could only be formed therefore by a relative subsidence of its bottom, such, for example, as that shown in the annexed diagram, which represents a transverse section of a valley

Fig. 2.



with its lake: *a b* is a section of the fault which runs along the valley, and on opposite sides of which the strata are relatively displaced through the space *c′ c*. If this relative subsidence do not extend to the mouth of the valley, or be less there than in the upper part of it, a lake will necessarily be formed. It is probable that in some of the English lakes, the extension of the subsidence towards the mouth of the valley has been arrested suddenly by a fault transverse to the valley, as appears from the great depth in the case of Wastwater, for instance, at an inconsiderable distance from its lower extremity. This general explanation will apply to all the lakes of the district, and appears to me to be the only intelligible one which can be given of their origin*. The evidence thus obtained of great faults ranging along the lake valleys is scarcely less conclusive than that afforded by the discontinuities of the limestone band above described.

It would be absurd to suppose that the ranges of the faults in these valleys are confined to those spaces only where we now find demonstrative evidence of their existence. There can be no doubt of their extension frequently along the whole course of such valleys, or, in

* The probable origin of these lakes in diverging dislocations is too obvious to have escaped the notice of such an observer as Professor Sedgwick, who has spoken of it in his memoir on this district. I am not aware, however, that the argument in favour of this view of their origin has been hitherto placed in that more determinate and demonstrative form which I have given it in the text.

many cases, beyond their limits. Again, we must not conclude that the relative subsidence to which the formation of a lake is immediately referrible, was contemporaneous with the first formation of the fault with which that subsidence is associated. Such a question must be decided, not by any such restricted hypothesis, but by the evidence afforded by the circumstances of each particular case.

9. *Origin of Valleys.*—Though the lakes afford direct evidence of the existence of faults, we must not in fact consider them as more than the secondary and accidental consequences of the faults with which they are associated, the primary effects being the valleys in which those lakes are situated; for, whatever may have been the agency by which the masses once occupying those valleys have been removed, it is easy to see that it would act more efficiently along lines of great dislocation than elsewhere; and since the existence of dislocations along the lake valleys may be considered as established, it would seem impossible to avoid the conclusion, that those valleys must themselves have originated in such dislocations. We are thus led to conclude that a dislocation was produced before the valley began to be formed; that this led to the formation of the valley by denuding causes; and that the subsidence which caused the lake was one of the last of that series of repeated disturbances which might occur during the long interval of time which was probably necessary for the completion of the valley.

10. And here again we are led a step further by the closest analogy. If the valley of Wastwater originated in a great dislocation, it is hardly conceivable that the adjoining valley of Eskdale should not have had a similar origin. And again, if the valleys of Troutbeck and Kentmere, on the south-eastern side of the district, have been caused by dislocations, as shown above, it is difficult to suppose that the valley of Long Sleddale should have been formed independently of a similar cause. I would observe, however, that this view of the origin of valleys of this kind must be considered as applicable principally in places nearest the centres or axes of elevation. In other cases they may have arisen altogether from aqueous action, or, when they originated in dislocations, they may have had their directions so altered, and their character so modified, by denuding causes, as to retain no distinct traces of their origin. This obliteration would of course be most likely to occur in the parts of a district situated at the lower levels, and which must have been longest subjected to the action of denuding causes. In such cases valleys may afford very dubious indications of the existence or directions of dislocations, and such as ought not to be received without evidence of a more positive character. At higher elevations, however, a well-marked and continuous valley may frequently afford the strongest presumptive evidence of a corresponding disruption. Of such cases in this district, I may instance, in addition to those already noticed, Borrowdale and Langdale (both of which extend nearly up to Scaw Fell), and the valley of St. John's, and its continuation through Thirlmere across the centre of the district.

§ *Series of Geological Events in the District.*

11. It may be useful, both as regards a clear conception of what has been already advanced and of what I am about to offer in the next section, on the denudation of this district, to state the order of geological events according to the view now presented of them.

(1.) The first great system of movements of which this district preserves the record, is that by which the beds of the older formations were brought into their present highly-inclined position. To this period I should refer the injection of all the masses of igneous origin existing among these old sedimentary beds; because I can trace no relation which they bear to the actual elevation of the district. These movements were probably contemporaneous with those which determined the actual strike of the similar masses in Wales, and might extend also far northward, constituting a system of movements of far greater superficial extent than those which have probably given to the district we are considering its peculiar configuration. They would doubtless be attended with enormous dislocations, among which we may reckon a part, but not the whole, of those above described.

(2.) Abstracting all effects of denuding causes, the necessary effects of such disturbances would be immense superficial inequalities, forming hills and valleys, with all that ruggedness of surface which must result from the protrusion of the broken edges of highly-inclined strata. All these inequalities, however, must have been worn down by the long-continued operation of denuding agencies, till the surface became a smooth and very nearly horizontal plane beneath the surface of the sea, as represented in fig. 3. (Art. 4.)

It is not to be inferred from this extensive denudation, that the surface of the disturbed mass was always beneath that of the ocean; it was probably partly above and partly below that level. The mass above the surface of the ocean might be removed by the process of *littoral denudation*, similar to that now going on along the coasts of existing continents and islands, while minor inequalities beneath the sea, and not too remote from its surface, might be worn down by *superficial denudation*,—that produced by the action of the ocean on the surface of a mass submerged beneath it. At the same time there would always be a tendency to fill up the deeper hollows in the bed of the ocean by detritus derived from the degradation of the higher portions of the disturbed beds. The old red conglomerate found in several places about the lakes, and in a great mass near the foot of Ulswater, is thus easily accounted for.

(3.) This denudation was succeeded by the deposition of the mountain limestone and Carboniferous system.

When this deposition was completed, and before its subsequent elevation and consequent partial removal by aqueous agency, the general average thickness of the whole group (taking the surrounding district as well as that with which we are immediately concerned) cannot be estimated at much less than 3000 feet, which is probably much greater than the depth at which any considerable number of organic beings would be found existing. If this be true, it is manifest that the bottom of the ocean in which the lower beds of the mountain limestone were deposited, must (since they contain many organic remains) have gradually subsided during the deposition of the whole Carboniferous system. A gradual subsidence of this kind to a greater or less extent may be regarded as a necessary consequence of the state of dislocation in which the disturbed mass of the older rocks beneath the sea had been left by the previous subterranean movements. During the subsequent repose the subsidence would probably continue for a great length of time, as a consequence merely of gravity; in the present case the subsidence would be increased by the superincumbent weight of the newly-deposited matter.

Fig. 4 is intended to represent a section of the district immediately after the deposition of the Carboniferous system, and before its elevation. The system is represented as divided into two portions, the lower consisting principally of limestone, and the upper of the millstone grit and coal. Both portions are supposed to extend over the whole tract, though with less thickness about L, the present locality of the Lake district. If it be conceived to have existed there in still smaller thickness, or even to have been entirely wanting, it will make no material alteration in my view of the subject, so long as we suppose there to have been no considerable relative elevation of that portion of the surface of the grauwacké group.

(4.) This process of deposition was succeeded by those great movements by which the Carboniferous system was broken up and elevated. Fig. 5 shows the position which it is supposed the beds would have assumed after their complete elevation, supposing no part of them to have been removed by denuding causes during that movement. The figure represents, therefore, the effect of the elevation only, and not the combined effect of elevation and denudation, which probably went on simultaneously for a very long period of time. At S the great Penine fault is indicated, and at L are three faults, intended to represent generally those formed in the Lake district by this elevation. Fig. 6 represents, by the dotted lines, the mass supposed to have been carried away by denudation during the time which intervened between the *commencement* of this elevation and that of the deposition of the magnesian limestone, or magnesian conglomerate and new red sandstone. There is nothing hypothetical in this extensive denudation, for in numerous instances we have distinct evidence of the existence of enormous faults in all parts of our coal and mountain limestone districts, without any elevation (such as represented at L and S) of the existing surface on one side of the fault as compared with that on the other; proving, in such cases, denudation like that represented by the dotted line in the diagram. This might be effected in the case before us in either of the two ways above-mentioned in (2.), according as the movement by which the mass was dislocated, elevated its surface above the sea or not.

It may be doubted whether the surface of the tract about the present lakes was entirely submerged beneath the sea, as represented in fig. 6, at the epoch then referred to. It is not essential to any object I have in view, to assert that it was so. The same reasoning,

Fig. 3.

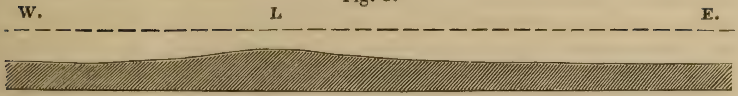


Fig. 4.

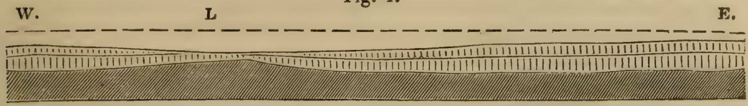


Fig. 5.

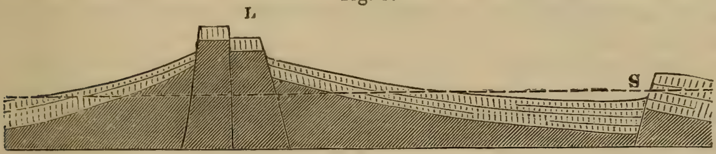


Fig. 6.

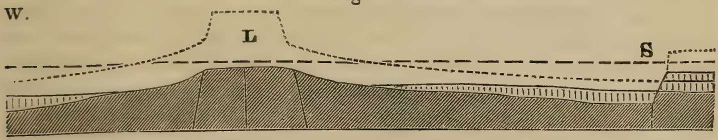


Fig. 7.

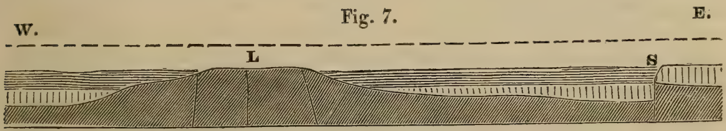


Fig. 8.

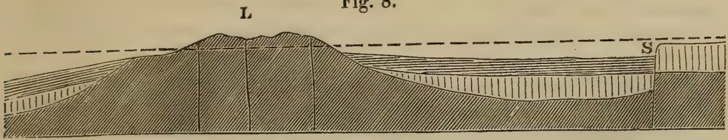
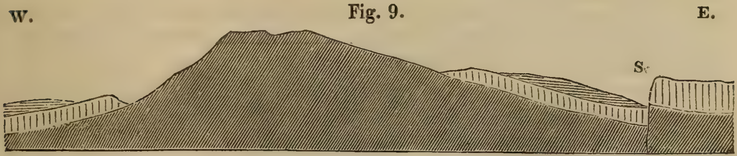
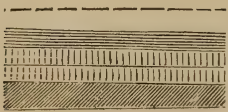


Fig. 9.





Sea level.
N. R. sandstone.
Upper part } of Carboniferous formation.
Lower part
Older formations.

however, by which I have shown the former probable extension of the mountain limestone over the district, may be applied to the new red sandstone on the west and south-west of the district. Its rise towards the centre of the district is so rapid, as to show that no part of the surface of the district could, at the time of the deposition of the sandstone, have attained to any considerable elevation. Analogy with the surrounding districts also goes far to establish this conclusion. Ingleborough has manifestly been beneath the sea since the great dislocating movements of the Carboniferous series; and, in fact, the reasoning of the preceding paragraph would establish the same conclusion with respect, probably, to the very highest portions of the mountain limestone range. All this is in perfect harmony with my conclusion respecting the district with which we are immediately occupied.

I have supposed the whole of the Carboniferous series above the limestone along the line of section to have been removed between the Lake district and the Penine fault, there being no evidence of its actual existence there.

(5.) The succeeding period was again one of repose, in which the deposition of the Saliferous system took place. It is represented in fig. 7 previous to its dislocation and subsequent denudation. I have seen no accurate estimate of the thickness of the existing new red sandstone in the vale of Eden, but it must be several hundred feet in the sandstone hills near Penrith; nor is it likely to have been originally less in the deeper part of the vale, near the Penine fault. We cannot, I think, suppose its thickness there to have been less than 500 or 600 feet.

The height of the lowest part of the limestone ridge across Stainmoor is stated to be about 900 feet above the valley below, where we find the conglomerate already mentioned as the lowest bed of the new red sandstone group. Consequently, supposing the relative elevation on opposite sides of the Penine fault to have remained the same as at the epoch referred to in fig. 7, the depth of the ocean at the foot of the limestone ridge, and opposite to that part of it which now constitutes Stainmoor, may not then have exceeded 300 or 400 feet.

But I consider it highly probable that the relative elevation of the ridge produced by the Penine fault has been increased since the epoch we are speaking of. In some parts of the Tynedale fault this elevation has undoubtedly been increased since the deposition of the magnesian limestone, which was probably contemporaneous with that of the conglomerate of Kirkby Stephen. This latter formation has also been considerably disturbed near Brough*, and in such a manner as to indicate an increase in the height of the limestone ridge. Further, the new red sandstone has been very much disturbed, as already stated, on the western side of the Lake district. I consider, therefore, an increase in the relative height of the Penine range since the entire deposition of the new red sandstone to be at least so far pro-

* These facts are stated by Mr. Phillips in his Geology of Yorkshire, vol. ii.

bable, that we are as much at liberty to make that hypothesis as any other, should independent facts appear to render it necessary. If we suppose this additional elevation at Stainmoor to have been such that, when added to the thickness of the new red sandstone, the whole amount would be about 900 feet (the present elevation of Stainmoor above the valley below), the depth of the ocean along the line of our sections must have been no greater over the sandstone than across the limestone ridge of Stainmoor. The subaqueous valley must then have been entirely filled up. This would require the posterior elevation now spoken of to be 300 or 400 feet, assuming the thickness of the whole new red sandstone group to have been 500 or 600 feet, as above supposed. This however is the extreme hypothesis; a less increase of elevation would leave a submarine valley of comparatively small depth (fig. 7). This point is not altogether unimportant in considering the transport of boulders over Stainmoor from the Cumbrian mountains.

(6.) The next period was one of elevation, more especially of what is properly termed the Lake district, which I conceive to have been now first raised permanently to any considerable height above the level of the sea. The great inclination of the new red sandstone beds on the west of the district, and the considerable disturbance which we observe in them as far to the south-west as Furness Abbey (as already noticed), afford the best proofs we can possess of the amount of elevation in the central portion of the district during the period we are now considering. In fact, the dip of the sandstone beds in these localities did not appear to me to differ sensibly from that of the beds of mountain limestone, showing incontestably that the principal part of the elevation of these latter beds, and therefore of the whole western and more mountainous portion of the district, took place as just stated, and not at any previous period. We must not here confound *dislocation* and *elevation*. The former might be great and the latter comparatively small, or the converse. Great dislocations may have been the result of more violent, and great elevations that of more continued or more frequently repeated action of elevatory forces.

Fig. 8 represents the increased elevation of the Cumbrian portion of the district, immediately before the emergence of Stainmoor from beneath the surface of the ocean, when that tract must have formed a channel connecting the oceans on the east and west of the great Penine range. The denudation of the new red sandstone is represented as already partly effected by ocean currents; I consider it to have been completed during subsequent elevation, when the valley formed an arm of the sea, or after its entire emergence. Stainmoor may not have finally emerged from the water till after the Tertiary period. According to any subaqueous theory, the transport of erratic blocks across that tract must have taken place before its emergence; the diluvial theory, which I shall speak of in the sequel, connects this transport with successive movements, to which the increased elevation of the Cumbrian district represented in the figure is considered to be due.

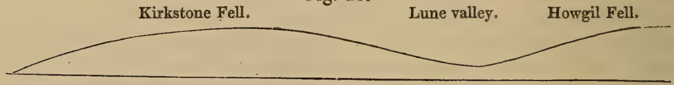
Fig. 9 represents an actual section of the district.

(7.) The formation of the existing lakes must have been one of the last of the series of these geological events, for it is manifest that they could not be formed till the valleys themselves had been scooped out. Their formation must also have been accompanied with considerable movements, as already shown (Art. 8), producing displacements along the former lines of fracture; a circumstance which justifies the supposition that such movements may have frequently occurred during the progressive formation of the valleys, should observed phænomena seem to render such an hypothesis necessary.

§ *Theory of the Elevation of the District.*

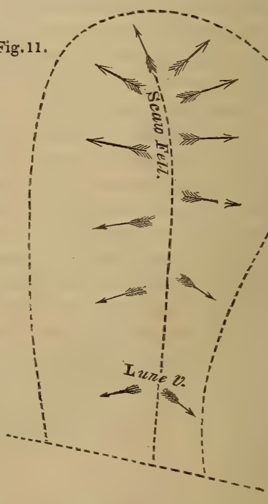
12. If we conceive the surface of junction of the mountain limestone and older formations to be continued, precisely as in Article 5, over the central portion of our district, the elevation of this imaginary surface will represent that *geological elevation** which has given to the district its general external configuration, independently of local irregularities. This surface, if seen from a point sufficiently distant on the west, would present the appearance of a flat dome; and if seen from the south, its outline would resemble that of the annexed diagram, which represents a section along the axis of the district from

Fig. 10.



W.N.W. to E.S.E. Also the form of the area of the district bears a general resemblance to that of the following diagram; and the dip of our imaginary stratum will be as represented at each point by the arrows. The tendency of this dip between Kirkstone Fell and the valley of the Lune, towards the N.E. on the north of the axis, and to the east of south on the south of the axis, is owing to a declination in the axis itself from Kirkstone Fell to the valley of the Lune, as represented in the former of these diagrams. This, combined with the dip perpendicular to the axis, produces that represented in the figure.

Fig. 11.



Great limestone fault.

It must be recollected that the dip of the imaginary stratum here described is altogether independent of the unconformable stratification of the grauwacké group, but would coincide with the mean dip of the mountain limestone, independently

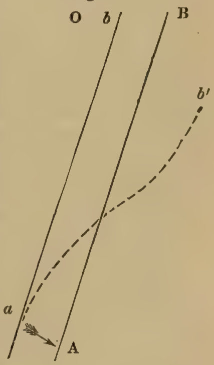
* I speak of *geological elevation* (as I have elsewhere defined it) as the elevation above its undisturbed horizontal position, of any stratum, of which the continuity

of irregularities due to dislocation, if it now existed over the whole of the district.

13. A very general conclusion in the Theory of Elevation which I have elsewhere developed, is this :—*that the directions of dislocation will approximately coincide with those of the mean dip, or with those of the mean strike of the beds.* Accidental deviations from this law may of course arise from local and irregular causes which can in no way be reduced to calculation ; but all such deviations are not to be deemed anomalous. They may not unfrequently proceed from causes which, though in a certain degree local, may be brought within the sphere of our mechanical theory, and may even in some instances afford one of the best tests of its accuracy. The above rule, however, will in most cases be approximately true, and may be applied with great facility.

The dislocations of the older rocks in the district with which we are occupied must be considered with reference to both the great movements, or series of movements, of which we here recognize the effects, viz. the movements prior to the deposition of the Carboniferous series, and those by which it was subsequently dislocated, since the older rocks must necessarily have been acted on by both these movements. The great longitudinal dislocations which accompanied the first of these movements would, according to our theory, approximately coincide with the mean strike of the older beds, so far at least as that strike coincides with that originally given to those beds by the first general action of the elevatory force to which the commencement, and therefore the directions of the dislocations, are to be referred. A subsequent movement, following a different law, might destroy this coincidence of direction. Thus, supposing the original movement of the older beds to have given them a strike to the N.N.E. and S.S.W. ; and conceive the dome-like configuration of the district to have been given by a subsequent and local movement ; then would the coincidence of direction in the longitudinal dislocations and the strike be destroyed. Thus, let A B represent a line of fracture, and *a b*, parallel to it, a line of strike, the direction of the dip being denoted by the arrow at *a* ; then will *a b* be a horizontal line on the stratum passing through *a b*. Conceive now a subsequent and local movement to produce a dome-like elevation, of which O should be the highest point ; the line *a b* will no longer remain horizontal, *i. e.* it will no longer be the line of strike, which will evidently assume some such position as *a b′*, running round the last-formed elevation. The degree of deviation of *a b′* from *a b* will depend on the pre-existing inclination of the older beds, and on the strike and inclination which the local movement alone

Fig. 12.



over the whole district is real or imaginary ; this is the elevation with which we are properly concerned in any theory on the subject. The mere *superficial elevation* (or that of the actual surface independently of local irregularities) is only here important so far as it gives us an approximation to the *geological elevation.*

might tend to give to them. The greater the former of these, the less, *cæteris paribus,* would be the deviation, which would be zero, if the beds were vertical; for it is manifest that no vertical movement (such as I am here supposing the local elevation to arise from) could affect the strike of a vertical bed. For this reason the direction or *strike of the fault* will not be changed by such a movement, the plane of the fault being (as it may be assumed to be) very nearly vertical. Consequently, the original parallelism of strike and dislocation would be destroyed by any subsequent movement which should affect the strike of the beds.

14. The great faults of the Duddon, Coniston, Windermere, and Troutbeck, coincide in direction with what appears to be the general strike of the older beds; and in their more southern portions they coincide nearly with the actual strike in these localities; while in approaching the central group of mountains, there is a deviation from this coincidence precisely similar to that represented in the last diagram*. These theoretical considerations would therefore lead me to conclude that the great faults are referable to the original elevation of the older rocks, but that a subsequent elevation gave to the district of the Lakes its actual configuration.

I conceive the greater part of the other dislocations, more especially those most distinguished by their *divergency* from the centre of the district, to have originated in this subsequent local elevation; for a system of dislocations thus characterized would necessarily result from such an elevation. Making this hypothesis, let us compare the actual with the theoretical directions of these fractures as given in the second diagram of Article 12, supposing the directions of dip and fracture to coincide. Those along the valleys of Borrowdale and Derwentwater, Buttermere, Ennerdale, Wastwater, and the upper part of Eskdale, appear to coincide accurately with the mean dip which would be given by the local elevation we are considering, and indicated in the diagram. Along Crummock lake the direction is somewhat more northerly than the theoretical direction, which is again resumed however along Loweswater. The deviation must be considered accidental. The lower part of Eskdale would present some anomaly if considered as having originated in a dislocation ranging along it; but for reasons already assigned (Art. 5), the portions of such valleys most remote from the centres and lines of elevation can never be taken safely as indicating directions of dislocation, unless, as in the case of the valley of the Duddon, independent evidence of fracture can be detected.

The valley of Long Sleddale does not deviate from its theoretical direction in an appreciable degree; that of the Lune (immediately south of Tebay) slightly perhaps from the N.E. On the north-eastern side, the Haweswater dislocation must coincide with our mean dip as nearly as we can estimate it. If we take the mean direction of Ulswater from Glencoin to Pooley Bridge, the deviation from the mean

* The strike is distinctly indicated by the calcareous bed, the dislocations of which, as already explained, indicate the great faults above mentioned.

dip might at first sight be estimated at nearly two points of the compass. Considering however the great height of Helvellin, the deviation does not probably exceed one point.

The direction of St. John's Valley and Thirlmere appears to accord accurately with theory. The longitudinal valley of Langdale deviates perhaps about a point from the mean strike, or that which theory would assign to it.

The upper part of Ulswater, from Glencoin to Patterdale, (of which the direction is anomalous,) may probably be referable to one of those irregular fractures of comparatively small extent, of which there must doubtless have been many, accompanying those greater dislocations from which we gather the laws of the phænomena, and which have impressed on the district its great and distinctive features. The same observation may be applied to the upper part of Winandermere, above the point where it is joined by the valley of Troutbeck. It should be remarked, however, that in neither case is the portion of the lake now spoken of to be considered as necessarily referable, like the other portions, to a line of fault.

15. Hence then I conclude that these diverging lines of fracture in this district are due to a local elevation, *posterior* to that which produced the great longitudinal faults of the grauwacké system. Beyond this there is nothing in the previous reasoning to determine the epoch of this local elevation. It may have been that of the elevation of the Carboniferous system, or prior to the deposition of that system, at the conclusion, for instance, of the movements which elevated the older beds, the directions of dislocation of those beds having been determined in the commencement of those movements. This point must be determined by other evidence.

In a former part of this memoir (Arts. 4, 5) I have stated my reasons for believing the bottom of the ocean on which the lower beds of the carboniferous series were deposited, to have been very nearly plane and horizontal; and also that the actual geological elevation of the district was given to it by the movements which elevated the mountain limestone and new red sandstone. Those reasons appear to me of great weight, and, admitting their validity, we are led to refer the diverging dislocations to the same epoch. If we refer them to a prior epoch, it would appear necessary to suppose the district to have been then raised into a form like the present, to have been again levelled by denuding causes previous to the deposition of the Carboniferous system, and then to have been again elevated, on the breaking up of that system, into its present form, with the reproduction of the former dislocations. These conclusions are equally in accordance with our theory of elevation, but it appears to me that the greater simplicity of the first recommends it strongly to our preference.

16. The peculiarity of the case before us with reference to our theory, consists in its presenting, at the western extremity of the elevated district, a complete apse, up to which the elevatory force to which the local movement above spoken of is referred, has acted with sufficient intensity to develope the peculiar characters which

theory in such case assigns to the resulting phænomena. These characters are theoretically described in my memoir on Physical Geology in the Transactions of the Cambridge Philosophical Society (Art. 57), from which I make the following extract:—"If we suppose the superficies of our elevated mass to be of finite length, and to be bounded for instance by a line approximating to the form of an elongated ellipse, the directions of the fissures in the transverse system, as we approach towards either extremity of the elevated range, will gradually change from perpendicularity with the major axis (the axis of elevation) till they become parallel to it, at the extremities of the ellipse, always preserving their approximate coincidence with the directions of the lines of greatest inclination of the general surface of the mass." It will be observed how exactly this description accords with the Wastwater, Ennerdale, and Buttermere lines of dislocation.

Professor Sedgwick, in the memoir already alluded to, not only recognized the law of arrangement in these lake valleys, but had evidently also the idea of the kind of mechanical action to which it must be due, regarding the centre of radiation as a *centre of elevation*. When the subject is regarded, however, with reference to more precise theoretical views than Professor Sedgwick had then probably any object in discussing, it is manifest that the western extremity and highest point of the elevation is to be considered as the termination of a central *line* of elevation, and the part of that line where the elevatory force has been more intense than in other parts, especially those immediately west of the Lune. And this is the reason why the radiating arrangement of the lines of dislocation, so beautifully exhibited on the west, is more imperfectly preserved on the eastern side of what is properly termed the Lake district.

Part II.

§ *Phænomena of Denudation.*

17. It will not be necessary to enter into any details respecting the well-known phænomena of the distribution of detritus and erratic blocks which have proceeded from the Cumbrian mountains as a centre. The most curious of these phænomena, and apparently the most difficult to account for, are those connected with the dispersion of boulders of Shap granite. Their transport across the deep vale of the Eden and the lofty pass of Stainmoor, with their distribution from thence along the vale of York, and upon the high Eastern Wolds of that county, constitute one of the most curious problems of this kind which Geology presents to us. The immense mass of smaller detritus spread out over the more level plains of Lancashire will also have to be considered in this branch of our subject; and finally, the formation of the great valleys from which I conceive this detritus to have been in great measure derived. There is probably in the present day no wide discrepancy in the opinions of geologists respecting the origin and formation of great valleys like those in the district we are considering. It will be generally allowed, I conceive, that they have originated in dislocations, and that their formation has been effected

by aqueous agencies. In fact, the inspection of a model in which heights and distances are on the same scale (like that already alluded to of Mr. Flintoft's), must make it apparent that the actual widths of the valleys in question could not possibly be derived from the fractures in which we may conceive them to have originated. Part of the masses which once occupied them may have disappeared by subsidence, as in the formation of the existing lakes; but that such has been the case in any considerable proportion is extremely improbable in all cases, and in some demonstrably absurd. Any satisfactory theory, therefore, of the distribution of detritus around the Cumbrian mountains must also account for the formation of the great valleys of that district.

I now proceed to make some observations on the theories which have been propounded on this subject—the glacial, the diluvial, and the iceberg theories—as regards their applicability to the case before us. I shall avail myself of the opportunity of giving further developments and a more determinate character to the diluvial theory than it has hitherto received. With respect to the glacial theory, it must be expressly understood that I shall speak of glaciers only as a means for the wide and distant dispersion of blocks and detritus, without entering at all into the question of their possible former existence in the recesses of the more elevated regions of the Cumbrian mountains.

§ *Glacial Theory.*

18. A few observations only will be necessary on this branch of our subject. I shall at once assume the former existence of a great glacier filling the valley of the Eden after descending in different branches from the more elevated parts of the Lake district and the contiguous portion of the Penine chain, and proceed to consider its probable course. Part of its sources must have existed on the hills surrounding Kirkby Stephen, *i. e.* on Stainmoor Fell, Bow Fell, Howgil Fell, and the intermediate eminences. Small lateral feeders must have descended from the Cross Fell range on the east, and large tributaries must be supposed to have descended along the valleys from the central group of the Cumberland mountains on the west. According to the existing configuration of the surface, we may conceive a glacier proceeding from the granitic region of Shap Fell along the valley between Orton and Howgil Fells, and debouching to the south of Kirkby Stephen. There it would be met by another large glacier descending between Millerstang and the lofty Fells on the east of it. From the point of junction the whole glacier must necessarily have descended along the valley of the Eden, as the direction of greatest descent, and that of least resistance from opposing obstacles. Under these circumstances, any one who has watched the course of a glacier composed of several tributary ones, and observed the manner in which each component glacier preserves its own identity in the compound one, will at once recognize the extreme difficulty of conceiving how the moraines of the Shap Fell glacier could pass over to Stainmoor, from which it would necessarily be separated by

the glacier from Millerstang. The granite blocks would thus have formed a middle moraine in the great glacier of the Eden, and instead of being transported to the eastern coast of Yorkshire would have been transported to the shores of Solway Firth.

Without insisting, therefore, on *à priori* objections to the glacial theory, I consider it to be entirely insufficient to account for the most important phænomena of distant transport from the Cumbrian mountains, to whatever extent we should admit the former existence of glaciers in that region. It would be useless, therefore, to discuss its application to other transported masses of this district.

§ *Diluvial Theory.*

Before I enter upon the application of this theory to the case before us, I shall make a few general remarks on the limits of the period during which the subaqueous transport of existing blocks may have taken place, and the nature of the surface over which they must have been conveyed.

19. *Period of Transport of Erratic Blocks.*—It appears usual to regard the transport of erratic blocks as having taken place only at one particular period, and that period one of the latest recognized by geologists in the history of our planet. It seems to have been determined, partly at least, on the principle on which we determine the period of deposition of a formation unconformable to those beneath it, in which case we conclude the whole formation to be more recent than the most recent of those on which it reposes. The accuracy of this conclusion manifestly depends on the assumed fact of the deposition of the formation having proceeded contemporaneously throughout its whole extent. In like manner the period of erratic blocks has been assumed to be more recent than that of the tertiaries, because such blocks are found to repose upon those formations. There is however a great difference between the grounds on which these conclusions rest. We can have no reasonable doubt of the contemporaneous deposition of a continuous formation, characterized throughout by the same fossils and similar mineralogical structure; but the stratum (if we may be allowed such application of the term) of erratic blocks has no such character of continuity, and therefore no such necessary contemporaneity in the formation of its several parts, which may on the contrary have occupied an indefinite period of time reckoned from the transport of the earliest existing blocks from their original sites. Blocks which now repose on a recent formation may previously have remained for ages on an older one. The only demonstrable conclusion which can be drawn from the actual position of an erratic block is this—that *the last stage of its movement* was posterior to the formation of the stratum on which the block reposes.

A similar conclusion will hold also with respect to gravel containing recent organic remains. Its immediate transport to the locality which it now occupies must necessarily have been posterior to the existence of the animals whose remains are imbedded in it; but we cannot possibly apply the same reasoning to prove that the removal of the gravel from the original sites of its component materials was posterior to the same epoch.

There is another consideration, however, which must be admitted as imposing a further limitation on the age of erratic blocks, especially when of considerable magnitude. When such a block is found reposing on a surface which we believe to have once been rough and uneven, but of which all the asperities have been worn down till the surface has become comparatively smooth and even, by the operation of denuding agencies, we may conclude that the transport of the block to such locality was posterior, not only to the deposition of the beds on which it rests, but also to any dislocation by which their surface might have been rendered *rugged*, and to the subsequent process of denudation, by which such ruggedness must have been again destroyed. For it must be admitted that the same action which should wear down the asperities of the surface on which the block reposes, would also reduce the block itself to comminuted pebbles, unless the block were much harder than the beds it rests upon, in which case the above conclusion would manifestly not be necessarily true. Thus, for instance, a block of hard crystalline granite might originally repose on a non-crystalline mass of sand or clay, the surface of which might be modified in almost any degree by a gradual and gentle operation of denuding agencies, insufficient to produce any appreciable effect on the block itself.

The most recent formation on which the erratic blocks repose in the immediate neighbourhood of the Lakes is the new red sandstone. Consequently their transport could not commence till after the deposition of that formation, which defines the earliest possible limit to the time of transport. Again, since numerous blocks have been conveyed over Shap Fell, their transport, supposing it to have been subaqueous, must have taken place before the emergence of the fell from the ocean, which emergence, on the above supposition, defines the latest limit to the period of transport. During what part of the interval thus defined, the operation was commenced or principally carried on in the neighbourhood of the Lakes, it is impossible, I conceive, to demonstrate. The transport of the blocks now resting on the Wolds of Yorkshire must have been *concluded* subsequently to the deposition of the oolites; and other blocks, for a similar reason, may not have completed their course till after the tertiary period; but to conclude, therefore, that every block from the central mountains of Cumberland, which now reposes, for instance, on the mountain limestone of Kendal Fell, was not transported there till the post-tertiary period, is to form an opinion which, I believe, has not the slightest foundation to rest upon. We are unquestionably at liberty to suppose them removed at a much earlier period, should any well-founded theory require such supposition.

20. *Surface over which the Blocks have been transported.*—This is also a point of great importance in our discussions of theories of erratic blocks. It seems to have been generally assumed in the discussions on the efficacy of currents, that the subaqueous surface over which blocks have been transported by that agency had the same

configuration as at present, when it is elevated above the surface of the sea; and thus an apparent difficulty has been created, which in my opinion has been much too strongly insisted upon by the opponents, and too easily admitted by the friends, of this theory. The assumption is, as I conceive, entirely untenable in the majority of those cases in which it has been made, and is inconsistent with the primary hypothesis of the theory,—the existence of currents sufficient in force and in frequency to produce the effects in the transport of blocks which the theory attributes to them. The difficulty alluded to arise from the supposed existence of irregularities of surface, such as deep valleys, or high escarpments in directions *transverse* to the transporting currents. And such a valley might undoubtedly be formed as the immediate effect of a great dislocation, and such an escarpment might be formed by a great fault; but the formation of the one or the other, as the effect of great ocean-currents, is altogether inconceivable, even supposing these currents to have the most favourable directions; and especially does it become so when we acknowledge the existence of great transverse currents, under whatever conditions they may have existed. Observations likewise on the forms of subaqueous surfaces, where the water is sufficiently shallow to subject them to the action of ocean-currents, prove the great leveling tendency of such currents. I contend, therefore, that the surfaces over which boulders, according to the theory of currents, must have been conveyed, presented in general none of those abrupt inequalities, great or small, which usually distinguish subaërial surfaces (and which would render the transport of blocks across them difficult or impossible), with the exception of those cases in which the inequalities are attributable to elevation and fracture. The case before us of the transport of blocks from Shap Fell to the Eastern Wolds of Yorkshire, which I shall discuss in the sequel, will serve to elucidate these remarks.

21. *Theory of Currents**.—If a considerable area at the bottom of the sea were *suddenly* elevated, nearly the whole superincumbent mass of water would be elevated in nearly the same degree, and a great wave, which has been called a *wave of translation*, would diverge in all directions from the central disturbance, and would be accompanied by a current diverging in like manner, the velocity of which would depend principally on the depth of the sea, the height of the original elevation of the water, and the distance to which the wave had been propagated. These currents may be termed *currents of elevation*, and are those alone with which we shall here be concerned. I can conceive no others of sufficient power to have

* In this memoir, as originally presented to the Society, I had entered into considerable details respecting the nature of a wave of translation, and the effectiveness of its attendant current in transporting erratic blocks; but I have not thought it necessary to preserve these details, having subsequently given the mathematical exposition of the subject in the 'Transactions of the Cambridge Philosophical Society,' vol. viii. part 2, to which I would refer the reader. I shall only preserve here a few words of general explanation, and some results of calculation with their application to the case before us.

had any material effect in the transport of blocks from the Lake district.

The velocity of the current at any particular point of the surrounding sea would rapidly increase after the wave had reached that point and then decrease till the whole wave had passed by, after which the current would cease. If it acted on a block very much smaller than the greatest one it was capable of moving, it would communicate a considerable velocity to the block, which would then be made to accompany the wave to a considerable distance. If, on the contrary, the block should be nearly as large as the greatest one which the current with its maximum velocity could move, it would be only for a very short time that the current would be effective in moving the block, which would thus be transported only to a comparatively small distance. Consequently the transport of large blocks to considerable distances would require many repetitions of the action of these currents, and therefore many distinct movements of elevation, since each such movement would only produce its single wave of translation. Thus this theory becomes related to our theories of elevation, since it requires a succession of elevatory movements of a paroxysmal character; and I may here add, that I believe such movements to be those by which we can best account for the general phænomena of elevation and denudation.

22. To convey a distinct idea of the effectiveness of currents which may be produced in the manner here supposed, I will give a statement of certain calculated results, which may be taken as correct to a degree of approximation sufficient for our purpose.

Depth of the Sea.	Height of the Wave.	Velocity of the Current.
Feet.	Feet	Miles per Hour.
200	25	6½
	50	12
	100	22
300	25	5½
	50	10½
	100	19½
400	25	5
	50	9
	100	17
600	150	20½
800	200	28

The *depth of the sea* here given is its depth independent of the wave; the *height of the wave* is the height of its crest, or highest point; and the *velocity of the current* is the maximum velocity, or that which exists under the crest of the wave.

It will be observed that for the same depth the velocity of the curr nt is nearly proportional to the height of the wave; and also that for a given height of the wave the velocity of the current decreases regularly as the depth increases. Thus, from the velocity of the current corresponding to a wave 150 feet high in a sea of the depth of 600 feet, we may conclude that the velocity of the current for a wave of 100 feet high in the same sea would be about 14 miles an hour; and in the same way we may conclude, from the results given in the table for the velocities of the currents attending waves of 200, 300, and 400 feet respectively, that the velocity for a wave of the same height in a sea of 500 feet deep would be about $7\frac{1}{2}$ miles an hour.

I have before remarked that these results must be considered only as approximative, but they prove beyond all doubt that paroxysmal elevations, beneath the sea, varying from 50 to 100 feet in height, may produce currents of which the velocities shall vary from at least 5 or 6 to 15 or 20 miles an hour, provided the depth of the sea do not exceed 800 or 1000 feet.

We have next to consider the magnitude of the blocks which might thus be moved.

23. The magnitude of the force which a given current can exert on bodies of certain forms entirely immersed in the fluid, has been determined by numerous and satisfactory experiments, as well as the law according to which the force varies with the velocity of the current. The force exerted on a surface given in magnitude and position, is found to increase as the square of the velocity, up to the greatest velocities which have been experimented on, about 9 or 10 miles an hour; and the same may doubtless be extended by induction to much greater velocities. A curious consequence results from this law, when we estimate the force of the current (as we are naturally led to do in the case before us) by the weight of the largest block of a given form which it is capable of transporting. Thus estimated, the force varies as the *sixth power of the velocity of the current*. Thus, a certain current being able to move a cube of given weight, another current of double the velocity would move a cube of 64 times the weight of the former; if the velocity were treble that of the first case, the weight of the cube which could be moved by it would be 729 times as great, and so on. This is the result of the simplest calculation, and shows how mistaken an estimate we might form of the motive power of currents of great velocity, from the consideration of that of ordinary streams.

The magnitude of the block which may be moved by a given current depends much upon its form, those forms which approach nearest to the spherical being most favourable. It also may depend, in certain cases, on the depth of the water, the most favourable being that which should not be greater than the height of the block. The depth however will have little effect on the effectiveness of the current, if the block be of such a form and be so situated that the water can have access to nearly the whole of the lower surface. If therefore we take those blocks which are under the most favourable conditions for being moved (as we have a right to do), it is probable that it will be approximately correct to omit the effect of the depth of the water. In that case, supposing the form of the block as nearly spherical, as many erratic blocks are observed to be, there is no doubt that blocks of 5 tons and upwards might be moved by a current of 10 miles an hour; and, assuming the force of the current to increase at the square of the velocity for greater velocities than that, it follows that a current of 15 miles an hour would move blocks of similar forms of the weight of 56 tons and upwards; while a current of 20 miles an hour would move similar blocks of 320 tons and upwards. For other forms the weights might be much less; but these calculations demonstrate beyond doubt, that while an ordinary stream of between 2 and 3 miles an hour may be insufficient to move a pebble, a current of from 10 to 20 miles an hour may have motive power sufficient to transport blocks of enormous magnitude.

24. *Application of the preceding theory.*—In the practical application of these views, the great wave of translation and its attendant current are to be attributed to the elevation of the district whence the blocks have been conveyed previously to its emergence above the surface of the sea. We must further suppose such elevation to have been sudden, of a *paroxysmal* character, in which case the height of the wave would be approximately that of the elevation, as already stated. Its breadth would depend on the extent and form of the elevated area. If we suppose that area approximately circular, and the wave to diverge freely, its breadth would be at least equal to the radius of the area, and might be considerably greater. We thus see how *diverging currents*, of enormous transporting power, may be simply accounted for. Nor does this view of the subject require the hypothesis of paroxysmal elevations of great magnitude; for it appears, from what has been stated, that an elevation of 100 or 150 feet would produce a current capable of transporting, for at least a short distance and under favourable conditions, a block of immense weight.

The hypothesis respecting these elevations which may be deemed most favourable to this theory of transport, is, that they were paroxysmal and frequent, but not necessarily large. The effectiveness of this cause will also be increased if we suppose these successive elevations to have been attended (as they probably must have been) with alternations of subsidence; for in such case it may have required a much greater number of these paroxysmal elevations to produce as their result an existing elevation of given magnitude, than if they had been unattended by frequent subsidence.

I have already explained my reasons for believing the inadmissibility of the glacial theory to account for the phænomena of the blocks of Shap granite. In adopting either of the other theories we must necessarily suppose the pass of Stainmoor to have been beneath the surface of the ocean at the period of transport of these blocks. I have also stated my reasons (Art. 11 (6.)) for believing that the district of the Lakes had scarcely begun to emerge from the ocean at the epoch at which the transport of boulders *may* have commenced, *i. e.* not long after the deposition of the new red sandstone. According to this view, therefore, there must have been, since that period, an elevation of the centre of the district of 1500 or 2000 feet over and above that of Stainmoor, which is now about 1500 feet above the sea. It is to the succession of movements to which this relative elevation is considered to be due, that we must attribute the great waves of transport. This height of 1500 or 2000 feet is probably much more than necessary to allow of paroxysmal movements, attended by alternations of gradual or sudden subsidence, sufficient both in number and magnitude for the transport of blocks from this district.

25. Let us now consider the surface over which the Shap Fell blocks must have passed in their course to the Eastern Wolds of Yorkshire. I have shown that the vale of Eden must have been, at least to a considerable degree, filled up by the deposition of the new red sandstone. At what period did the denudation which gave to the valley its present configuration take place?

Mr. Phillips has stated, as one of the curious facts of the case before us, that in the eastern parts of Yorkshire there are boulders of a peculiar conglomerate subjacent to the new red sandstone, containing small angular masses of limestone, of which the only known locality is the neighbourhood of Kirkby Stephen. It appears to have been collected in the lower part of the valley of the Eden previous to the deposition of the sandstone, and therefore probably never existed at a much greater relative elevation than at present. Admitting the fact, then, above stated, it would follow that the denudation of the valley must have taken place in a very great degree before the emergence of Stainmoor (over which the boulders must have passed) from beneath the surface of the sea.

The currents I have described would be the most efficient agents we can conceive in this denuding process, which, in such case, must have proceeded contemporaneously with that of transport of the blocks. But whatever may have been the immediate agency by which the denudation was effected, we can have no grounds for supposing that it was completed previous to the conveyance of the blocks across the valley; and much more would it be inadmissible to suppose that the surface between Shap Fell and Stainmoor had, as the bottom of the then existing ocean, all the minor irregularities which now characterize it. On the contrary, it must necessarily, as I conceive, have been a comparatively *even* surface (Art. 20), and the depth of the submarine valley must, at the period of the transport, have been less, possibly much less, than that of the existing valley, of which the denudation was doubtless completed in the course of the elevation which has ultimately raised it above the level of the sea.

I have here reasoned as admitting the fact above stated respecting the Kirkby Stephen conglomerate; but I should state that some geologists doubt the possibility of identifying the conglomerate boulders with this formation. If we reject the facts as supported by insufficient evidence, I should merely modify the above conclusions by supposing that less denudation of the valley probably took place, by the action of the transporting currents, before the emergence of Stainmoor, and a greater portion during the subsequent elevation of that region. I shall have again to notice the fact above spoken of in reference to the theory of transport by floating ice.

Passing to the east of Stainmoor, it must be observed, that the present height of the Eastern moors is about 800 or 900 feet above the sea, which is less than that of Stainmoor by 600 or 700 feet. Hence we must conclude that when the latter tract was under water the former must have been so likewise, and probably at a considerably greater depth. Consequently I conclude that the oolitic escarpment of the Wolds (due as it is to denudation) could not have existed at that period (Art. 20). Such an escarpment would be the necessary consequence, under the most simple and probable conditions, of the denuding power of water during a gradual elevation of the land ; but, as I have before remarked, is inconceivable as the effect of ocean-currents acting on a surface entirely submerged.

Hence then I conclude that the transport of blocks towards the east was not impeded by those numerous irregularities of surface which now exist, and may be attributed to the partial and local operation of denuding causes. Nor was there any great oolitic escarpment to surmount ; the only apparent impediment was the great limestone ridge, of which Stainmoor is the lowest part, due, not to denudation, but to elevation, and of which the general outline was the same as at present. Similar observations are applicable to the surface of other portions of the district. While in its general outlines it would resemble the existing surface, the subordinate inequalities would be wanting.

26. We may now examine the progress of one of our great waves, produced, I will suppose, by a general elevation of the district of the Lakes. The wave and the current attending it would diverge from the central point of elevation, so that the current from Shap Fell would set very nearly in the direction of Stainmoor. The portion of the wave opposite that pass would, in approaching it, be compressed into a narrower space, both by the diminution of depth, and by the hills rising above the sea on the north and south of the pass, and leaving there a contracted channel for the current, the velocity and power of which would thus become greatly increased. When the current was directed to the north of Stainmoor, it would be turned northwards by the projecting Cross Fell range ; and in like manner another powerful current would be directed southwards by the continuation of the same range in that direction. On the other sides of the district the wave would radiate from the centre with little interruption.

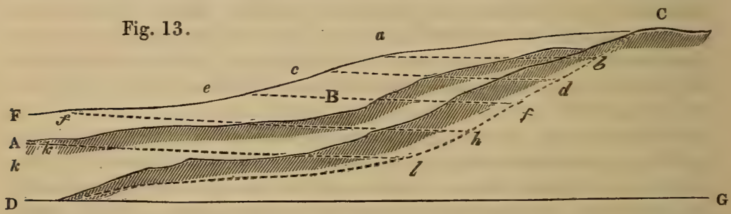
The absence of a satisfactory cause for powerful diverging currents, and the passage over Stainmoor, have been two of the great difficulties which have hitherto beset the problem before us : they are entirely removed by the explanations now given. Diverging currents, in fact, of greater or less magnitude would be the necessary consequence of movements beneath the sea such as we are sure must have taken place ; and the increased power which the current would acquire in approaching Stainmoor, as above shown, explains the transport of the blocks in their passage over that elevated tract. This current would be sufficient to carry the blocks considerably further to the east, but it is probable that their transport to their extreme limit in that direction would be completed by currents originating in the elevatory movements by which the great central chain, after the transport of the blocks across it, was elevated above the surface of the ocean. The denudation of the vale of York and the formation of the oolitic escarpment of the Wolds would take place subsequently during the gradual elevation of that region, in the manner in which the German Ocean, or English Channel, is now performing a similar work of denudation, and forming similar escarpments along our existing coasts. The existence of boulders from the Cumbrian mountains on the highest parts of the Eastern moors is thus I think simply explained, and the third great difficulty of the problem entirely removed.

27. It should be observed, that though I have contended against the extreme limitation which many geologists have appeared inclined to impose on the period of transport of erratic blocks, it is not necessary to insist on any material extension of that period as essential to the explanations of the theory above-given, which admits of as recent an epoch of erratic boulders as any theory which assumes their subaqueous transport.

The transport of boulders in the other directions in which they are found, and the spreading of an extensive layer of smaller detritus over the surrounding plains, would be the necessary consequences of the great waves above described. It is unnecessary to enter into any details respecting these phænomena: it only remains, in order to complete the view now given of the denudation of this district, to explain the manner in which I conceive its great diverging valleys to have been formed.

28. *Formation of the Valleys.*—Let the following diagram represent an elevated range with the valley A B C D deeply cut into it, by the agency of water during the gradual emergence of the range from beneath the surface of the ocean. The dotted line C *b d* . . . D represents a section of the bottom of the valley by a vertical plane and C *a c* . . . F a section by the same plane of what would have been the surface of the elevation if there had been no denudation. *a, b, c, d,* &c.

Fig. 13.



are horizontal lines indicating the positions of the surface of the ocean with respect to the elevated mass, at different epochs during its elevation. Let us also suppose a dislocation to have passed along the line of the valley,

Previously to the surface of the ocean occupying the position *a b*, all the portions of the mass above that plane, and between the actual surface and the imaginary one C F, would be denuded, and the upper extremity of the valley would be formed where the dislocation of the mass rendered it less able to resist the action of the waves. In a similar manner the part of the valley included between *a b* and *c d* would be formed during the absolute rise of the land, or relative depression of the sea through a space equal to the distance between those lines; and in the same manner the lower parts of the valley would be cut out by the action of the sea during successive periods of the elevation. While the finer particles would be transported to a distance, the coarser detritus would be deposited at some lower level on the side of the mountain, being carried lower and lower by successive removals, so that in some cases the lower part of the valley might be cut out partly from the original rock and partly from the accumulated detritus at the foot of the elevation, and the greater the accumulation of detritus by successive removals and additions, the more likely would it be that this should be the case.

In the process above described, I have supposed the agency to be merely that of water acting like ordinary waves on a cliff at a point where a previous dislocation or any other cause has rendered it less able to resist their repeated action. But to these effects we must also add those of the great waves already described as taking place during the elevation of the district. It is to these waves that the transport of the smaller detritus, as well as that of large boulders, to the more distant localities, is to be attributed.

§ *Iceberg Theory.*

29. In many of those cases in which blocks of enormous magnitude and sharp angular forms have been conveyed to great distances from their original sites, it seems highly probable that floating ice may have been the agent by which the transport has been effected: but in the case before us the evidence afforded by the blocks themselves appears to me strongly opposed to this view of the subject. In the first place, there is no obvious reason why blocks thus conveyed from one place to another should have their surfaces rounded and polished; and therefore it would be probable that a considerable portion of them at least should retain their original angular outlines. And secondly, there is no reason why the largest blocks should always be conveyed to the shortest distances, or why those which have travelled farthest should be the most worn and rounded, since they could be subject to no attrition in the act of transport. We might frequently expect them, whether large or small, to be most numerous near their original site, and to decrease in number, but not necessarily in magnitude, as they should be more remote from it. These considerations appear to me to furnish the best tests for separating the effects of floating ice from those of currents.

Now the blocks which I examined from Orton Fell to the top of Stainmoor* appear (I believe without exception) to be highly polished, and must therefore have been long exposed to powerful aqueous action, while those (so far as I can ascertain) which have been

* I have not examined them to the east of Stainmoor.

carried to a greater distance bear the same testimony. It also appears that the blocks become smaller as we approach the coast of Yorkshire, till they degenerate into pebbles and gravel in the more remote localities in which the Cumbrian rocks can be identified. These facts are strongly in favour of those views which would refer the transport of these masses to diluvial currents.

I have already alluded to the statement of Mr. Phillips, that boulders are observed in Yorkshire from the Kirkby Stephen conglomerate, but that others have doubted the possibility of identifying them with sufficient certainty. The angular form, however, of the fragments of limestone imbedded in this conglomerate gives to it a very peculiar character, and no individual testimony can be deemed stronger than that just quoted. We may be justified, therefore, in reasoning on this fact as supported by strong, if not by absolutely conclusive, evidence. If it be admitted, it affords an absolute proof of the existence of currents such as those above described, since it is evident that no floating ice could possibly transport a boulder from the depths of the vale of Eden over the heights of Stainmoor. These boulders, therefore, well merit the attention of those who may have the opportunity of examining them. Their transport presents not the smallest difficulty in the diluvial theory.

I may remark in conclusion, that while the diluvial theory as above developed assigns an adequate cause for the transport of blocks from the Cumbrian mountains, it explains far better than any other the actual disposition of the smaller detritus in extensive superficial layers, and the scooping-out of the great valleys of the district. The phænomena of elevation, of denudation and transport, regarded in the point of view in which I have endeavoured to place them, appear to me to present that general accordance and harmony which afford one of the best tests of truth.

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I. TRANSACTIONS AND JOURNALS.

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II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

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Babbage, C. Observations on the Temple of Serapis at Pozzuoli.

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Catullo, T. A. Osservazioni sulle Rocce Levigati delle Alpi Venete.

——— Osservazioni sopra uno Scritto del Nob. Achille de Zigno.

Davidson, T., and J. Morris. Description of some species of Brachiopoda.

Des Moulins, C. Examen des Causes qui paraissent influer particulièrement sur la Croissance de certains Végétaux.

——— État de la Végétation sur le Pic du Midi de Bigorre.

——— Note sur le Sisymbrium Bursifolium.

Dumont, A. Mémoire sur les Terrains Ardennais et Rhénan.

——— Fragment d'une leçon faite, le 5 Mars 1847, à l'Université de Liége sur la Valeur du Caractère paleontologique en Géologie.

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The following communication was read:—

Description of Teeth and portions of Jaws of two extinct Anthracotherioid Quadrupeds (HYOPOTAMUS VECTIANUS *and* HYOP. BOVINUS) *discovered by the Marchioness of Hastings in the* EOCENE DEPOSITS *on the N.W. coast of the* ISLE OF WIGHT: *with an attempt to develope* CUVIER'S *idea of the Classification of Pachyderms by the Number of their Toes*. By Professor OWEN, F.R.S., F.G.S. &c.

WHILST in Paris in the month of September last, I was favoured by the Marchioness of Hastings with information of the discovery of the fossils that form the chief subject of the present communication. Her ladyship wrote,—"My search in a particular part of the Eocene beds of the Isle of Wight, where formerly I found that *Lophiodon* or *Palæotherium* bone figured in your 'British Fossil Mammalia *,' has been eminently successful. I have got two portions of jaw and many other bones. I have sketched them for you. Are they *Coryphodon* or *Anoplotherium*?" The pen-and-ink sketches, executed with the skill and accuracy of an accomplished artist, showed the fossils to belong to the Anthracotherioid family of *Ungulata*, with an evident resemblance to that species in the upper molars of which Cuvier had

* P. 309, fig. 106.

detected a closer resemblance to the *Anoplotherium* than the same teeth of the typical genus *Anthracotherium* present.

Cuvier briefly describes the fossil teeth of the species referred to, in a supplementary note to his concluding volume of the 'Ossemens Fossiles*': they were discovered in a freshwater eocene deposit mingled with gypsum in the neighbourhood of Puy-en-Velay, by M. Bertrand Roux, or de Doué, as Prof. de Blainville writes, who cites his excellent figure of a jaw of this species in a memoir on the geology of the 'Bassin du Puy,' which I have not yet seen. Cuvier says that the upper molars of this Anthracotherioid differ from those of the typical *Anthracotherium* (*A. magnum*) of Cadibona in being "larger than they are long:" "and they would also resemble," he says, "the teeth of the *Anoplotherium*, were it not that their external surface is excavated by two deep grooves, one for each point. The tooth that precedes the last three (true) molars is quite like its correspondent in the *Anoplotherium* †." Cuvier, with his usual judicious reserve, refrains from assigning to these fragments a formal generic or specific name; but later acquisitions demonstrate that the Anthracotherioid of the Puy-en-Velay differed from the typical *Anthracotherium* in the smaller proportions of the canines, in a different relative position of the first premolar, and in modifications of the crown of the inferior molars corresponding in degree with those in the upper molars.

M. de Blainville has recently published good figures of the instructive and more perfect fossils of the Anthracotherioid from the Puy-en-Velay ‡, and adopts M. v. Meyer's indication of its specific distinctness, by adding, as in the 'Palæologica' (1832), p. 82, to Cuvier's "Anthracothère du Velay," which was a reference to its locality, the Latin binomial of *Anthracotherium velaunum*.

The Anthracotherioids discovered by Lady Hastings in the Isle of Wight belong to the same aberrant section as the one from Puy-en-Velay by the modification of the molar teeth, and the generic distinction from *Anthracotherium* proper is more decisively established by the more complex premolars. For this genus I propose the name of *Hyopotamus*; and for the species from the *Insula Vectis* on which it is founded, that of *H. vectianus*: a larger species indicated by molars as big as those of the Ox, I propose to call *Hyopotamus bovinus*. The generic characters, as indicated by the upper grinders, are well displayed in the specimens belonging to *Hyopotamus vectianus*, figured in Plate VII. figs. 6 & 7; more especially by the teeth *p* 3 and *p* 4.

The characters of the true molars are boldly marked in those of the larger species, *Hyopotamus bovinus*. The crown of the tooth, probably the last true molar of this species (fig. 1), is quadrate; its transverse diameter (0·032) exceeding the antero-posterior diameter (0·029), and being twice the vertical diameter of the enameled crown. This supports five three-sided pyramidal lobes, four of which are normal, in two pairs (*o*, *o'* & *i*, *i'*), and answer to the four symmetrical lobes in *Merycopotamus*, the *Ruminantia*, and *Anoplothe-*

* Tom. v. part ii. p. 506, 4to (1824). † Tom. cit.

‡ Ostéographie, fasc. xxi. *Anthracotherium*, pl. 1.

rium; the fifth lobe, *p*, answers to the small internal lobule in some *Ruminantia*, and to its more developed homologue in *Anoplotherium*, which is marked *p* in pl. 134. fig. 5. and pl. 135. fig. 2. of my 'Odontography,' and in fig. 5 of pl. 3, Quart. Geol. Journ. vol. iv.; but which in *Hyopotamus* is not only larger, but is moved to the inner and anterior angle of the crown of the tooth. In the present memoir this will be described as the fifth lobe, and the others (*o*, *o'* & *i*, *i'*) as the parial or normal lobes of the tooth. The external side of each normal lobe is concave, but is deepest in the two outer lobes, *o*, *o'*, fig. 1, and is divided from the other two sides by sharp, curved ridges; the angle between the other two sides is less sharp, and is rounded off in the inner and posterior lobe, as it is in the fifth lobe, *p*, both of which thus present a convexity towards the inner or palatal side of the tooth (fig. 3): the fifth lobe (*p*) is a rounded cone, with one ridge along its outer side; the valley between it and the inner and anterior normal lobe, *i*, is much less deep than those which divide the normal lobes: the summits of all the five lobes are pretty sharp, that of the fifth being the lowest; they are worn chiefly down the sides of the angles, indicating high-pointed lobes on the lower teeth of a size and shape that could penetrate the deep valleys of those of the opposing teeth above.

The outer side of the base of the crown (fig. 2) presents three bulging parts, one very large and prominent at the middle, upon which the opposite and contiguous angles of the two outer lobes are continued and meet, describing a strong curve convex outwards, and bounding a deep excavation on its inner side, leading to the deep middle transverse valley of the crown: a second protuberance (*a*) forms the anterior angle of the outer side of the base, and the third smallest protuberance the posterior angle of the same side: this side of the base is not traversed by any ridge. The outer sides of the outer lobes are made hollow by the projection of the three tuberosities which render the intervening parts concave; but above these depressions the outer sides of those lobes are nearly flat, each being traversed there by a very feeble longitudinal median rising. The inner side of the base of the crown is equally free from any ridge; it is formed by the convex sides of the two inner pyramidal lobes, *i'* & *p*: a nearly vertical ridge (*r*) ascends from their interspace upon the anterior surface of the posterior lobe. A very strong ridge traverses the base of the anterior side of the crown (fig. 5, *f*): it is continued backwards from the anterior and external angular bulging (*a*), forms a slight angle at each interspace of the three lobes on that side of the crown, and thus presents a feebly festooned course, and gradually subsides at the anterior and internal side of the crown. A well-marked but narrower ridge (*h*) traverses the base of the posterior side of the crown (fig. 4), and rises in a slight angle upon the posterior ridge of the posterior internal lobe.

The bases of the four roots are indicated at the fractured part of the alveolar process of the jaw which is still attached to this tooth: the two external roots were obviously distinct: the two internal and smaller roots appeared to have been connate.

The upper molar teeth in other mammalia, with which the one above-described may be compared, are those of the *Chæropotamus* * and *Anthracotherium* of Cuvier †, and also those of the genera *Dichodon* ‡ and *Hyracotherium* §.

The teeth of the typical *Anthracotherium* (*Anthr. magnum*) described and figured by the great Anatomist in his immortal 'Ossemens Fossiles,' are the same (second and third true molars, left side, upper jaw) as those here compared, which are the only complete upper molars in the series of the remains of the present species (*Hyopotamus bovinus*) obtained by Lady Hastings. I shall begin the comparison, however, with the molars of the *Chæropotamus*, of which fortunately a beautiful cast of the upper jaw described by Cuvier exists in the Museum of the Royal College of Surgeons. In the upper true molars of this genus, the fifth lobe (*p*) is so situated and developed as to appear like one of the four normal lobes; the internal and anterior normal lobe *i* being proportionally reduced so as to appear like a mere accessory tubercle: the crown also presents a sixth still smaller lobe or tubercle between the two posterior principal lobes; of this there is no trace in *Hyopotamus*. The middle of the deep transverse valley is not interrupted in *Hyopotamus* as in *Chæropotamus* by any tubercle: a slight ridge extends from it to the interspace between the antero-external (*o*) and the antero-median (*i*) lobe: in *Chæropotamus* there rises an irregular, slightly bifid tubercle at this part. The whole base of the crown of the tooth in *Chæropotamus* is girt by a ridge, which rises into tubercles at different parts ‖. In *Hyopotamus* the 'cingulum,' or basal ridge is limited to the anterior and posterior parts of the base of the crown; and there is no tubercle between the two inner lobes. The lobes of the molar of the *Hyopotamus* are loftier, and with sharper summits and sharper anterior and posterior angles; the longitudinal rising at the middle of the outer sides of the two outer lobes is much more developed in *Chæropotamus*: the bulging or prominence at the outside of the interspace between those lobes ("vers le milieu du bord externe," *Cuv.*) is, on the other hand, much larger and more prominent in *Hyopotamus*.

If we next compare the penultimate upper left molar of *Hyopotamus* with the homologous tooth in *Anthracotherium*, we shall find that, although the anterior internal lobe *i* is indicated in Cuvier's figure, and in that copied from M. de Blainville's 'Ostéographie,' in Pl. VII. fig. 9, *m* 2 and *m* 3, between the two larger anterior lobes, it is comparatively so little developed that Cuvier omits to mention it, and says, "la pénultième molaire ne porte que quatre pointes." In the external protuberance from the basal interspace between the two external lobes, and in the curve formed upon it by the uniting oppo-

* Ossemens Fossiles, 4to, t. iii. p. 262, pl. 68. fig. 1 (the penultimate molar, left side).

† *Ib.* p. 399, pl. 80. fig. 1 (same molar).

‡ Quart. Geol. Journ. vol. iv. pl. 4.

§ British Fossil Mammalia, figs. 166, 170, pp. 422, 424.

‖ "Enfin, toute la dent est entourée d'un collet qui s'élève lui-même en tubercules à l'angle antérieur externe, et vers le milieu du bord externe." (Cuvier, *l. c.* p. 263.)

site angles of those lobes, the *Anthracotherium* resembles, more than the *Chæropotamus* does, the homologous tooth of the *Hyopotamus*; but the protuberance is relatively less, and the outer facets of the two outer lobes are, like those of the *Chæropotamus*, much more convex in *Anthracotherium* than in the *Hyopotamus*. Cuvier says, *e. g.*, "La face externe de celles ('pointes' ou lobes) qui regardent en dehors est un peu plus bombée que la face interne de celles qui leur sont opposées;" and he then adds, "mais les faces par où elles se regardent ont chacune une arrête saillante, irrégulière, quelquefois bifurquée, qui les rendent anguleuses,"—a differential character which strongly indicates the generic distinction of *Anthracotherium* from *Hyopotamus*.

The two fossil upper grinders (last premolar and first true molar) of a small Pachyderm from the tertiary deposits on the banks of the Brahmputra river, Bengal, referred to the genus *Anthracotherium* by Mr. Pentland, under the name of *Anthracotherium silistrense**, differ from those of the typical *Anthracotherium* of Cadibona in the outer facets of the two inner lobes being concave, whilst the opposite facets of the two outer lobes are convex; and, as in *Dichodon* and *Merycopotamus*, there is no trace of a fifth lobe. In the convex protuberance at the outer side of the interspace between the two outer lobes, the *Anthracotherium silistrense* resembles the *Hyopotamus*; but it differs therefrom both in the absence of the fifth lobe, and in the antero-posterior diameter of the tooth exceeding the transverse diameter. The antero-posteriorly extended crown of one of the premolars, which supports two transverse pairs of lobes and a fifth anterior lobe, still more decisively distinguishes the Indian fossil from the true *Anthracotherium*, and brings it nearer the allied genus *Dichodon*. The inferior molars figured by Mr. Pentland in the same plate (45. figs. 1 & 13) also resemble those in the genus *Dichodon*, as well as the present genus *Hyopotamus*.

The generic difference between *Hyopotamus* and *Chæropotamus* will be made manifest when we compare the dentition of their lower jaws. And this is the more important, because there is a bare possibility that the upper molars ascribed by Cuvier to the genus *Chæropotamus*, which he founded on dental characters of a lower jaw, may not have belonged to the same animal as that jaw; and M. de Blainville has in fact availed himself of the absence of absolute demonstration to refuse assent to the conclusion which Cuvier, from the strongest evidence short of that which an entire skull of a *Chæropotamus* would have yielded, arrived at.

In the height, the sharpness and the general form of its four principal lobes, the upper molars of the *Merycopotamus*, Falconer and Cautley, described and figured in my 'Odontography†,' more nearly resemble that of the *Hyopotamus* than do those of either *Anthracotherium* or *Chæropotamus*; but there is no fifth lobe (*i*) between the principal pair on the anterior side of the tooth‡. The opposite

* Geol. Trans. 2nd Series, t. ii. p. 392, pl. 45. figs. 2, 3, 4 & 5.

† Pl. 140. fig. 8, and in Quart. Geol. Journ. vol. iv. pl. 4. fig. 7.

‡ Its absence may be interpreted, homologically, either by supposing the

angles of the two outer lobes do not coalesce upon a large median protuberance, but are quite separated by a minute intermediate basal tubercle; the basal ridge is continued round the inner side of the crown, and the outer sides of the outer lobes are much more protuberant at their middle part in *Merycopotamus* than in *Hyopotamus*. The teeth compared in the last two genera are of the same size; that of the *Anthracotherium magnum* is nearly twice as big; and that of the *Chæropotamus* is one-third less than the corresponding molar of *Hyopotamus bovinus*.

The upper molars of the *Dichodon*, especially the second, resemble, in the general form of the crown and the particular shape of the four lobes, the tooth of the *Hyopotamus*: the outer sides of the lobes in particular have nearly the same slight degree of general concavity with the median longitudinal rising: the opposite angles of the two outer lobes equally meet upon an external median basal prominence, but at an acute angle, and the prominence itself is not so convex or bulging, and it also developes a small cusp on each side the entering angle. Moreover, the (antero-intermediate) lobe (*i*) is equally wanting in *Dichodon* as in *Merycopotamus*, and the enamel, which is smooth and polished in *Dichodon*, is strongly wrinkled in *Hyopotamus*. The generic distinction between *Hyopotamus* and *Dichodon*, which I should have regarded as quite sufficiently marked by the above-described differences in their upper molar teeth, is most satisfactorily and remarkably manifested in the dentition of the lower jaw.

The upper molars of the little *Hyracotherium** resemble those of the *Chæropotamus* more than they do those of the *Hyopotamus*; but they appertain to the same general type of configuration; and this type—of *quadrate crown, with four principal pyramidal and more or less distinctly trihedral lobes, divided by deep valleys, not filled up by cement, but, in some genera, interrupted with minor tubercles and ridges*,—characterises a great natural group of *Ungulata*, most of the members of which are extinct, but which tend to fill up, in the zoological series, the wide interval that now divides the Peccari or the Hippopotamus from the Ruminants.

The generic or subgeneric modifications of structure at present recognized in this great natural group are signified by names given to the partially restored genera:—*Anthracotherium*, *Hyopotamus*, *Merycopotamus*, *Hippohyus*, *Chæropotamus*, *Adapes*, *Dichodon*, *Hyracotherium*, *Dichobunes*, and *Anoplotherium*, to which also we ought perhaps to add *Calicotherium*. *Hippohyus* and *Chæropotamus* seem to have stood nearest to the existing Peccari and the Hog-tribe; *Anthracotherium* or *Merycopotamus* were, perhaps, more nearly allied to *Hippopotamus*. Cuvier thought that the *Anoplotherium* bore a close affinity to the *Camelidæ*, and *Dichobunes* seems to have approached the Musk-deer (*Moschidæ*).

antero-internal lobe not to have been developed, and its place in the ruminant molar to be now occupied by the greatly developed accessory lobe *p*; or by supposing this lobe not to have been developed, and the antero-internal lobe to be the homologue of the lobe *i* in the ruminant upper molar.

* British Fossil Mammals, p. 422, fig. 166.

According to the descriptions and figures in the 'Ossemens Fossiles,' the generic characters of *Anthracotherium* could only be deduced from the true molars, which were apparently $\frac{3-3}{3-3} = 12$: the upper ones having the form above described, the lower ones being narrower, but supporting four conical lobes, and the last molar having a fifth similar lobe and a ridge behind. The number of premolars was uncertain; but those that were known to Cuvier had a thick conical irregularly compressed crown, surrounded by a slightly prominent basal ridge. One of the anterior teeth*, either an incisor or a canine, had a crown terminating in a point, with sharp borders, convex on its outer side, and impressed on its inner side with two slight furrows parallel with the borders of the crown. Cuvier compares it with the lower incisors of certain Phalangers, and to the canines of the Camel or Tapir; but it also, as I shall presently show, presents some obvious characters of resemblance with the superior incisors of the genus *Sus*.

M. Pictet† assigns to the *Anthracotherium* '7 molars' (on each side) above and below, 'canines' $\left(\frac{1-1}{1-1}\right)$, 'like those of the Tapir,' and four incisors in the lower jaw, procumbent like those of Pigs.

Giebel‡ gives "sechs Schneide- einen Eck- und sechs Backzahne" to the *Anthracotherium*, meaning probably the formula

$$i\,\frac{3-3}{3-3};\; c\,\frac{1-1}{1-1};\; m\,\frac{6-6}{6-6} = 40.$$

The discovery, however, by the Abbé Croizet of an almost entire lower jaw of a true *Anthracotherium*, in Auvergne, and the transmission to the Parisian Museum of complete series of both upper and lower teeth, from Digoin, Moysac, and other localities of central and southern France, have furnished Prof. de Blainville with the materials for determining the true dental formula of the genus *Anthracotherium*; viz.

$$in\,\frac{3-3}{3-3};\; c\,\frac{1-1}{1-1};\; m\,\frac{7-7}{7-7} = 44\S.$$

The upper incisors are strong, with conical slightly curved crowns, decreasing from the first to the third: the upper canines are indicated by their sockets to be pretty large, 'assez fortes,' and round at the neck. The first molar is the smallest of all the teeth, is single-rooted, and situated almost equidistant from the canine and the second molar ||; but in the description of the figure of the teeth of the upper jaw of the *Anthracotherium*, M. de Blainville acknowledges that in his plate (pl. 1) "they are ranged by analogy in the order of their natural position;" but by what analogy is not stated. The extreme differences presented by the genera *Dichodon*

* *Loc. cit.* pl. 80. figs. 6 & 7.
† Traité élémentaire de Paléontologie, 8vo, 1844, tom. i. p. 259.
‡ Fauna der Vorwelt, 8vo, 1847, p. 195.
§ Ostéographie, fasc. xxi. (1846) p. 121.
|| "Presque équidistante de la canine et de la seconde." *ib.* p. 128.

and *Chæropotamus* in the arrangement of a dentition of precisely the same numerical formula, and with molars of the same type as those of the true *Anthracotheres*, do not allow of much confidence being placed in an arrangement of teeth adopted on an unexplained analogy. With regard to the lower jaw, it also appears from M. de Blainville's description and figure of the specimen discovered by the Abbé Croizet, that the incisors and canines are placed in the order figured in his pl. 1, according to some unspecified analogy. The crowns of the incisors are described as being "en palette, subsymmétrique," *i. e.* subquadrate, and with the summits worn. The second incisor is a little narrower than the first; the third (outermost) is much larger, and with the crown obliquely truncate. The canine, which is stated to be "parfaitement en place *," is a little thrust outwards, and less procumbent than the incisors; moderately strong, oval (?), slightly compressed and recurved in its exserted part.

The first premolar is represented by a single and distant root, *i. e.* it is separated by a vacant interval from the other premolars as well as from the canine. The second, third and fourth premolars have triangular, unicuspid, subcompressed crowns; a basal talon being developed behind the third, and of somewhat larger size behind the fourth. The three true molars have the same proportions (M. de Blainville says) as those of the "Lophiodon de Nanterre"; but their transverse ridges are less thin and trenchant, and more rounded, as well externally as internally; the middle part which separates the two mammillæ being less elevated, contrary to the oblique ridge, departing from the internal posterior mammilla to go to join the external anterior mammilla, whence there results four mammillæ which, by usage, give rise to a little more complication of the folds of enamel, a disposition which slightly recalls that which exists in the Peccaris †. The last molar is terminated by a rounded lobe or talon, rather narrower than the body of the tooth, but as long at least as the entire moiety ("aussi long au moins que la moitié totale ‡").

M. de Blainville is led, by the subsequent acquisitions made to the Parisian collection since the time of Cuvier, to acknowledge the genus *Anthracotherium*, but he virtually abrogates the Cuvierian genus, by extending its characters and signification so as to admit not only the typical species, *Anthr. magnum*, but likewise the *Anthr. velaunum*, and the *Dichodon*, as the *Anthr. minutum* §: he also refers the upper jaw of *Chæropotamus* to *Anthracotherium*, and transfers the lower jaw of *Chæropotamus* to the genus *Sus*. On the other hand, M. de Blainville is inclined to think the *Anthr. alsatiacum* of Cuvier to be the young of the *Anthr. magnum*, although the crowns of the permanent molars certainly indicate, as Cuvier well observes ||, "une espèce intermédiaire pour la grandeur entre la plus grande de *Cadibona* (*Anthr. magnum*) et la plus petite du même lieu."

With respect to the *Anthracotherium velaunum*, M. de Blainville has been able to add much to the brief notice by Cuvier in the 'Supplement' to the last volume of the 4th edition of the 'Osse-

* Ostéographie, fasc. xxi. (1846) p. 129. † *Ib.* p. 130. ‡ *Ib.*
§ *Ib. Anthracotherium*, p. 138, pl. 3. || Ossem. Foss. t. iv. p. 501.

mens Fossiles' (1824), by the subsequent acquisition of the almost entire upper jaw discovered by M. Bertrand de Doué in the 'Bassin du Puy'; and by a crushed cranium with the dental system tolerably complete, and portions of the lower jaw, discovered in the same locality by M. Bravard. With regard to the upper true molars in these specimens, M. de Blainville says that in proportion to those of the other *Anthracotheria*, they are "plus large que longues," "et que les collines transversales de la couronne sont bien plus prononcées par la profondeur de la gouttière qui les sépare, et parceque les deux points de chacune sont plus détachées et plus aigués, avec le bord externe bien plus versant en dedans et plus anguleusement sinueux." All the teeth, M. de Blainville adds, "offrent en outre une particularité différentielle remarquable, en ce qu'elles sont constamment comme striées ou plissées verticalement, surtout vers le collet."

After his comparison of the rich materials at present accumulated in the Parisian museums of Palæontology, M. de Blainville sums up the dental characters of the genus *Anthracotherium* as follows:—

$$\textit{Formula}\ \frac{3}{3}+\frac{1}{1}+\frac{7}{7}\ \text{dont}\ \frac{3}{3}+\frac{1}{1}+\frac{3}{3}:$$

which signifies that there are 3 incisors, 1 canine and 7 molars on each side of both upper and lower jaws; and that of the 7 molars 3 are 'avant-molaires,' 1 'la principale,' and 3 are 'vraies molaires.' The tooth here called 'principale' being the last, or fourth premolar.

"The incisors are sublateral above, terminal and procumbent below. The canines of moderate size and pretty much curved ('médiocres, assez arquées'). The three anterior premolars with conical, more or less compressed crowns, with two roots above as well as below: the first equidistant; the fourth ('principale') below appearing like a moiety of the true molars. The upper true molars formed of two transverse ridges, each divided into two points, the outer one foliaceous, the inner one conical. The lower true molars with the transverse ridges elevated into a point at their extremities; the last molar provided with a pretty strong third ridge *."

To the genus *Anthracotherium*, as defined by such characters, it would be easy to refer the fossils from the Isle of Wight now under review; but it becomes necessary to consider the value of the differences observable in these fossils, as compared with the first-defined *Anthracotheria*, and by aiming at a true interpretation of those differences, to endeavour to give more precision to the definition of the true genus *Anthracotherium*.

The differences presented by the upper molar (Pl. VII. figs. 1–5) of the Anthracotherioid from the Isle of Wight from that of the true *Anthracotherium* (*ibid.* fig. 9, *m* 3) have already been pointed out; and with regard to the value of these differences it may be remarked, that the ultimate molars of *Camelus*, *Camelopardalis*, *Alces* and *Bos* show a less amount of difference of structure from one another than exists between the molar of the *Hyopotamus bovinus* and that of

* *L. c.* p. 143.

the *Anthracotherium magnum*. With respect to the lower jaw and teeth of the *Hyopotamus*, their distinctive characters will be best brought out by comparing the specimens from the Isle of Wight with the beautiful and instructive example of that of the lower jaw and teeth of a typical Anthracothere (*Anthr. magnum*) from Auvergne, presented to the Parisian collection by the Abbé Croizet, and which is figured of half the natural size in the last published part of the 'Ostéographie' of Prof. de Blainville (G. *Anthracotherium*, pl. 1. A. D'Auvergne), and which I have copied, to facilitate the comparison, into Pl. VIII. figs. 6 & 7. As the fore-part of this jaw and its teeth have most suffered, and as the corresponding teeth (incisors, canines, and first premolars) are wanting in the fossil jaw about to be compared (Pl. VIII. figs. 1–4), I shall commence with the last molar tooth, which is entire and in place in both specimens, both having belonged to adult individuals, with the second or permanent dentition complete. The last lower molar in *Hyopotamus* (M 3) is longest in the antero-posterior diameter, and supports, as in *Anthracotherium* and *Chœropotamus*, five principal pyramidal lobes, four in two transverse pairs, and the fifth single and posterior; the two transverse clefts dividing each pair from the other and from the fifth lobe are much deeper in *Hyopotamus*, and the three primary divisions of the crown thus marked off are narrower, higher, and sharper: the transverse clefts descend obliquely, or sink deeper, in passing from the inner to the outer side, where they are closed, as it were, by tubercular ridges connecting the opposite sides of the bases of the pyramids;—but are not continued along the outer side of those bases, as in the true *Anthracotherium*. There is a feeble rising along the inner side of the base of the antero-internal lobe which is continued into an angular tubercle at its fore-part, viz. at the internal and anterior angle of the crown, whence a ridge ascends obliquely along the fore-part of the crown to the summit of the antero-external lobe; a parallel ridge passes from the inner side of the first transverse valley to the summit of the second external lobe, and a third parallel ridge passes from near the outer end of the second transverse valley to the summit of the fifth or posterior lobe: all these three ridges have been worn obliquely by the action of the upper grinders. From the middle of the two anterior of the oblique ridges a shorter ridge ascends to the summit of each of the two internal lobes; and these are connected with the external lobes by a crescentic ridge passing from summit to summit across the back part of the common base of each pair of lobes. There is a ridge along the anterior part of the base of the crown: but there is no basal ridge upon the back part of the posterior lobe, as in the *Anthracotherium magnum*. A sharp, subcrenate ridge extends from the inner end of the second valley to the summit of the fifth (posterior) lobe. The inner sides of the two inner lobes are broader and less convex than the outer sides of the two outer lobes: the opposite shorter sides of each pair of lobes, those viz. that are turned towards the middle line of the crown, are nearly flat. In *Dichodon*, which *Hyopotamus* resembles in the sharp summits and general form of the lobes of the lower molars, more than it does *Anthra-*

cotherium, the outer sides of the inner lobes are convex; and in *Anthracotherium* the inner sides of the outer lobes are ridged. The second true (penultimate) lower molar (M 2, figs. 1–3) consists in *Hyopotamus*, as in *Anthracotherium*, *Chæropotamus* and *Dichodon*, of two primary divisions, each subdivided into two pyramidal lobes: these are also higher, narrower antero-posteriorly, and sharper than in *Anthracotherium*; and the oblique ridge forming the anterior angle of the postero-external lobe *o′*, instead of crossing the transverse valley to terminate upon the antero-internal lobe *i*, as in *Anthracotherium*, terminates at the internal end of the transverse valley: thus each pair of lobes are more distinct from one another than in *Anthracotherium*, and both in this respect as well as in the general form of the lobes, *Hyopotamus* more resembles *Dichodon* than it does *Anthracotherium*. The tooth in question differs from its homologue in *Dichodon* by the absence of the accessory cusps at each side of the inner base of the inner lobes, and in the irregular shape, instead of the smooth convexity, of the outer sides of the same lobes. The penultimate molar further differs from both that of *Dichodon* and that of *Anthracotherium* in having merely a narrow basal ridge at the back part of the crown, which does not develope a tubercle there. Such tubercle is distinctly shown in both fig. 2 (*Anthr. magnum*) and fig. 5 (*Anthr. minimum*) of pl. 80. of the 'Ossemens Fossiles' (tom. cit.), as well as in M. de Blainville's figure of the fine lower jaw of the *Anthracotherium*, which he supposes to be *Anthr. magnum*, from Auvergne. There is no basal ridge along either the inner or outer sides of the crown of the penultimate molar of *Hyopotamus*: the anterior basal ridge rising obliquely from the external to the internal side, developes a tubercle at the antero-internal angle of the base of the crown. The outer sides of the two outer lobes are more convex, the inner sides of the inner lobes less convex in *Hyopotamus* than in *Anthracotherium*. There is a small tubercle at both the outer and the inner end of the transverse valley, which is much deeper at the outer than at the inner side of the crown: the inner tubercle attaches itself to the anterior rather than to the posterior of the two inner lobes; the ridge at the inner side of the transverse valley of the crown of the same tooth in *Anthracotherium* is continued upon the posterior of the two inner lobes. When it is remembered what important anatomical differences are associated with the mere addition of an accessory tubercle to one of the molar teeth in the genus *Semnopithecus*, as compared with *Cercopithecus*, in the Quadrumanous order, the necessity of the above-detailed comparisons will be appreciated. In all the features by which the penultimate and last molars of the *Anthracotherium* differ from those of *Hyopotamus*, they approach the characters of the same teeth of *Chæropotamus*, from which therefore *Hyopotamus* in a like degree deviates. The first true (antepenultimate) molar of the *Hyopotamus* (Pl. VIII. M 1, figs. 1–3) is smaller than the second, but closely resembles it in structure: the lobes are lower, being more worn, but the differential characters from *Anthracotherium* on the one hand and from *Dichodon* on the other are as well-marked as in the case of the second molar tooth.

The fourth premolar (P 4) offers a notable difference from that of *Dichodon*, and resembles in its smaller size and comparatively simple conical crown the homologous tooth of the *Anthracotherium* and *Chœropotamus*. The principal lobe is a higher and narrower pyramid than in those genera; but, as in them, it is a half-cone, convex only on the outer side, which is bounded by an anterior and a posterior worn angle or edge: the anterior edge descends to a small sharp tubercle on the inner and anterior angle of the base of the crown; the posterior edge terminates at the middle of the broad posterior basal ridge or 'talon.' The internal basal ridge rises into a point upon the middle of the inner surface of the principal lobe, and between this point and the summit of that lobe there is a third small point or cusp. There is a well-marked anterior basal ridge. The third premolar (P 3) equals the fourth in vertical and antero-posterior extent, but is narrower transversely: the anterior and posterior trenchant margins of the pointed crown are sharper, but similarly disposed. There is no intermediate cusp between the angle of the internal basal ridge and the apex of the crown: the internal basal ridge is almost obsolete on the anterior half of the crown. The anterior basal tubercle and the posterior talon are relatively smaller.

The socket of the second premolar (P 2) shows that tooth to have been rather smaller than the third; but, like this and the fourth, to have had two fangs. It is situated close to the third. The socket of the first premolar (P 1) is removed to a distance equal to the antero-posterior extent of both second and third premolars from those teeth: it shows the tooth to have been about half the size of the second premolar, and to have been implanted by a single fang, or rather by two connate fangs. A diastema of rather more than half the extent of the interval behind divides the first premolar from the canine (c). The socket of this tooth is close to that of the outer incisor (ɪ 3), and bounds on each side the curved series of the six incisive sockets round the fore-part of the symphysis of the jaw, as in the Ruminants. The socket of the canine differs from that of the incisors by a slight superiority of size, and a feeble longitudinal projection from its inner wall, indicating a groove on that side of the fang, such as we see in the lower canine of the *Dichodon*: the obliquity of the socket is nearly parallel with that of the external incisive socket. The sockets of the incisors are six in number, close together, more oblique, and showing their teeth to have been less procumbent than in the Hog; with long subcylindrical fangs, very slightly diminishing in size from the third to the first or innermost.

The parts of the lower jaw preserved are the symphysis and left ramus as far as the base of the coronoid process (Pl. VIII. figs. 1 & 3), and as much of the right ramus as supports the third and fourth premolars and the three true molar teeth (fig. 2). The entire lower jaw has been unusually long, narrow and shallow; but each ramus is thicker than in the Ruminants, though not so thick as in the *Chœropotamus*; its chief peculiarity is the small depth as compared with the size of the teeth, in which character it approaches the *Dichodon*. The symphysis is long, narrow, almost horizontal, with the original joint obliterated; its upper concavity deepens as it recedes, but without contracting transversely, as in the Hog. The depth of the symphysis is more suddenly gained than in the Hog or Peccary. Viewed from below (fig. 4) there is a very slight expansion at the alveoli of the canines (c); but this is not attended with any widening of the upper channel of the symphysis. The posterior third of the under surface of the symphysis is excavated by two wide and shallow channels, one on each side of a slight median ridge.

The upper border of the diastema, before and behind the first insulated premolar, *p* 1, fig. 3, is flat and rough, as if the edge had been rubbed down on a plane surface; but I believe it to be a natural feature of the fossil. The posterior limit of the symphysis is just behind the socket of the first premolar. The outer buttress of the anterior base of the coronoid process begins to swell out below the hind lobe of the last molar tooth. The first or anterior outlet of the dental canal is a little in advance of the socket of the second premolar: the second outlet is beneath the third premolar. The outer wall of the jaw does not swell out so much as in *Chœropotamus Cuvieri*, and the inner surface is flatter than in that species.

According to the value of the characters which determine and distinguish genera and subgenera in the present accepted systems of Mammalogy, I estimate those differences which have just been pointed out in the upper and lower true molars, and in the proportions and relative positions of the lower premolars and canines of the fossils figured in Pl. VII. figs. 1–5, and in Pl. VIII. figs. 1–5, as of themselves equivalent to establish at least the subgeneric distinction of the pachyderm to which they belonged from the *Anthracotherium* of Cuvier.

With those fossils, however, Lady Hastings was fortunate enough to discover, in the same stratum and locality, a series of upper molar and premolar teeth of a smaller species (Pl. VII. figs. 6, 7, 8), showing the same subgeneric modifications of the true molars, together with a well-marked generic deviation from *Anthracotherium* proper, in the greater complexity and different form of the posterior upper premolars.

Of these the fourth (*p* 4, figs. 6 & 7) resembles the true molars, except in its rather smaller size; the anterior basal ridge developes a small cusp at the antero-external angle of the tooth. The entering angle between the two exterior lobes is more acute. The posterior basal ridge is continuous with the internal one, rounding the base of the postero-internal lobe. The tooth is implanted by two external fangs and two internal ones partially connate. The third premolar (*p* 3) has a subtriangular crown, elongated in the axis of the jaw, with four lobes; two, *o'* and *i*, in the same transverse line forming the base, and the fourth (*a*), at the fore-part of the crown, forming the rounded apex. The third intermediate lobe (*o*) consists of two confluent lobes, indicated by a notch on its outer side. Viewed externally, therefore, this tooth appears trilobate, as at *p* 3, fig. 7.

Here, therefore, a well-marked and important generic distinction of *Hyopotamus* is afforded, and we are taught to appreciate the signification of the minor but well-marked deviations of the true molars from those of *Anthracotherium*. The corresponding premolars in that genus present a sudden change of form and simplification of structure, as compared with the true molars (see fig. 9, *p* 4, *p* 3); and herein we may discern the closer affinity of *Anthracotherium* with *Chœropotamus*. *Hyopotamus* on the other hand resembles *Hyracotherium* *, the fourth premolar of which presents externally the same number of lobes (two) as the true molars, and is simplified only by the suppression of a cusp on the inner side of the crown and its smaller size. With regard to the third premolar of *Hyopotamus*, it is only in the *Dichodon* that we find its elongated quinquelobate character repeated; and it appears to me, therefore, that we have in this new genus discovered by Lady Hastings a most interesting annectent form, that, whilst it is in some measure intermediate between *Hyracotherium* and *Dichodon*, links both with the typical *Anthracotheria*.

The close agreement of the molar (fig. 1) of *Hyopotamus bovinus* with the true molars of the smaller species, *Hyop. vectianus*, might reasonably lead to the inference that the same conformity would extend to the premolar teeth; but I refrain from too confidently anticipating the results of subsequent discoveries of the now unknown parts of its dentition. It will be observed that the fourth premolar in the lower jaw (Pl. VIII. figs. 1, 2, 3, *p* 4) does not repeat the corresponding degree of complexity of the one in the upper jaw (Pl. VII. fig. 6, *p* 4), nor the third premolar the trilobate exterior division of the crown which we find in the lower molar of the *Dichodon* (see Pl. IV. fig. 3).

The last two molars in the lower jaw (Pl. VII. figs. 1–3) have, however, the same antero-posterior extent as the corresponding teeth from the upper jaw of *Hyopotamus bovinus*, of which the most perfect specimen (*m* 3) is figured in Pl. VII. figs. 1–5. A fragment of the lower jaw of the *Hyop. vectianus*, with the penultimate and last molars much-worn, shows the same correspondence between those teeth and the upper molars, *m* 2 & *m* 3, in figs. 6 & 7. Pl. VII.; and these lower molars agree so closely in structure with their homologues in the larger species (Pl. VIII. fig. 1, M 2 & M 3), as to render a figure of them unnecessary.

The less-instructive and determinative specimens of teeth discovered in the same deposit and locality as those above described, consist of one small two-fanged premolar tooth (Pl. VII. figs. 10 & 11), one thick-rooted but small-crowned canine (fig. 12), and five single-fanged teeth resembling the upper incisor of the great Anthracothere figured by Cuvier in pl. 80. fig. 6 (tom. cit.), and somewhat like those teeth which M. de Blainville has represented, by analogy, as the three incisors of the upper jaw in the *Anthracotherium* from Digoin. One of the single-fanged teeth (Pl. VII. figs. 20, 21), with a portion of its cylindrical fang, is too large for any of the incisive or canine sockets of the under jaw above described: it may, therefore, be an incisor of the upper jaw of the same species. The crown is of an oval shape, with an obtuse summit, convex on the outer side, concave on the

* British Fossil Mammalia, fig. 166. p. 422.

inner side, with the margins blunt and subcrenate: along the middle of the subconcave side runs an irregular ridged longitudinal prominence, with a channel or groove on each side, bounded outwardly by the margins of the crown: these margins incline to each other at their origin, but do not meet at the base of the inner surface of the tooth. The convex side of the crown (fig. 20) is indented by a longitudinal groove near one of the margins; where this groove begins the enamel does not pass so far upon the fang, as in the rest of the basal circumference of the crown. This tooth, therefore, with the same general character as the Anthracotherian incisors above-cited, differs from them in the much less breadth of the longitudinal rising along the middle of the subconcave surface of the crown, and in the absence of the ridge continued across the base of that surface.

A second (upper incisive?) tooth (figs. 18, 19) presents little more than the crown, which is triangular or heart-shaped, and more pointed than the former; convex in front, concave behind; with the longitudinal rising between two lateral channels on the concave side, and the submarginal longitudinal groove on the convex side, where the enamelled crown is shortest.

A third specimen (figs. 16, 17) consists of the crown only of a tooth similar to, but rather smaller than, the second, with the margins more unequal: the median ridge on the inner side stronger and narrower; the sublateral groove on the outer side shallower.

The position of this groove proves that all the three teeth are from the same side of the jaw; their general correspondence in form and character indicates that they are from the same animal; their single root shows that they are not premolars, their number that they are not canines: I conclude, therefore, that they are upper incisors, and that they are probably from the same premaxillary bone. The enamel has the same partly wrinkled, partly polished surface in these teeth, as in all the others: both the teeth and the bones are densely impregnated with iron, and present a deep black colour, which resembles polished jet on the enamelled parts of the teeth.

The tooth (figs. 13, 14, 15), in the general shape of the crown and the single, long, curved fang, so far resembles the preceding teeth, that it might pass for an incisor: but the obliquity of the basal line of the enamel being in the opposite direction shows it to be from the opposite side of the jaw: it is not, however, the precise counterpart of any of the three incisors which I have supposed to belong to the same animal: there is only one deep excavation at the concave side near the margin of the crown, the rest of that surface being moderately concave and somewhat worn: the convex side of the tooth shows a longitudinal ridge near the margin where the enamel is shallowest. That margin is a good deal worn by working against an opposite tooth. The fang is 0·035 in length, rounded, curved, and tapering to an obtuse closed point. On showing these teeth to Dr. Mantell, he immediately recognized their close general resemblance with those of his *Iguanodon*. There is no known existing mammal whose incisors approach more closely to those remarkable ones of the *Hyopotamus* than the Hog. In the upper jaw of the latter quadruped the incisors, as shown in the specimen, figs. 24 & 25, are curved; their crown is pointed; the basal line of the enamel is irregular, a piece being, as it were, cut out of one side; the concave surface of the crown of the tooth presents a median protuberance, and one of its borders is crenate: it chiefly differs in being more compressed, so that the crown is rather semiconical than conical or cordate.

From the foregoing details it will be seen that we have now to add to the catalogue of extinct British Mammals two quadrupeds, one at least as large as the Tapir, the other as the Boar, and, as the lower jaw would indicate, with the full complement and kinds of teeth characteristic of the typical *Ungulata*; viz.

$$in\,\frac{3-3}{3-3};\ c\,\frac{1-1}{1-1};\ p\,\frac{4-4}{4-4};\ m\,\frac{3-3}{3-3}=44.$$

The extent of the dental series in the lower jaw of the *Hyopotamus* (Pl. VIII.) is 0·200 (8 inches), or about equal to that of the Tapir or the Ass; but though one of the true upper molar teeth surpasses in size any of those of the above-cited existing pachyderms, the jaws were much more slender and attenuated anteriorly. The extent of the contiguous molars and premolars in the lower jaw is 0·115, or $4\frac{1}{2}$ inches. The presence of what I have described as the typical* or 'most complete system of Ungulate dentition†' is exemplified in the actual creation only in the genus *Sus*, in which it is not always constant; but it appears to have been common in the primæval forms of hoofed animals. *Palæotherium, Anoplotherium, Dichobunes, Hippohyus, Dichodon, Hyracotherium, Anthracotherium*, and *Hexaprotodon* were all so endowed, and the same perfect dentition seems to have characterized, with certain minor modifications of proportion and position, the allied genus *Hyopotamus*.

It now remains for consideration in what light we ought to regard, with a view to the best interests and steady progress of Palæontology, such minor modifications of the typical dental system. The chief characters of the molar and premolar teeth demonstrate that the *Hyopotamus* belonged to the same great natural group of even-toed (Artiodactyle) Ungulates as the *Hippohyus, Hyracotherium, Dichodon, Chœropotamus, Merycopotamus* and *Anthracotherium*, which link together the existing genera *Sus* and *Hippopotamus*, and closely connect both with the Ruminants.

In assigning a name to the present interesting addition to this remarkable group, I might have followed either the system which widens the signification of the generic term, to the extent, *e. g.* which renders *Sus* equivalent with *Phacochœrus, Dicotyles*, &c., or that which restricts it to express the combination of such particular and closely-defined characters as are understood by the generic terms *Sus, Phacochœrus, Dicotyles*, &c. in most modern systems of mammalogy.

M. de Blainville has manifested throughout his great work on Osteology a disposition to return to the use of generic terms in the wide acceptation which they had in the time of Linnæus, or even

* History of British Fossil Mammalia, p. 433.
† Odontography, p. 523.

in the vaguer sense which they bore in times antecedent to the great Reformer of the Nomenclature of Natural History. Thus, for example, he extends the term *Felis* to *Machairodus*; that of *Elephas* to *Mastodon*; and, under the name of *Anthracotherium*, ranks not only the aberrant species from Puy en Velay, of which Cuvier points out the difference in the structure of the molars, but likewise the *Hyracotherium* (see his 'Ostéographie,' *Anthracotherium*, pl. 3) and *Dichodon*, of which three true molars are figured in the same plate under the name of *Anthracotherium minutum*. Consistently with this use of the generic term *Anthracotherium*, M. de Blainville contends for its extension to the *Chœropotamus* of Cuvier. In fact, the difference of structure of the molar teeth presented by the typical *Anthracotherium magnum* and the so-called *Anthracotherium velaunum*, is hardly greater than that between the typical *Anthracotherium* and the *Chœropotamus*; but the dentition of the lower jaw of *Chœropotamus*, as described and illustrated in the Transactions of the Geological Society (2nd Series, vol. vi. p. 41. pl. 4), opposed a difficulty to the suppression of Cuvier's genus, which could only be surmounted by repudiating the determination of the lower jaw there attempted to be demonstrated. I may be permitted therefore, having recently visited Paris for the purpose of comparing the original specimens on which Cuvier founded the genus *Chœropotamus*, to offer a few remarks in confirmation of the conclusions arrived at in the Memoir, which the Geological Society has done me the honour to publish in their 'Transactions' (2nd series, vol. vi.).

The restoration of the lost species of animals is usually a work of time and the result of successive approximations; it may be retarded by attempts to destroy the value of previously-acquired evidence, and confidence in results laboriously and conscientiously arrived at, and intrinsically true, may for a time be shaken by the hardy contradictions of authors in the position of the distinguished Professor of Comparative Anatomy in the Garden of Plants. What, for example, can be the aim, or what the gain to zoology, of such statements as that a fossil mandible,—which, according to the figures copied by M. de Blainville into his own work, has its angle produced backward, and its symphysis unexpanded; in which the canines are small, and the first premolars large,—has nevertheless belonged to an animal "*probablement d'une espèce de* Sus"? The characters of the genus *Sus* have been acknowledged and confirmed by the zoological experience of a century. All the features of resemblance, and they are of minor importance, which the lower jaw and teeth of the *Chœropotamus* present to the Porcine family, are limited to the Linnæan genus *Dicotyles*, which forms, as it were, a barrier preventing closer approximation of the extinct *Chœropotamus* to the genus *Sus*.

M. de Blainville, after giving an extract of my description of the lower jaw of the *Chœropotamus*, observes, in reference to that genus, "que M. R. Owen lui a attribuée avec quelque probabilité, mais sans une certitude absolue, comme nous le verrons plus loin." Farther on, after affirming that my attribution of the lower jaw in question to the *Chœropotamus* was made "sans discussion, probablement d'après sa grandeur, un peu d'après les dents," and perhaps, M. de Blainville even adds, because I found it not to belong to either *Anoplotherium* or *Palæotherium*, he says he is far from thinking that it belongs to the *Chæropotamus* of M. Cuvier.

The portion of the lower jaw from the Paris basin, which is the original basis of that genus, recalls to M. de Blainville rather the characters of the *Anthracotherium* of Cadibona and Digoin; whilst the mandible, referred to *Chæropotamus* by me, seems to him to have belonged to a great species of *Sus**. M. de Blainville then proceeds to compare with the original fragment of the lower jaw of the *Chæropotamus* from the Paris basin, the upper jaw subsequently referred to the same species by Cuvier.

M. de Blainville gives a description of the teeth in that upper jaw in some respects less accurate than that originally given by Cuvier: he admits a well-marked difference between the third premolar and that in the *Anthracotherium*, but states that the form of the three true molars perfectly recalls that of their homologues in the *Anthracotherium* of Cadibona and Digoin, save that the tubercles are less salient and less angular, which gives a rounder circumference to the teeth†. M. de Blainville then proceeds to describe the original fragment of the lower jaw on which Cuvier founded the genus *Chæropotamus*, and from which I shall transcribe the description of the tooth the homologue of which exists in the Isle of Wight mandible. "Sur cette même pièce, on trouve, après une barre tranchant médiocre, une première dent assez forte, triangulaire, un peu comprimée, le sommet légèrement arqué, avec deux racines très-divergentes et subégales."

In his account of the Isle of Wight mandible, referred by me to the *Chæropotamus*, M. de Blainville writes :—"Après une barre qui paraît n'avoir offert à M. R. Owen aucune trace de dent ni d'alvéole, vient une première dent triangulaire comprimée, légèrement recourbée au sommet, et portée sur deux racines très-divergentes, *la postérieure bien plus grosse que l'antérieure.*"

M. de Blainville then describes the parts which exist in the Isle of Wight specimen, but which are wanting in the Parisian one, and concludes:—"D'ou l'on voit combien il y a peu de rapports entre ce système dentaire et celui de la mandibule de Paris." However, the only difference which he mentions in the parts which he could compare, is the subequality of the two fangs of the first premolar in the Paris specimen, and the larger size of the hind fang in the Isle of Wight specimen, which difference really does not exist.

In a recent visit to Paris I took over a good plaster-cast of the fossil mandible in question from the Isle of Wight, and compared it with the original fossil fragment described by Cuvier: from the difference alleged by M. de Blainville to exist between its dentary system and that in the Isle of Wight mandible, I was led to suppose

* "Tandis que le mandibule que lui a rapportée M. R. Owen me semble provenir d'une grande espèce de Sus." (p. 150.) Yet the mandible of the Wild Boar is one-third larger than that of the *Chæropotamus Cuvieri*.

† Ostéographie, fasc. xxi. p. 131.

that the original might exhibit more of the system requisite for the comparison than Cuvier's figure warranted, but I found this not the case. So much however, both of the characters of the bone and dental system as that representative of Cuvier's *Chæropotamus* manifests, was most precisely repeated by the corresponding parts in the Isle of Wight specimen; and M. Laurillard, whose experience and judgement in the comparison of fossil remains are unequalled, pronounced them to be unquestionably parts of the same species of animal. The cast of the Isle of Wight *Chæropotamus* is now placed by the side of the original Parisian specimen in the Geological Museum at Paris, and the accuracy of my original reference of the more complete mandible to the genus and species founded on the less complete one may be readily tested. Admitting, however, that the under jaw from the Isle of Wight is identical with the under jaw from Montmartre, which is the basis of Cuvier's genus *Chæropotamus*, the accuracy of Cuvier's ascription of the upper jaw figured in the 'Ossemens Fossiles,' 4to, iii. pl. 68, to the same genus and species remains to be vindicated.

M. de Blainville, after asserting how few are the relations between the (nearly entire) dentary system of the Isle of Wight mandible, and that (very incomplete one) of the Paris basin, and after admitting the marks of resemblance which I had pointed out in the form and dentition of the lower jaw of the *Chæropotamus* with those in the Peccary, denies that there is any evident resemblance between the premolars in the Parisian specimen of *Chæropotamus* and those in the Peccary. He affirms that there is still less resemblance between the premolars of the upper jaw of the so-called *Chæropotamus* of the Paris basin and those in the Peccary, and observes, "that it will be very difficult to admit that one species of animal should so much resemble another by its lower jaw, and yet have scarcely any such resemblance in its upper jaw." Whence he concludes that the upper jaw attributed by Cuvier to the *Chæropotamus* belongs to the genus *Anthracotherium*, and that the lower jaw attributed by me to the *Chæropotamus* belongs to the genus *Sus*.

The first fallacy in the reasoning leading to the above conclusion is in the statement implying that the premolars of the mandible from the Isle of Wight resemble those of the Peccary, whilst the premolars of the mandible from the Paris basin do not. The descriptions and figures of the two specimens copied by M. de Blainville demonstrate equally with the original figures by Cuvier and myself, that whatever amount of similarity or difference one of these specimens of the lower jaw of *Chæropotamus* offers in comparison with that of the Peccary, is precisely repeated in the other specimen. The value of M. de Blainville's argument will depend, therefore, upon the determination of the relative amount of resemblance which the almost entire lower jaw of the *Chæropotamus* from the Isle of Wight and the almost complete upper jaw of the *Chæropotamus* from the Paris basin respectively present to the same parts in the Peccary. The comparison in both is at present restricted to the premolar and molar teeth.

With regard to the three true molar teeth of the upper jaw, those of the *Chæropotamus* resemble those of the *Dicotyles* in the general form of the crown, in having four chief lobes, with some minor ridges and tubercles: the generic distinction is *indicated* by difference of form and arrangement of these eminences: the generic distinction is *established* by the marked difference and simplification of the contiguous premolars (*p* 4 & *p* 3) in the *Chæropotamus*.

Precisely the same thing obtains in the lower jaw. The first and second true molars of *Chæropotamus* resemble those in *Dicotyles* in their four principal lobes, with minor accessory cusps, and in their proportionally narrower dimensions as compared with the same teeth in the upper jaw. The last molar of *Chæropotamus* also resembles that of *Dicotyles* in its fifth accessory lobe. The generic distinction is *indicated* by the same kind and degree of difference of form and arrangement of the minor accessories, as it is in the upper molars. The generic distinction is *established* in the lower jaw, as in the upper, by the sudden simplification and consequent marked difference in the contiguous premolars (*p* 4 & 3). The assertion that the deviation of the characters of the upper jaw and teeth of *Chæropotamus* described and figured by Cuvier (*loc. cit.*) from those of *Dicotyles* is so wide, and the approximation of the same characters in the lower jaw and teeth described and figured by me in the 'Geological Transactions' to those of *Dicotyles* is so close, as to make it difficult to admit the reference of such fossil upper and lower jaws to the same species of animal, is one, the nature and value of which may be left to the judgement of future palæontologists, without in the meanwhile lessening our confidence in the reference of both fossils to the genus *Chæropotamus*, or interfering with the acceptance of that genus as fully entitled, by the characters manifested in both the upper and lower jaws, to stand in the zoological catalogues according to the present philosophy or rules of mammalian classification.

In truth, the penetration and sagacity of Cuvier are nowhere better exemplified than in his appreciation of the former existence of a new, and, until then, unsuspected generic form, by the feeble gleam of light reflected from a small fragment of a lower jaw containing but two or three of the least significant of the teeth. The subsequent discovery of the almost entire jaw of the same extinct and remarkable genus (*Chæropotamus*) confirmed the accuracy of the great Anatomist's first glance. If M. de Blainville could have demonstrated that jaw to have belonged to a common existing genus of quadrupeds, he might then have plucked away one of the leaves from Cuvier's laurels. But these have been too well earned and too justly awarded to render it necessary to expose the futility of the too frequent endeavours of the same kind, that detract from the merit and utility of M. de Blainville's admirably illustrated work on Mammalian Osteology.

The digression on the present occasion into the case of the *Chæropotamus*, and its title to a generic character, may serve however to show the position on which I have based my views of the nature and affinities of the new acquisition made by the Marchioness of Hastings to the series of extinct *Ungulata* in general, and to British Palæontology in particular. If zoologists were disposed to sink the minor characters of particular form, number and position of the secondary cusps and ridges of the true molar teeth, and of the form, proportions and position of the false or premolar teeth, then *Chœropotamus* might merge, not indeed into *Sus*, but into *Dicotyles* or into *Anthracotherium*, according to the future determination of the number and kind of its upper incisors and canines. The best interests of science would seem however to be served by availing ourselves of the distinctions clearly shown by the characters of the teeth already known, to demonstrate that there once existed a quadruped which was neither a *Sus*, a *Dicotyles*, nor an *Anthracotherium*; and such demonstrated difference appears to be most conveniently expressed by the generic or the subgeneric name, *Chœropotamus*, devised by Cuvier. In like manner, therefore, it seems to me to be desirable not to mask the equally demonstrable and equally important differential characters in the dentition of the *Hyopotamus*, by extending to it the generic name of *Anthracotherium*, on the principle by which M. de Blainville would apply that name to *Dichodon* and *Chœropotamus*; for such an extension of the original signification of a name only serves to hide essential distinctions which exist in nature, and to render Cuvier's generic name *Anthracotherium* vague and uncertain.

Anthracotherium, as represented by *Anthr. magnum*, *A. minus*, and *A. minimum*; *Hyopotamus*, as represented by *Hyopotamus vectianus*; *Merycopotamus*, as represented by the Himalayan species, on which the genus was founded by Cautley and Falconer; *Chœropotamus*, as represented by the *Chœr. Cuvieri*, seu *Parisiensis*; *Dichodon*, as represented by *Dich. cuspidatus*; *Hyracotherium*, as represented by *Hyr. leporinum* and *Hyr. cuniculus*; *Dicotyles*, as represented by the existing Peccaries of South America,—are respectively so many generic or subgeneric forms of one great natural group of Artiodactyle (even-toed) Ungulates, and form as many links in a chain connecting the now widely-dissevered genera *Sus*, *Hippopotamus*, *Anoplotherium*, and *Camelus**.

M. de Blainville has lost or voluntarily abandoned the opportunity afforded him by the instructive specimen of *Dichodon* at his command, to point out the nature and true zoological status of one of those interesting links, by referring that specimen to the genus *Anthracotherium*. The three molar teeth figured under that name in "G. *Anthracotherium*, pl. 1." of the last published fasciculus of the 'Ostéographie' (f. xxi.), are the last premolar and first and second true molars of the *Dichodon*; they could only be supposed to belong to *Anthracotherium* by reversing, as M. de Blainville has done, their true position, and regarding the last premolar as the last true molar,

* The Peccary might seem at first sight to be an exception to the rule, as it has three toes on the hind-foot; but the difference between the condition of these and that in the true tridactyle Tapir, or in the Horse, shows that such exception is more seeming than real. Only two toes are functionally developed on the hind-foot of the Peccary, where they form a symmetrical pair, as in the Hog; but their metatarsal bones are confluent, as in Ruminants; and, instead of having two abortive or rudimental digits, the Peccary has but one, represented by a little flattened style, attached to the base of the 'cannon-bone.'

in which case the disproportion of its bicuspid transverse lobes to those in the supposed anterior teeth would be truly singular, as M. de Blainville is compelled to admit*. The hypothesis that the long and narrow anterior three-lobed and sex-cuspid tooth might be the last of the deciduous series, is in accordance with ordinary analogies; but the entire and nearly adult jaw, with the series of teeth of the *Dichodon*, described in a former memoir, demonstrates that this Anthracotherioid genus, like the *Dinotherium*, could have a permanent grinder with a three-ridged crown, in advance of other grinders with only two transverse ridges, without such three-ridged tooth being necessarily the last of the deciduous series.

M. de Blainville, in re-describing the fossil portion of the Anthracotherian jaw figured in vol. iv. pl. 39. fig. 5 of the 'Ossemens Fossiles' (ed. cit.), says, "On doit voir dans le quatre dents molaires assez entières qui en garnissent le côté droit, un mélange évident de deux dentitions. La troisième est certainement la dernière de lait à trois lobes:" and he argues thence, that instead of its belonging to the *Anthr. alsatiacum*, it must be the young of the *Anthr. magnum*. The reader of the 'Ostéographie' might suppose, from the absence of any allusion to Cuvier's perception of the real nature of the fossil, that the discovery of its mixed dentition was due to the author of the 'Ostéographie.' But Cuvier, in his description, expressly says, "cette mâchoire est celle d'un jeune animal, qui n'avoit pas entièrement changé ses dents. En effet la molaire, *b*, qui précède celle que nous venons de décrire, y a trois paires de collines, comme doit les avoir la dernière persistante, signe infaillible que celle molaire, *b*, est une dent de lait." Now had M. de Blainville shown how this assertion of Cuvier's required to be qualified, and the predicament shorn of its infallibility, by rightly interpreting the phænomena which the teeth of the *Dichodon* in his possession offered to his observation, or even by remembering the peculiar character of the adult dentition of the *Dinotherium*, he would have made a real step in advance of his great master, but he contents himself with repeating the assertion, that the three-lobed tooth in advance of the two-lobed molars was 'certainly a deciduous one.' M. de Blainville does not repeat Cuvier's statement, that, although the jaw of the *Anthr. alsatiacum* was that of a young animal, its mature stature might be judged of by that of the persistent molars already in place, "et qui ne changeront plus," as Cuvier well remarks; and that these teeth demonstrated a species intermediate in stature between the *Anthracotherium magnum* of Cadibona and the *Anthr. minus*, of which Dr. Buckland had communicated to Cuvier a tooth from the same locality.

It is very true that in those Ungulates in which the last lower true molar has a lobe or division more than the rest, the last lower milk molar has the same additional division; but it is now necessary to

* "Ces trois dents sont assez singulières par la proportion des collines transverses bicuspides qui les constituent, et qui diminuent assez rapidement de la première à la dernière; c'est-à-dire que la dent antepénultième est sensiblement plus épaisse que la pénultième, celle-ci plus que la dernière," &c. The reverse of this being the case in nature, as respects the specimen described.

bear in mind that in certain extinct Ungulates the last permanent premolar or the first permanent true molar may also have a third lobe or transverse division of crown when the molars succeeding them have but two such lobes or transverse divisions. From these considerations I am induced to regard the tripartite (six-lobed) tooth as the first permanent premolar in the Anthracotherioid (*An. silistrense*) figured in the Geol. Trans., 2nd Series, vol. ii. pl. 45. figs. 2 & 3, and the bipartite (four-lobed) contiguous tooth as the first true molar, in which case the Indian fossil represented by those teeth would be much more nearly allied to *Dichodon* than to *Anthracotherium*: the lower molars (figs. 1, 13, in the same plate) resemble, like those in *Dichodon*, the lower molars of *Dichobunes* more than they do those of the typical *Anthracotherium*.

Lady Hastings, in the letter above-cited, relative to her discovery of the fossil jaw and teeth of the *Hyopotamus*, asks, "Are they Coryphodon?" And, in fact, the high and sharp-pointed lobes of the teeth might well suggest a probable relationship to the rare British eocene Pachyderm, described on account of its multi-cuspidate molars under that name*. However, the last molar of *Hyopotamus*, though contracting posteriorly, like that of *Coryphodon*, presents a distinct third cuspidate division in place of a mere basal talon, and the two points of the anterior division of the crown are divided by a deeper and more decided cleft than in *Coryphodon*. M. de Blainville, it is true, unwilling to admit the force of the evidence of a new genus when manifested by a small portion only of the dentition of an extinct species, supports his charge of temerity against me by suggesting that the tooth which I have described as the last molar may be the *first* molar in the fragment of fossil jaw figured in my work. But, were this the case, it would still remain to be shown what recent or fossil species or genus of mammals has an anterior molar tooth like that described and figured in pp. 299–305, cuts 103, 104, 107, of the 'British Fossil Mammalia.' M. de Blainville suggests that it may belong to some small species of *Dinotherium*†. Now what the relation may be between the fossil tooth of *Coryphodon* and that of a hypothetical and unknown species of *Dinotherium*, cannot of course be determined; but with respect to the known species of *Dinotherium*, the anterior molar of these has neither the posterior talon, nor the posterior bicuspid transverse ridge, nor the complex tricuspid anterior lobe with an anterior talon, which would be requisite to support M. de Blainville's idea of the nature of the tooth of the *Coryphodon*. For with respect to the 'some one or other' of the anterior teeth of a *Dinotherium*, it could only be with the foremost that this tooth of the *Coryphodon* could be compared, on the hypothesis that it belongs to the fore-part of the series; because the portion of jaw preserved with it demonstrates it to have been the terminal tooth of the molar series. Now against the supposition that it has terminated the series anteriorly there is the swelling out of the jaw on its exterior

* British Fossil Mammalia, p. 299.

† "A' moins que ce ne soit quelqu'une des dents antérieures d'un petit Dinotherium." (*l. c.* p. 109.)

side, which swelling is present in no *Dinotherium*, nor in any other mammal, save such as have huge canines, requiring that enlargement; but were the swelling of the Coryphodon's jaw of this nature, it would show some trace of the socket of such canine tooth, which it does not. In fact, the only colour to the supposition of the entire tooth in the fragment of the jaw of the *Coryphodon* being an anterior and not a posterior grinder, is a slight diminution of vertical diameter of the jaw beneath the smaller end of the tooth. But the form of the jaw produced by such diminution is not very singular amongst extinct pachyderms. M. de Blainville, in repeating my description of the lower jaw of the *Chæropotamus*, says that it is "assez bombée et épaisse dans sa branche horizontale, un peu convexe à son bord inférieur, comme étranglée à ses deux extrémités et surtout à son point de jonction avec la branche montante." (*l. c.* p. 149.)

It is the same character in the lower jaw of *Coryphodon* that gives rise to the posterior constriction manifested in the fragment described and figured in my work. The prominence on the outside of the jaw, parallel with the hinder division of the last molar tooth in *Coryphodon*, is the commencement of the base of the coronoid process; the inner side of the jaw is nearly flat, as is usual in that situation. In his criticism of the comparisons which I have made between the *Coryphodon* and the *Lophiodon* of Cuvier, I am led to believe that M. de Blainville has not rightly comprehended the passage in my work in which these comparisons are given, but which he says he has literally translated: "dont j'ai traduit mot à mot le passage*." My words are, alluding to the family-likeness between the parts in the fossil and the corresponding parts in the French Lophiodonts, "but the jawbone below the last tooth in the English fossil is deeper in proportion to the size of that tooth than in the *Lophiodon Isselanus*," p. 301; which M. de Blainville renders, "plus d'épaisseur de la mandibule en arrière de la dent entière, qu'il (M. R. Owen) regarde comme une dernière, et proportionellement pour cette dent, que dans le grand L. d'Issel†." Thus, a character which I have drawn from the relative *depth* (vertical diameter) of the jaw *below* the last tooth is changed by M. de Blainville into a character taken from the *thickness* (transverse diameter) of the jaw *behind* the same tooth. This puts my comparison of *Coryphodon* with *Lophiodon* in a different point of view from what I intended, or is suggested by the nature of the parts; and a reader of the 'Ostéographie,' not having my work to refer to, would derive an entirely erroneous notion of the grounds on which my conclusions as to the relationship of *Coryphodon* to *Lophiodon* have been founded.

This digression also will, I trust, be pardoned, since it relates to the establishment of an additional genus of extinct Pachyderms, to the restoration of another of the lost forms of our ancient British quadrupeds, and to the support of a conclusion, assailed with much ingenuity by a deservedly eminent name in osteological science; the conclusion expressed by the indication of the genus *Coryphodon* being, also, one which I cannot but regard as important to maintain,

* *Loc. cit.* p. 108.

† *Ib.* p. 108.

as a point or centre for future discoveries and comparisons of parts of large Lophiodontoid pachyderms in our ancient tertiary strata. I am disposed, indeed, to anticipate that the *Coryphodon* will prove another of those links completing the series of that group of Ungulate quadrupeds which the sagacity of Cuvier first led him to characterize by the uneven number of toes in the hind-foot.

The early Memoirs of Cuvier in the 'Annales du Muséum' contain many indications of a perception of the value of the characters of 'odd' and 'even' in the number of the hind-toes of hoofed animals. In the 'Résumé' of these Memoirs which formed the first edition of the 'Ossemens Fossiles' he more expressly generalises on this subject. In the preliminary remarks, for example, to the second volume of that work*, Cuvier says, "Les dents de devant ne sont pas le seul rapport du Cheval avec le *Tapir*, le *Palæotherium* et le *Rhinoceros*. Les os des extrémités de ces animaux sont très-semblables : quoique le *Cheval* ait l'air de n'avoir qu'un doigt, il en a réellement trois ; les latéraux presque réduits à rien se trouvant cachés sous sa peau, et nous verrons une espèce de *Palæotherium* où le doigt du milieu de derrière est déjà beaucoup plus grand que les deux autres."

In his restoration of the hind-feet of the extinct pachyderms of the Paris basin, Cuvier observes, in reference to that instructive bone the astragalus :—"Les uns ont la face tarsienne en forme de poulie divisée en deux gorges par une arrête saillante, comme dans les *Cochons* et les *Hippopotames*, en un mot, *les pachydermes à doigts pairs*, et comme dans les ruminans ; les autres ont cette face tarsienne presque plane avec une facette cuboïdienne étroite, comme dans les Tapirs, les Rhinocéros et les Chevaux, en un mot, *les pachydermes à doigts impairs*†."

With respect to the latter genera, Cuvier, in another place, says :— "Mais ces animaux bien qu'appartenant à la même famille naturelle, ne sont pas tellement pareils que l'on ne puisse concevoir des genres intermédiaires qui les uniraient."—"Ces intervalles, ces sortes de hiatus laissés dans leur série, paraissent avoir été remplis autrefois par des genres dont nous ne connaissons plus que les débris fossiles, mais dont les dents, les pieds et les autres organes charactéristiques tiennent en partie de l'un, en partie de l'autre, et qui différent de tous par l'ensemble. Ainsi nous verrons, dans nos environs de Paris et ailleurs, le genre des Palæotheriums qui ressemble aux Tapirs par les incisives, les canines, et surtout par ses os du nez disposés pour porter une trompe, mais dont les mâchelières sont à peu près celles des *Rhinocéros* et des *Damans*‡."

In this group of odd-toed (perissodactyle) Pachyderms Cuvier is disposed to believe "que l'Elasmotherium se rangera aussi quand on le connaîtra mieux ;" and there seems equal probability for so regarding the genus *Coryphodon*, by reason of the indications of its affinity to the *Lophiodon* ; an affinity which by a misconception of my description has been called into question by M. de Blainville. Now Cuvier has proved the *Lophiodon* to be by its dentition one of

* 4to, 1812, p. 9. † *Ib.* t. iii. (ed. 1822) p. 72.
‡ *Loc. cit.* t. ii. p. 163.

the 'animaux fossiles voisins des Tapirs;' and therefore a member of his group of Pachyderms 'à doigts impairs.' It is true that the direct proof of this inference was wanting when the great Reconstructor of lost species finally wrote on the genus *Lophiodon*:—"Mais l'on ignore encore plusieurs points essentiels de cette ostéologie, et nommément le nombre des doigts à chaque pied et la forme des os du nez. C'est de la détermination de ces points essentiels que les observateurs auront désormais à s'occuper."

The stimulus which Cuvier's immortal writings have continued to exercise in the progress of Palæontology has procured for his successor in the celebrated school of Comparative Anatomy at Paris, the opportunity of resolving the problem and of testing the accuracy of his great predecessor's powers of prevision in the present instance. "Nous voyons bien," says the author of the 'Ostéographie,' in his chapter on Lophiodon*, "qu'on rapporte à plusieurs des espèces proposées un astragale, os qui, dans l'ordre des Ongulogrades actuellement vivants, les partage assez nettement en deux sections, de 'Digités impairs' et de 'Digités pairs,' suivant qu'il n'est pas ou est *en osselet*†. Dans le Lophiodon d'Issel, le fragment d'astragale qui lui est attribué n'est pas en osselet et se rapproche beaucoup de celui des Palæotheriums."—"Parmi les pièces sur lesquelles reposent les troisième et quatrième Lophiodons du Dépôt d'Argenton, nous avons eu grand soin de signaler un astragale et de faire observer qu'il n'est pas en osselet. Il résulte de là, ce me semble, que le genre Lophiodon était, sous ce rapport comme sous celui du système dentaire, extrêmement rapproché de celui des Palæotheriums, et que, comme lui, il était pourvu de trois doigts à chaque pied."

In a work of high merit, but the tone of which, towards the memory and discoveries of Cuvier, every lover of science must deplore, we look in vain for any acknowledgment of the source of the beautiful generalization of the relation of particular forms of the astragalus to the parity or imparity of the hinder digits, or any ascription of the credit due to a prevision which it had been the good fortune of the author of the 'Ostéographie' to verify.

What concerns, however, the palæontologist and zoologist chiefly, is the satisfactory recognition of the genus *Lophiodon*, together with the *Tapirotherium*, the *Palæotherium*, *Hippotherium*, *Acerotherium*, *Macrauchenia*, *Elasmotherium*, and *Coryphodon*, as links filling up the now broken series of perissodactyle or odd-toed Ungulates, represented by the existing genera *Rhinoceros*, *Hyrax*, *Tapirus*, and *Equus*.

The progress of palæontological discovery, and especially the additions from our British eocene strata, have tended considerably to complete that other and parallel chain of Ungulata, a portion of which Cuvier designated as 'les Pachydermes à doigt pairs,' and which are

* 4to, 1847, p. 114.

† It is by this term 'osselet' that M. de Blainville vaguely expresses the characters of the astragalus so neatly and intelligibly defined by Cuvier, as "la face tarsienne en forme de poulie divisée en deux gorges par une arrête saillante."

represented in the actual creation by the widely dissevered links, *Sus*, *Dicotyles*, and *Hippopotamus*.

The genera *Adapis*, *Chæropotamus*, *Hyracotherium*, *Merycopotamus*, *Hyopotamus*, *Anthracotherium*, *Dichodon*, with *Xiphodon*, *Dichobune*, *Chalicotherium* and *Anoplotherium*, tend not only to bridge over the chasms now separating the few existing forms of artiodactyle or even-toed Pachyderms, but to connect them so closely with the Ruminants as to render it inconsistent with such knowledge to regard the *Pecora* of Linnæus as the equivalent and very circumscribed order which they are represented to be in our existing Systems of Zoology.

Cuvier, though retaining the *Ruminantia* in both editions of his 'Règne Animal' as one of the eight primary orders of *Mammalia*, and even characterizing it as "peut-être le plus naturel et le mieux déterminé de la classe*," had recognized in his previous and less systematic writings the aberrant characters of some members of this supposed most natural and circumscribed order. In reference to the didactyle feet of the *Anoplotherium*, for example, he says, "that they resemble in part those of Pachyderms and in part those of Camels." "Ils ont des chameaux la division en deux doigts seulement, les formes des os du tarse; ils ont des pachydermes la séparation des os du métatarse; et les chameaux ont de leur côté, en commun avec les anoplothériums et d'autres pachydermes, la petitesse et la forme symmétrique des derniers phalanges. Les dents des chameaux s'éloignent, au reste, beaucoup moins de celles des pachydermes que les dents des autres animaux. Non-seulement les chameaux ont des canines, ils ont aussi des incisives à la mâchoire supérieure; elles-y sont au nombre de deux†."

The acute and experienced authors of the 'Remarks on the genus *Anoplotherium*, in the Proceedings of the Geological Society for 1843–4 (p. 240),' have shown that it is not exclusively to the Pachyderms that the Anoplotherium is allied by the division of its cannon-bones, since the same division obtains in the *Moschus aquaticus*, an aberrant ruminant, which, like the Camels, has canine teeth. Nor is this fact surprising when it is remembered that the bipartition of the metacarpal and metatarsal bones is common to all ruminants at an early period of their existence, and that the 'cannon-bone' is not, therefore, an absolute character of the order, but rather a mark of a certain period of life in most of its members.

In like manner the discovery by Prof. Goodsir ‡ of the rudimental upper incisors and canines, and by myself of the rudimental anterior premolars § in a species of ruminant in which those teeth are wanting in the adult state, shows, as I argued in defence of my views of the value of the Ruminant group, when called into question by some of the eminent foreign zoologists at the Meeting of the British Association at Oxford (June 1847), that the absence of incisors and canines in the upper jaw is also a character not absolute in the order *Ruminantia*, but a modification or sign of a certain progress to maturity.

* Règne Animal, ed. 1829, t. i. p. 254.
† Ossemens Fossiles, iii. p. 148.
‡ Report of British Association, 1838.
§ Odontography, p. 530.

The retention of the full complement of the Ungulate dentition in the Anoplotherium, the persistence of the division of its cannon-bones, or rather of the individuality of its two chief metacarpals and metatarsals, and the non-development of horns at any period of life, all contribute to give it the character rather of an over-grown embryo-ruminant—of a ruminant in which growth had proceeded with arrest of development, than of a pachyderm, or animal of a different order of mammalia.

The well-grounded confidence which Cuvier's vast experience had given him in the law of correlation of animal structures led him to express the suspicion that the stomach of the Anoplotherium would more resemble that of the Ruminants than do those of the Peccari and Hippopotamus—the pachyderms that have also a much-divided stomach. "Et l'on sait du reste que l'estomac des chameaux, bien que véritable estomac de ruminant, s'écarte en plusieurs points de ceux du reste de cette famille*."

Now, since the third cavity of the ruminant-stomach (*psalterium*) is that which is last developed in the typical *Pecora*, and is wanting in the embryo-state of these, we may even infer that the point or main point in which the complex stomach of the *Anoplotherium* must have differed from that of the typical Ruminant, would be in the absence of the 'psalterium.'

One cannot doubt, at least, the accuracy of Cuvier's idea that the stomach of the Anoplotherium must have been subdivided or complex, and we may with equal reason ascribe to it a comparatively small and simple cæcum, as in the Camel and other ruminants.

Cuvier cites the Tapir as being one of the pachyderms with a complex stomach (l'estomac très-divisé): but my dissections of both the American and Indian species confirm the statement by Mr. Yarrell†, that the stomach of this three-toed pachyderm is 'a single cavity.' It resembles, in fact, the stomach of the Rhinoceros and Horse; and has a thick cuticle or epithelium continued over part of its cardiac end. The cæcum of the Tapir is capacious and sacculated on longitudinal bands, as in the Horse and Rhinoceros.

This interesting conformity in the main features of the alimentary canal with the other "pachydermes à doigts impairs," with which it had been associated by Cuvier, has led me to repeat with care a series of researches on the alimentary canal of the odd-toed and even-toed hoofed quadrupeds, the results of which were embodied in the characters of a classification of the UNGULATA, proposed in my 'Odontography' (p. 523), in which the *Ruminantia* take their place as a subordinate group of the great natural even-toed (artiodactyle) division of the hoofed section of mammals.

* *l. c.* t. iii. p. 149.

† Zoological Journal, vol. iv. 1829, p. 211, pl. 7. fig. 3.

The characters are as follows :—

UNGULATA.

I. **Artiodactyla***. Hoofed Quadrupeds with toes in even number, as *two* (fig. 1) or *four* (fig. 2), and which have a subdivided or complex stomach (fig. 3), and a moderate-sized simple cæcum (fig. 4). Ex. *Ox, Hog, Peccary, Hippopotamus.*

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

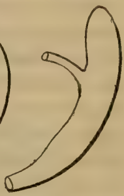
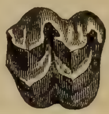


Fig. 5.

Fig. 6.



Artiodactyle characters.

II. **Perissodactyla**†. Hoofed Quadrupeds with functional toes, on the hind-foot, in uneven number, as *one* (fig. 7) or *three* (fig. 8), and which have a simple stomach (fig. 9) and an enormous or complex cæcum (fig. 10). Ex. *Horse, Tapir, Rhinoceros, Hyrax.*

Fig. 7.

Fig. 8.

Perissodactyle characters.

* Ἄρτιος, *par*, δάκτυλος, *digitus.*
† Περισσοδάκτυλος, ‘qui digitos habet impares numero.’

Fig. 9.

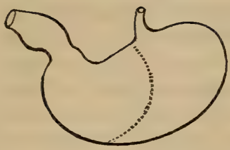


Fig. 10.

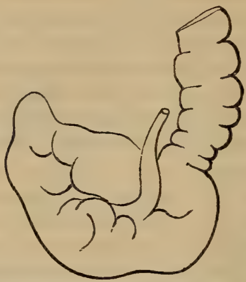
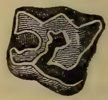


Fig. 11.

Fig. 12.



Perissodactyle characters.

III. Proboscidia, resembling the preceding in having toes in uneven number (*five*, fig. 13), in having a comparatively simple stomach and an enormous cæcum, but combining, with a long proboscis, so many other peculiarities of structure as to merit the rank of a distinct group of *Ungulata*.

In the 'Odontography' I have termed the even-toed Ungulates 'isodactyle' and the odd-toed Ungulates 'anisodactyle': which terms I propose to change, at the suggestion of my esteemed and learned friend the Rev. Mr. Rigaud, M.A., into the more appropriate terms 'artiodactyle' and 'perissodactyle': and this change I adopt the more readily since the former terms have already been applied to certain groups in Ornithology.

Judging of the views of Cuvier regarding the classification of the Hoofed Quadrupeds by his final arrangement in the 2nd edition of the 'Règne Animal,'—an arrangement essentially the same with all later classifications,—I did not call to mind, in 1839, the scattered allusions in the 'Ossemens Fossiles' to the more natural classification to which I had then been led by original observations on the dental, osteological and visceral characters of the Ungulata.

I proceeded to show that the dental characters of these three groups were well-marked, each distinct from the other, and each having many characters in common; the molars few in number, huge in size, and with a maximum of complexity in the Proboscidians; the molars with a certain symmetrical character, with lobes in regular pairs, for example (fig. 6), in the even-toed Ungulates; whilst the molars, especially those of the upper jaw, were less symmetrical, usually crossed by oblique ridges (fig. 12), in the odd-toed Ungulates. The fore-part of the astragalus is divided into two equal facets (fig. 5) in the Artiodactyles; but into two unequal facets (fig. 11) in the Perissodactyles. Nay, the character of odd and even extends to the development of those excrescences called 'horns' and 'antlers.' In the Artiodactyles these are always developed in one or more symmetrical transverse pairs. In the Perissodactyles this is never the case: the Rhinoceros has either one horn, or one behind the other on the same median line of the head, therefore essentially a single or odd horn.

Cuvier first appreciated the distinctive and natural characters of the Proboscidian as well as of the Perissodactyle groups. In addition to the osteological characters derived from the skeleton of the feet, by which Cuvier illustrated the affinities linking together the Perissodactyle pachyderms, he first pointed out a common character in their femur, the presence viz. of the third trochanter. This character is absent not only in the 'pachydermes à doigts pairs' of Cuvier, but also in the Ruminants. In addition to the common characters of the digestive canal, viz. complexity of stomach and simplicity of cæcum, which have seemed to me to justify the association of the even-toed *Belluæ* of Linnæus with his *Pecora*, there is a positive osteological one which has not received the attention it merits, in the question of the affinity of the 'pachydermes à doigts pairs' to the *Ruminantia* of Cuvier. Both these groups, or, in other words, the Artiodactyle Ungulates, have the same number of what the anthropotomist calls 'true vertebræ,' *i. e.* moveable or unanchylosed vertebræ, intervening between the skull and sacrum. The vertebræ of the cervical region are of course seven in the Artiodactyles, as in other *Ungulata* and in most *Mammalia*: but the rest, viz. the dorsal and lumbar vertebræ, are nineteen in number in all the Artiodactyles, neither more nor less; whilst they exceed that number considerably in all the Perissodactyle group, where they range between twenty-two (*Rhinoceros*) and twenty-nine (*Hyrax*). What seems to have masked both the fact and the import of the constancy in the number of the dorso-lumbar vertebral series, as evidence of the natural character of the *Artiodactyla*, is the variable number of the ribs in some of the species, which *e. g.* are reckoned at fifteen pairs in the Hippopotamus and twelve pairs in the Camel. And the value of this distinction has been exaggerated, through the prevalence of the anthropotomical conception of the ribs as independent bones, quite distinct from the vertebræ, and not as equivalents with the neurapophyses or other autogenous but anchylosed vertebral elements. The discovery of rudimental ribs (pleurapophyses) attached to the ends of the lumbar diapophyses in the fœtal Pig and some other quadrupeds*, which afterwards become anchylosed, and the known pleurapophysial nature of a part of the so-called perforated transverse process of the cervical vertebræ, show how arbitrary and essentially incorrect is that definition of a dorsal vertebra which calls it one that supports ribs. It is convenient, no doubt, in comparative tables of vertebræ, to give the number of such vertebræ of the trunk as habitually support their pleurapophyses without anchylosis; but the differences sometimes occurring in this respect within the limits of the same species must cease to have their importance over-estimated when the true nature of a rib is recognized. Mr. Eyton's interesting observation of fifteen dorsal and four lumbar vertebræ in a Chinese Boar, and of thirteen dorsal and six lumbar vertebræ in an African Sow†, for example, depends on the varying extent to which the lumbar pleurapophyses have become anchylosed in those varieties. The actual number of dorso-lumbar vertebræ does not vary; it is the normal one in the Artiodactyle order, viz. 19. So also if we examine the

* J. Müller, Anatomie der Myxinoiden, 1834, p. 238.
† Proceedings of the Zoological Society, 1837.

'Tableau du nombre des vertèbres dans les Mammifères' in the richly-stored posthumous edition of Cuvier's 'Leçons d'Anatomie Comparée' (t. i. 1836, p. 182), we find the Wild Boar (Sanglier) put down for *d*, dorsal, 14, and *l*, lumbar, 5, which is = 19; the Peccary for the same; the Babiroussa and Wart-hogs for *d* 13, *l* 6, = 19; the Hippopotamus for *d* 15, *l* 4, = 19; the Reindeer and the Giraffe for *d* 14, *l* 5, = 19; the majority of typical Ruminants for *d* 13, *l* 6, = 19; the aberrant *Camelidæ* for *d* 12, *l* 7, still = 19. The American Bison, which has 15 pairs of ribs, has but 4 lumbar vertebræ; the Aurochs, which has 14 pairs of ribs, has 5 lumbar vertebræ; the Buffalo, which has 13 pairs of ribs, has 6 lumbar vertebræ: these facts are full of significance.

If we refer to the descriptions of those fossil Ungulates whose entire skeletons have been best restored, we shall find that the same law of conformity of vertebral structure prevailed in the most ancient of those mammals as in the existing species. The artiodactyle *Anoplotherium*, like the *Megaceros*, had *d* 13, *l* 6, = 19; the perissodactyle *Palæotherium* had *d* 16, *l* 7, = 23, or the same number of dorso-lumbar vertebræ as the Indian Tapir has*. The leading modifications of the Ruminant-stomach have been long known to and demonstrated by me in my Hunterian Lectures. Mr. Cooper has kindly furnished me with the following extract from the notes which he took of my Lecture on the Stomachs of Mammalia delivered at the Royal College of Surgeons June 7, 1838:—

"Lastly we come to *Ruminants*, which present three forms of stomach, always complicated:—

"1st. In the genus *Moschus*, or small Musk-deer, we find three cavities, with a small intercommunicating canal between the second and third; the lining membrane of the first is simply papillose†.

"2nd. In the *Camel*: three cavities, with a small intercommunicating sac between the second and third; the interior of the first sacculated.

"3rdly. In the Horned Ruminants, the stomach is divided into four distinct compartments."

These modifications and the observed act of rumination in a Kangaroo, which has also a very complex, but a differently constructed stomach from that of the Ruminants, long since led me to attach less importance than it had usually received to the Ruminant-stomach, as proving the order called *Ruminantia* to be peculiarly natural and

* Individual varieties in the number of the dorso-lumbar vertebræ occasionally occur in the same species, independently of the less important difference in the number of free or confluent ribs: thus the Human subject has sometimes *d* 12, *l* 6, = 18; and Mr. Eyton (*l. c.*) has recorded one instance of *d* 15, *l* 6, = 21, in an English domestic boar.

† Sir Everard Home, in the chapter of his 'Lectures on Comparative Anatomy' which treats of the intestines of quadrupeds, speaks incidentally of a small Deer from Prince of Wales Island in the East Indies as differing from the rest of its tribe in having no third cavity to the stomach. In my Hunterian Lectures for 1838 I demonstrated the absence of the psalterium in the *Moschus Meminna* and *Moschus javanicus*. The first published account, with figures, of this modification of the Ruminant-stomach is due, I believe, to Prof. Rapp of Tubingen.

well-defined. The subsequent discovery of teeth, supposed to characterize the Pachyderms, in the fœtal state of typical ruminants; the well-known occurrence of the supposed pachydermal character of the divided metacarpus and metatarsus, in the fœtus or young of all Ruminants, and its retention in the *Moschus aquaticus* and in a fossil species of Antelope; the pachydermal modification of the fœtal membranes in the *Camelidæ*, superadded to their retained upper incisors and canines, with the ascertained amount of visceral and osteological conformity of the varied group of Ruminants with the other artiodactyle Ungulata; and, above all, the number of lost links in that interesting chain which have now been restored from the ruins of a former world—have contributed and concurred to produce in my mind a different view of the nature and value of the Ruminant group, and to lead me to suggest a different arrangement of the recent and extinct *Ungulate* forms than are admitted in the present zoological systems.

In proposing this innovation on the established systems in my 'Odontography,' I was far from expecting that it would meet with early or general acceptance. I was gratified indeed to find that it had attracted so much attention as to be made the subject of objections, which were submitted to the Zoological Section of the British Association by some of the accomplished foreign zoologists (the Prince of Canino, Professors Nilsson and Van der Hoeven), which afforded me the opportunity of entering into those details in support of my views which the scope of a purely anatomico-physiological treatise rendered inadmissible. I think it also due to myself, in here, for the first time, in connection with an instructive addition to the Artiodactyle group, consigning those details and arguments to paper, to take a brief survey of the views entertained by the most eminent zoologists on the arrangement and sequence of the affinities of the great natural order *Ungulata* as defined by our immortal countryman RAY.

To commence with a contemporary Zoologist and countryman who deservedly ranks as our highest English authority in the Mammalian department of Natural History,—Mr. Waterhouse. In his excellent 'Catalogue of the Mammalia preserved in the Museum of the Zoological Society of London' (8vo, 1838), he divides the hoofed species into the Cuvierian orders (V.) PACHYDERMATA and (VI.) RUMINANTIA: and the genera described are arranged as follows:—*Sus, Dicotyles, Phacochœrus, Tapirus, Rhinoceros, Hyrax, Equus*; then come the Ruminant genera beginning with *Auchenia*. The perissodactyle Pachyderms thus intervene, as in the 'Tableau des Vertèbres' in the 'Leçons d'Anatomie Comparée,' t. i. (1836), between the artiodactyle Pachyderms and the Ruminants: so that the Horse, *Equus*, may lead on to the *Camelidæ*.

In the "Observations on the Classification of Mammalia," published in the 'Annals of Natural History' for December 1843, Mr. Waterhouse calls attention to the resemblance which the genus *Centetes* bears in the general structure of the skull and the greatly developed canines to *Sus*, and says:—"Other Pachyderms again (as the Horses) approach the Ruminants in a very marked degree;" and the Ruminantia, which form the 7th ordinal circle in the table, p.

399, touch by the genus *Camelus* the genus *Equus* in the contiguous circle of *Pachydermata*.

In the 'Synopsis of the Mammalia in the British Museum,' 8vo, 1843, in which Mr. Gray states that "the system followed may be regarded as a modification of those of *Ray* and *Linnæus*, adapted to the present state of zoological science," the genus *Equus* is placed between *Cervina* and *Elephantina*. After *Elephas* comes *Tapirus*, then *Sus* (*Suina*), next *Rhinoceros* (*Rhinocerina*), and *Hyrax*, followed by *Hippopotamus*, which leads to the family *Dasypidæ* commencing with the genus *Manis*, &c. I am not without hopes that the remarks here offered on the natural affinities of the even-toed Ungulates may dispose the active Curator of our national zoological collections to reconsider his arrangement of the hoofed species.

In the *Systema Vertebratorum* by Charles L. Bonaparte, Prince of Canino (4to, 1840), the accomplished author, adopting my primary division of the class *Mammalia* into the *Placentalia* and *Implacentalia* or *Ovo-vivipara*, arranges the *Ungulata*, like Cuvier, into the *Ruminantia* and *haud Ruminantia*, but prefers the Linnæan terms, *Pecora* and *Belluæ*, for these orders respectively. The progression of the hoofed families is as follows:—Elephantidæ, including *Dinotherina* and *Elephantina*: Suidæ, including *Hippopotamina*, *Rhinocerotina*, *Tapirina*, *Suina*, *Anoplotherina*: Hyracidæ, including *Hyracina*: Equidæ, including *Equina*; which leads to the *Camelidæ* and the rest of the order Pecora.

Prof. Milne-Edwards, in his excellent 'Elémens de Zoologie,' adheres to the system of Cuvier, as developed in the last edition of the 'Règne Animal' (1829), in which the '*Pachydermes*' and the '*Ruminants*' are made equivalent groups and the genera are arranged as follows:—Fam. Proboscidiens. *Elephas*, *Mastodon*. Fam. Pachydermes ordinaires. A. le pied en quelque sorte fourchu: *Hippopotamus*, *Sus*, *Phacochærus*, *Dicotyles*, *Anoplotherium*. B. qui n'ont pas le pied fourchu: *Rhinoceros*, *Hyrax*, *Palæotherium*, *Lophiodon*, *Tapir*. Fam. Les Solipèdes. *Equus*. Ord. RUMINANTIA, *Camelus*, &c.

In thus interposing the Perissodactyles (odd-toed Pachyderms) between the pachydermal and ruminant groups of Artiodactyles (even-toed Ungulates), it would seem that Cuvier had abandoned his earlier views of the true affinities of the Horse as removing it from the Ruminants, and of the close relations of the even-toed Pachyderms, through the Anoplotherium, with the Ruminants.

M. Lesson in his 'Manuel de Mammalogie,' 12mo, 1827, makes the *Pachydermes* his 6th order, with the three divisions *Proboscidiens*, *Pachydermes proprement dits*, and *Solipèdes*: the Ruminans are the 7th order.

The most elaborate revision of the groups and affinities of the Mammalia which has issued from the French school of Zoology since the decease of its great founder Cuvier, is that by M. Lereboullet, entitled 'Tableaux des Ordres, des Familles, et des Genres, des Mammifères, adoptés pour le Cours de Zoologie de la Faculté des Sciences, par M. Duvernoy:' 4to, 1834. In this essay the three Cuvierian divisions Proboscidiens, Pachydermes ordinaires and Soli-

PÈDES are raised to the rank of Orders, forming the VIIth, VIIIth and IXth of the series; the Order X., *Ruminans*, forming an equivalent group. The succession of the genera is as follows:—*Elephas, Loxodon, Mastodon, Rhinoceros, Tapirus, Hyrax, Palæotherium, Lophiodon, Sus, Babirussa, Phacochærus, Dicotyles, Hippopotamus, Anthracotherium, Anoplotherium, Xiphodon, Dichobune, Adapis, Equus,* which is followed by *Camelus* and the other Ruminants.

The German and Scandinavian naturalists seem as little as the French to have appreciated the true value of the indications of the affinities of the *Ungulata*, afforded by the even and uneven number of the digits of the hind-foot: the Hog and the Hippopotamus are associated with the Tapir, the Rhinoceros and the Elephant in the order *Multungula*, by Illiger. The Horse-genus forms an order *Solidungula*, equivalent on the one hand to the foregoing, on the other to the *Bisulca* or Ruminants.

The order PECORA in the mammalian system of Fischer is made equivalent to all the rest of the Ungulates, which are collected together into the order BELLUÆ, the Artiodactyles and Perissodactyles being indiscriminately mingled together.

Professor Wagner of Göttingen, in the last edition of his 'Lehrbuch der Zootomie' (1845), retains the same primary division of the *Ungulata* with the Cuvierian names *Pachydermata, Solidungula, Ruminantia*. And the learned Nilsson, in his 'Skandinavisk Fauna,' 8vo, 1847, in adopting the two Cuvierian orders PACHYDERMATA and RUMINANTIA, divides the former into those with 5 toes (*Elephas*), those with less than 5 and more than 1 (ex. *Rhinoceros, Hippopotamus, Sus*), and those with 1 only (*Equus*). But were the proportions of the middle and functional to the two lateral and rudimental digits regarded, as they exist in the embryo-Horse, the artificial, it might be termed ætatal, nature of the *solipedous* or *solidungulate* character would be better appreciated. It is probable that most of those naturalists who have made the Horse the transition from the Pachyderms to the Ruminants have believed its large middle metacarpal bone and corresponding metatarsal bone to be, like the cannon-bones of Ruminants, a confluence respectively of the proximal elements of two distinct digits, and the three successive phalanges supported by such metacarpal and metatarsal to be the result of a confluence of as many pairs of phalanges*. Were this so, all the views of the affinities of the Horse here advocated would be subverted; and from the Perissodactyle it would enter into the essentially Artiodactyle group, but would carry with it so many elements contradictory of the natural character of that group, as would render the proposed arrangement untenable. But the development of the feet of the Horse concurs with the structure of the carpus and tarsus

* The learned Professor of Comparative Anatomy in the University College affirms this to be the fact. "We observe that the phalanges, three in number in each toe, of the anterior and posterior extremities, are composed each of two bones anchylosed together, so that only one toe appears to touch the ground, which is covered with a large undivided hoof, from which they are called '*Solidungula.*'"—"The anchylosis seen in the cannon-bone of the Ruminantia has here proceeded downwards through the whole extent of the feet."—Dr. Grant's Lectures, 'Lancet,' No. 550. March 1834, p. 907.

to disprove that idea: I have not observed a trace of median bipartition of the cannon-bone of the Horse, or of any of the phalanges it supports, at any stage of their development. And the third trochanter, the single stomach and sacculated cæcum, the structure of the upper molars, truly discerned by Cuvier to be modifications of the Rhinoceros-type and not of the Ruminant-type of grinding surface, together with the number of dorso-lumbar vertebræ, all combine to establish the subordinate character of the *Equidæ* and their true perissodactyle affinities.

With regard to the systems of the German Natur-philosophical and the English Quinary schools, the *à priori* idea of the potency of the number 5 has served in neither case to supply the need, or anticipate the results, of pure inductive research as regards the solution of the problem of the natural affinities of the hoofed quadrupeds.

Mr. Macleay* and his followers make the *Bruta* of Linnæus (*Edentata* of Cuvier) a subdivision of the *Ungulata*; and Mr. Swainson, who has attempted most towards working out the details of the Quinary system, gives the following succession of the circular affinities of the primary groups or tribes of the *Ungulata*.

1. Pachydermes. 2. Anoplotheres. 3. Edentates (including the Monotremes). 4. Ruminants; and 5. Solipedes. Thus odd-toed, even-toed and proboscidian hoofed genera all meet together in the heterogeneous tribe No. 1; and the Anoplothere is separated by the Ornithorhynchus and Armadillo from the Ruminants!

In Prof. Oken's 'Naturphilosophie' the Cetacea are added to the Pachyderms and Ruminants, in order to form the great group of *Ungulata*; and it must be admitted that this addition to the naturally circumscribed hoofed animals is less arbitrary than that of the long-clawed *Edentata*. Among the typical forms of the *Ungulata* cited as examples of that division of the great group, which is made equivalent to the Cetacea on the one hand and the Ruminants on the other, Oken selects the genus

Hippopotamus	as characterized by the	Skin;
Sus	by the dental system or	Tongue;
Elephas	by the proboscis or	Nose;
Rhinoceros	by the large (?)	Ears;
and *Equus*	by the	Eyes.

But quitting these '*jeux d'esprit*,' in which certain previously known and inductively-established groups are played with, like so many pieces in children's geometrical puzzles and map-games, according to the predetermined rules of the quinary-circular, or the 5-senses systems, let us see whither and how far the thread of comparative anatomy will guide us in the maze of the affinities of the recent and extinct animals with hoofed extremities. It is evident at first glance that the known genera cannot be ranged in a single linear series in the order of their natural affinities: it will be equally evident by the digital, the osteological, dental and visceral characters above adduced, that the Horse is not the next of kin to the Camel or Ox, even among existing genera; but that, the Proboscidians apart, all the other Ungulate quadrupeds are divisible into two natural and upon the whole parallel

* Linn. Trans. xvi. (1833) p. 28.

series, having respectively the *Anoplotherium* and *Palæotherium* as their types, which genera, so far as our actual knowledge extends into the dark vistas of the past, were their first, or amongst their earliest representatives on this earth. The known families or genera of the odd-toed and even-toed hoofed quadrupeds, respectively headed by these two extinct genera, may be ranged as follows: but much additional special knowledge must be obtained before their order of juxtaposition can be precisely determined:—

UNGULATA.

ARTIODACTYLA.

RUMINANTIA.

Anoplotherium.
Chalicotherium.
Dichobune.
Cainotherium.
Xiphodon.
Moschus*.
Antilope.
Ovis.
Bos.
Cervus.
Camelopardalis.
Camelus.
Merycotherium.
Merycopotamus.

NON-RUMINANTIA.

Hippopotamus.
Dichodon.
Hyracotherium.
Hyopotamus.
Anthracotherium.
Hippohyus.
Chæropotamus.
Adapis (?).
Dicotyles.
Phacochærus.
Sus.

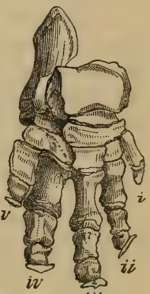
PERISSODACTYLA.

Palæotherium.
Paloplotherium.
Lophiodon.
Coryphodon.
Tapirus.
Macrauchenia.
Nesodon.
Hippotherium.
Equus.
Elasmotherium.
Hyrax.
Rhinoceros.
Acerotherium.

PROBOSCIDIA.

Elephas.
Mastodon.

Fig. 13.



The genus *Dinotherium* appears to make a transition from the Tapiroids to the *Proboscidians*, with an evident tendency also to the SIRENIA; and the genus *Toxodon* seems to lead towards the *Rodentia* with indications likewise of *Sirenoid* affinities. With these aberrant forms of *Ungulata* the present communication has no direct concern: it bears only upon the affinities of the typical four-footed groups. The presence of a divided metacarpus and metatarsus in one existing species of Ruminant, the existence of upper incisors and canines in another, and the presence of both characters in the embryos of most, if not all Ruminants, seem to me to make the assumption that *Anoplotherium* was not a Ruminant, and its allocation in a distinct order

* By the presence of the gall-bladder, amongst other family-characters, the Antilopes are more nearly allied to the *Moschidæ* than the Deer are.

(*Pachyderma*), more arbitrary than its association, as in the above Table, with the other Bisulcate even-toed Ungulates.

The arrangements of the recent and fossil genera in the 'Traité Elémentaire de Paléontologie' of M. Pictet (1844), and that in the still more recent 'Fauna der Vorwelt' of M. Giebel (tom. i. 1847), in one of which the genus *Equus* is separated from the *Palæotherium* and *Rhinoceros* by the *Anoplotherium*, and in the other by the *Anoplotherium* and the whole series of Ruminants, have chiefly weighed with me in taking the present opportunity of strengthening and explaining more fully the grounds for the arrangement of the *Ungulata* proposed in my 'Odontography' (vol. i. p. 523). The only author whom I have since found in accordance with me to any extent in that arrangement is M. de Blainville. In the *fasciculus* of the 'Ostéographie,' No. XXI. *Palæotherium*, p. 122, published, I believe, in the present year, the author says, in reference to the *Anthracotheria*, "qu'ils semblent indiquer encore un chaînon de la série des Ongulogrades, ou des Mammifères à sabot, intermédiaire aux deux sections que nous y avons établies d'après le nombre impair ou pair des doigts*."

In acknowledging, in his Note of 1819, the true author of the idea of the division of the hoofed quadrupeds into paridigitate and imparidigitate, M. de Blainville adds to the osteological characters adduced by Cuvier what he believes to be an additional one, viz. the junction of the transverse processes of the last lumbar vertebræ with each other and with the sacrum in the imparidigitate, and the absence of this junction in the paridigitate species. It was, perhaps, the discovery by Cuvier of the presence of this character in the *Hippopotamus*, especially cited by M. de Blainville as wanting it, which, with the supposed complexity of the stomach of the Tapir, tended to shake the confidence of the great Naturalist in the truth and importance of the idea that had originated with him.

Acknowledging, with M. de Blainville, the true source of the idea, I only claim the credit of the rectification of some of the observations

* "Voyez notre note à ce sujet dans le 'Bulletin des Sciences par la Société Philomatique' pour l'Ann. 1819, p. 41."

The following is the note to which M. de Blainville refers; it is entitled:—

"Sur un nouveau caractère ostéologique servant à distinguer les animaux quadrupèdes ongulés en deux sections, par M. H. DE BLAINVILLE.

"La Zoologie doit à M. le professeur CUVIER, la distinction des animaux mammifères ongulés en deux sections assez tranchées, caractérisées à l'extérieur par le système des doits complets ou incomplets des extrémités postérieures, qui peut être impair ou pair. À ce caractère extérieur, M. Cuvier en ajoute quelques autres, et entre autres la présence d'une sorte d'apophyse d'insertion du muscle grand fessier, à laquelle on a donné le nom de *troisième trochanter* dans le groupe à système de doigts impair, comme dans le Tapir, le Rhinoceros, le Cheval. Il y a déjà long-tems que M. de Blainville en a observé un autre, dont la connoissance peut être de quelque importance, surtout dans les recherches sur les ossemens fossiles, où l'on ne sauroit avoir trop de moyens pour se diriger; c'est que, dans toute la section à système de doigts impair, les apophyses transverses des deux dernières vertèbres lombaires, s'articulent les unes avec les autres dans une partie de leur étendue, et la dernière avec le bord antérieur de l'os sacrum, ce qui n'a jamais lieu dans tous les animaux ongulés à système de doigts pair, c'est-à-dire dans les Hippopotames, les Cochons, et les Ruminans." The same note is inserted in the 'Journal de Physique,' tom. XXXIX. p. 157, 1819.

that have opposed its application in systematic zoology, and the addition of other osteological characters, as the number of true vertebræ, and of modifications of the stomach and cæcum, which may tend to place the principle more truly before the eyes of the systematic Zoologist, and recommend it more favourably to his acceptance in the arrangement of the *Ungulata*.

DESCRIPTION OF PLATE VII.

Fig. 1. Grinding surface of the last upper true molar of *Hyopotamus bovinus*.
Fig. 2. Outer surface of ditto.
Fig. 3. Inner surface of ditto.
Fig. 4. Hinder surface of ditto.
Fig. 5. Fore surface of ditto.
Fig. 6. Grinding surface of a series of five upper molar and premolar teeth of *Hyopotamus vectianus*.
Fig. 7. Outer surface of ditto.
Fig. 8. Inner surface, showing the connate inner fangs of the second upper true molar of ditto.
Fig. 9. Grinding surface of a series of upper true molar and premolar teeth of *Anthracotherium magnum*, half the natural size:—from the 'Ostéographie' of M. de Blainville, fasc. xxi. *Anthracotherium*, pl. 1.

In each of the preceding figures,

m 3 is the last molar;
m 2 is the penultimate molar;
m 1 is the first molar;
p 4 is the last premolar;
p 3 is the third premolar;
p 2 is the second premolar. The letters on the grinding surface are explained in the text.

Fig. 10. Outer side of first premolar of *Hyopotamus* (?).
Fig. 11. Inner side of ditto.
Fig. 12. Upper canine of *Hyopotamus* (?).
Fig. 13. Upper incisor of ditto.
Fig. 14. Inner surface of ditto.
Fig. 15. Outer surface of ditto.
Fig. 16. Inner surface of crown of an incisor of ditto.
Fig. 17. Outer surface of ditto.
Fig. 18. Inner surface of crown of another incisor of ditto.
Fig. 19. Outer surface of ditto.
Fig. 20. An incisor of *Hyopotamus*, outer surface.
Fig. 21. Inner surface of ditto.
Fig. 22. An incisor of *Hyopotamus*, outer surface.
Fig. 23. Inner surface of ditto.
Fig. 24. Side view of an upper incisor of *Sus scrofa*.
Fig. 25. Inner surface of ditto.

DESCRIPTION OF PLATE VIII.

Fig. 1. Outside view of right ramus of mandible and teeth of *Hyopotamus bovinus*.
Fig. 2. Inside view of part of left ramus of mandible and grinding teeth of ditto.
Fig. 3. Upper view of right ramus and symphysis of mandible and teeth of ditto.
Fig. 4. Lower surface of symphysis of ditto.
Fig. 5. Anterior surface of second molar and section of mandible of ditto.
Fig. 6. Outside view of right ramus of mandible and teeth of *Anthracotherium magnum*, half the natural size:—from the 'Ostéographie' of M. de Blainville, fasc. xxi. *Anthracotherium*, pl. 1.
Fig. 7. Upper view of ditto, with the grinding teeth:—from the same work.

November 17, 1847.

Amos Beardsley, Esq., was elected a Fellow of the Society.

The following communications were then read:—

1. *Notes on the Geology of the Coasts of* Australia. By J. Beete Jukes, Esq., M.A., F.G.S.

In this memoir Mr. Jukes gave a short abstract of all the information collected by various travellers regarding the Australian continent, including his own observations.

The eastern coast is occupied by a great range of high land, appearing like a continuous chain of mountains when seen from the sea, and rising in several places to 5000 feet or more above the sea-level. This chain has an axis of granite, with occasional large masses of greenstone, basalt and other igneous rocks. It is flanked on both sides by thick beds of palæozoic formations, chiefly sandstone, but also containing limestone and coal. In the northern portion of the chain Dr. Leichardt found similar formations, and especially trap and granite near the Burdekin river. In the Port Philip district there are similar igneous rocks, and on the coast tertiary formations, which Mr. Jukes found resting on the edges of upturned palæozoic beds. In West Australia the Darling range consists of granite below, covered by metamorphic rocks; and between it and the sea is a plain composed of tertiary beds. In the colony of North Australia there is a great sandstone plateau, rising about 1800 feet above the sea, and probably of palæozoic age; whilst on the immediate shore and round the Gulf of Carpentaria are beds supposed to belong to the tertiary period. Similar formations constitute the substratum of the central desert, in which Capt. Sturt was compelled to turn, when half-way to the Gulf of Carpentaria, from the southern coast. Hence Mr. Jukes conjectures that these tertiary rocks are probably continuous through the whole central region, and that during the tertiary period all this portion of the country was submerged, whilst the high lands on the coast rose like four groups of islands from a shallow sea. In confirmation of this view, he remarked that a greater difference existed between the plants and animals of New South Wales and Western Australia, though in the same latitude, than between those at the southern and northern extremities of the eastern chain of mountains, distant 20° of latitude from each other.

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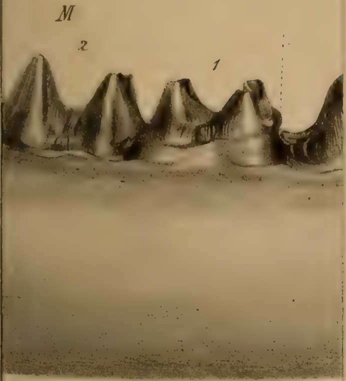
2. *Remarks to accompany a Geological Map of* Western Australia. By Messrs. J. W. Gregory and Francis T. Gregory.

In this memoir an account was given of the rocks and minerals observed in various parts of Western Australia, especially in a section from the sea-coast to the summit of the Darling range. Specimens of the rocks collected were also exhibited to the Society.

From Nature on Zinc by J. Erxleben. Day & Son lith^rs to the Queen.

Figs. 1–8, 10–21. Hyopotamus. Fig 9. Anthracotherium. Figs. 24–25. Sus.



erium.

From Nature on Zinc by J. Erxleben

Day & Son Lith^rs to the Queen.

Figs. 1.—5. Hyopotamus. Figs. 6.—7. Anthracotherium.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

November 1st to December 31st, 1847.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

AGRICULTURAL Magazine, June to November 1847.

——— Society (Royal), Journal. Vol. viii. part 2.

American Journal of Science. Second Series, Vol. iv. No. 12.

Asiatic and Colonial Quarterly Journal, December 1847. *From T. Hawkins, Esq., F.G.S.*

Astronomical Society (Royal), Memoirs, Vol. xvi.; Proceedings, Vol. vii. Nos. 1–17.

Athenæum Journal, November and December 1847.

Berg- und hüttenmännische Zeitung mit besonderer Berücksichtigung der Mineralogie und Geologie (Rédacteur C. Hartmann), Nos. 1 to 43, for 1847.

Berlin Academy, Abhandlungen for 1845.

——— Bericht, July to December 1846, and January to June 1847.

Chemical Society, Memoirs and Proceedings, Part 22.

Indian Archipelago, Journal of the, Nos. 4 and 5.

New York, Annals of the Lyceum of Natural History of. Vol. iv. Nos. 8 and 9.

Philosophical Magazine. *From R. Taylor, Esq., F.G.S.*

Vienna, Berichte über die Mittheilungen von Freunden der Naturwissenschaften in Wien. 1 band. Nos. 1–6.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Bellardi, L. Monografia delle Pleurotome Fossili del Piemonte.

Bohn, H. G. Catalogue of Books for 1847. Vol. i.

Da Hemsö, J. G. Cenni sull' Agricoltura e l' Industria dell' Africa Francese, &c.

——— Cenni Storici iponomici e statistici sulla Miniera di Rame, &c.

Dana, J. D. On certain Laws of Cohesive Attraction.

——— General View of the Geological Effects of the Earth's Cooling.

——— Conspectus Crustaceorum.

Delesse, Achille. Étude de quelques Phénomènes présentés par les Roches lorsquelles sont amenées à l'état de Fusion.

Falconer, Hugh, M.D. and Capt. P. T. Cautley. Illustrations to Parts 2 to 6 of the Fauna Antiqua Sivalensis.

Göppert, Prof. Uebersicht der Arbeiten der Schlesischen Gesellschaft für vaterländische Kultur im Jahre 1846.

Hopkins, W. On the Internal Pressure to which Rock Masses may be subjected.

M'Coy, F. On the Fossil Botany and Zoology of the Rocks associated with the Coal of Australia.

St. Helena. Observations made at the Magnetical and Meteorological Observatory at. Vol. i. 1840–43. *From Lt.-Col. Sabine, by direction of the British Government.*

Von Hauer, F. R. Die Cephalopoden des Salzkammergutes, aus der Sammlung seiner Durchlaucht des Fürsten von Metternich, ein Beitrag zur Paläontologie der Alpen. *From Herr W. Haidinger, by direction of Prince Metternich.*

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 1, 1847.

Samuel Hughes, Esq., George H. Sanders, Esq., Richard Meeson, Esq., John F. Bateman, Esq., Alfred Robertson, Esq., and John R. Lingard, Esq., were elected Fellows of the Society.

The following communication was then read:—

Report on the Fossil Remains of Mollusca from the Palæozoic Formations of the United States *contained in the Collection of* Charles Lyell, Esq.; *with Remarks on the Comparison of the North American Formations with those of Europe.* By Daniel Sharpe, Esq., F.G.S.

The following remarks have grown out of the examination of the fossil Mollusca from the older rocks of the United States, which Mr. Lyell has had the kindness to entrust to me. My principal object has been to ascertain what species are common to the American and European formations; how far such species have had the same duration in the two continents; and how far similar forms of animals have existed in both at what may be supposed to have been the same periods: thus collecting data illustrative of the history of the earlier marine animals. The next object has been to apply this knowledge to the classification of the American formations, and to try to learn how closely we are justified in comparing them with those of Europe.

These objects have already been zealously followed by the geologists of the United States; but it appears, that from a want of European specimens, they have usually been obliged to limit their comparison of species to the figures given in our geological works, which I need hardly state are seldom sufficient to afford palæontologists in a distant country much certainty of the identity of their species with ours. It is only by the comparison of specimens that we can hope to arrive at any certain conclusions; and we have never yet had so good an opportunity of making this desirable comparison as has now been offered by Mr. Lyell, who has brought together an extensive collection of specimens from nearly all the palæozoic formations of the United States and Canada.

My examination has been confined to the fossil Mollusca; Mr. Charles Bunbury has already favoured the Society with reports on the fossil plants collected by Mr. Lyell; and the corals and crinoidea have been placed by Mr. Lyell in the hands of other naturalists, from whom we may expect full information concerning them. The only part of this valuable collection still unexamined, is that containing the Trilobites and other crustacea.

Throughout my examination I have never hesitated in correcting what appeared an erroneous name or reference given by any of our American colleagues; but I trust that they will not impute this course to any want of respect for their labours, from which I have derived constant assistance: having specimens from the two countries before me, and knowing from their works that most of their comparisons were only of specimens against figures and descriptions, I adopted the conclusions which appeared drawn from the better evidence. I have been constantly assisted by our colleague Mr. Morris, and all points of difficulty, or of any peculiar interest, have been submitted to him. I cannot sufficiently thank him for the help he has given me, without which I should not have thought myself equal to so extensive a task.

Mr. Lyell's collection is very extensive and in excellent working order; the part examined contains nearly 200 species of Mollusca from formations ranging from the lowest fossiliferous beds to the top of the Devonian series. In general the specimens are in better condition than those we find in similar formations here; the Lower Silurian series in particular affords specimens in a condition far superior to what we are used to. The shells are rarely distorted, and most of the rocks appear both free from slaty cleavage and unaltered by igneous eruptions.

The bulk of the collection is from the state of New York; but there are also many specimens from Canada and Pennsylvania; all these may be considered as one series, since the New York geologists have traced their beds into both those countries. There is also a most excellent collection from the blue limestone of Ohio, and a few from some other beds of the Western States: these have been identified with the New York formations, so that the classification adopted by the state-geologists of New York forms the basis of all the following remarks.

The works principally consulted were the following:—

Annual Reports of the Geologists of the State of New York for 1838, 1839 and 1840.

Mr. Conrad on the Silurian and Devonian systems of the United States, with descriptions of new Organic Remains; in the Journal of the Academy of Natural Sciences of Philadelphia, vol. viii. p. 228, read 18th Jan. 1842.

Reports on the Geology of New York, viz.:—

Mr. Mather	on the	1st Geological District,		1842.
Dr. Emmons	,,	2nd	,, ,,	1842.
Dr. Vanuxem	,,	3rd	,, ,,	1842.
Mr. J. Hall	,,	4th	,, ,,	1843.

Dr. Dale Owen on the Geology of the Western States of North America; Journ. of the Geol. Soc. of London, vol. ii. p. 433.

Besides these, I have been favoured by Mr. Lyell with the use of a portion of an unpublished work by Mr. James Hall, on the Palæontology of the State of New York, which that gentleman has forwarded to Mr. Lyell as the sheets passed through the press. This work is to contain figures and descriptions of all the species of fossils of New York, with many of those of the surrounding states; and it promises to form, when completed, a standard work on Palæontology of so high a character, that it will be equally essential to European and to American students. In the face of this forthcoming publication of Mr. Hall's, I have felt it would be both unnecessary and unbecoming in me to undertake the description of any new American species, and I have limited myself to the examination and classification of the species already described, merely adding the number of unnamed species in Mr. Lyell's collection, to show the proportion of European species which it contains.

Hitherto English writers have not been in the habit of consulting American works for the descriptions of fossil species, but it has now become necessary for them to do so. In the following lists several English species are given, which though unnamed here, have been described and named in America; and when Mr. Hall's work is completed, the number of species in this position will undoubtedly be much increased *.

There is little difference between the various tables of the Palæozoic formations of New York published by the geologists just referred to; but they are far from being agreed as to the manner in which their formations are to be classed in comparison with ours. The

* M. de Verneuil's able paper on the parallelism of the palæozoic rocks of North America with those of Europe, which was read to the Geological Society of France on the 19th of April 1847, and printed in the Bulletin of that Society, t. iv. p. 646, has not been referred to above, because my paper was finished and in the hands of the Secretary of our Society before that part of the Bulletin reached England; and the regulations of our Society do not permit me to make any alterations in the paper after sending it to the Society.—*December* 1, 1847. D. SHARPE.

latest views on this subject which I have met with are those given by Mr. James Hall in the Report on the Geology of the 4th district of New York, p. 15 and p. 517; and they approach very nearly the conclusions to which I have been brought by the examination of the fossils.

Mr. Hall's tables are as follows; beginning with the lowest beds.

New York System.

Geographical divisions.	Geological subdivisions.	Equivalent in Great Britain.
Champlain division.	Potsdam sandstone.	Not yet recognized in Great Britain.
	Calciferous sandrock.	
	Chazy limestone.	
	Bird's-eye and Black-river limestone.	
	Trenton limestone.	
	Utica slate.	Llandeilo flags.
	Hudson River group.	Caradoc sandstone.
	Grey sandstone.	
	Oneida conglomerate.	
Ontario division.	Medina sandstone.	
	Clinton group.	
	Niagara group.	Wenlock rocks.
Helderberg series.	Onondaga salt group.	
	Water-lime group.	
	Pentamerus limestone.	
	Delthyris shaly limestone.	
	Encrinal limestone.	
	Upper Pentamerus limestone.	
	Oriskany sandstone.	
	Cauda-galli grit.	
	Schoharie grit.	
	Onondaga limestone.	
	Corniferous limestone.	
Erie division.	Marcellus shale.	Upper and Lower Ludlow and Devonian system.
	Hamilton group.	
	Tully limestone.	
	Genesee slate.	
	Portage group.	
	Chemung group.	
	Old red sandstone.	Old red sandstone.

Mr. Hall says at p. 24 of his Report, "The geographical divisions in this table, though convenient for reference, do not indicate any great natural divisions of the system as founded upon fossil characters. Such a mode of subdivision will follow only a perfect knowledge of the fossils both in this State and elsewhere." It thus appears that the four great divisions into Champlain, Ontario, Helderberg and Erie series have been arbitrarily adopted upon geographical grounds, those beds being classed together which are well-exposed in the same district. We are therefore at liberty to group the beds together as the examination of their organic remains may point out. For as all the beds comprised in the New York system are conformably superimposed on one another, there are no natural breaks in the series to assist us in subdividing them.

An English geologist looking over the preceding table is immediately struck by the great number of distinct groups of fossiliferous beds recognized as existing below the old red sandstone; but he will be much mistaken if he supposes these to have any analogy to the great groups of beds to which we have attached distinguishing names in this country. The difference lies in the greater degree of subdivision adopted by the New York geologists, who have given a separate name to every bed which offers any difference, either of mineral character or of fossil contents, from the beds adjoining it, whether its thickness be 10 or 1000 feet; so that if we were to name on the same principle all distinguishable beds between the old red sandstone and the bottom of the fossiliferous rocks of Wales, we should probably have to give them above a hundred different names.

Such subdivisions may be convenient for local purposes, but they ought also to be thrown together into a second series of larger groups representing the more important divisions. The want of such enlarged classification has led to very erroneous conclusions in the comparison of American and European formations: thus all the American geologists have adopted the opinion set out in Mr. Hall's table, that fossiliferous beds are found in New York of a much earlier period than any beds known in Europe: for having ascertained that the division between the Niagara and the Clinton groups corresponds to that between the Lower Silurian and the Wenlock formations in England; and finding eleven groups of beds below this line in the United States, while we in England have only distinguished two or three, they have come to the conclusion that they have many groups containing organic remains older than any of ours. A slight resemblance in mineral character between the Utica slate and the Llandeilo flags, has been caught at to strengthen this opinion.

Instead of admitting this view of the greater age of the lowest fossiliferous beds of the United States, I can see no grounds for believing that any such beds have been there discovered of an earlier age than the lowest fossiliferous beds of North Wales, by which I mean the beds in the neighbourhood of Tremadoc containing Lingulæ, discovered by Mr. J. E. Davis (Journal of Geol. Soc. vol. ii. p. 70), the position of which has since been better determined by Professor Sedgwick (Journal of Geol. Soc. vol. iii. p. 140, &c.). It is true that I have not been able to recognize as European any species found in beds below the Trenton limestone; but in that bed and its equivalent in the west, the blue limestone of Ohio, we find many of the species which are common here in the upper and middle parts of the Lower Silurian formation, but none of those peculiar to the base of that system. Mr. Hall mentions with some doubt the *Illænus crassicauda* as occurring in the Chazy limestone; this trilobite is found here in the limestone of Rhiwlas near Bala: even if the synchronism of these two beds were admitted upon this slight evidence, it could only follow that the lowest fossiliferous bed in the United States, the Potsdam sandstone containing Lingulæ and fucoids, was about of the same age as the Tremadoc bed containing Lingulæ and some bivalves; but this would not show a greater age in the American bed. As I must return to this subject again, I will not follow it farther at present.

It is a more serious objection to the divisions established in New York that they are far from being of equal geological importance; as some represent beds distinct both in mineral character and organic contents, while others contain nearly the same species of shells and have little to distinguish them mineralogically. Thus the Trenton and the Hudson River limestones form, according to Mr. Hall, one natural zoological group, and in the Western States unite to form the blue limestone of Ohio (Hall, Palæontology of New York, p. 61); and many of the beds of limestone in the Helderberg series contain so nearly the same species throughout, that there would be more reason for dividing our mountain limestone into a number of groups than there is for separating these.

This minute subdivision of beds has been indirectly another source of error. Many of the American geologists have been strongly imbued by the idea, which unfortunately has been promulgated by naturalists of eminence in Europe, that different species of animals are to be expected in each geological group or formation: and thus in multiplying their stratigraphical divisions they have increased the multiplication of supposed species. The result is seen in the great number of synonyms in the table of species given farther on, which would have been still more numerous if I had had a larger collection of specimens to work upon.

As a first step towards understanding the relative value of the American divisions of formations and comparing them with those of Europe, I have attempted to classify the New York beds according to the distribution of the organic remains found in them, following the ascending order after the example of all the American geologists. This may seem a bold attempt from one who has not seen the country and can have but limited means at his disposal: but the object to be gained is so important as to be worth the risk. With each group of beds is given a list of the species of shells which I have found in Mr. Lyell's collection to be identical with those of Europe, or the identity of which rests on undoubted authority. I might have increased these lists very largely by adding all the supposed identifications of species given by the American writers; but I have rarely availed myself of these for the reason already stated, that they appear to be built on the comparison of their specimens with our figures and descriptions, and not of specimens against specimens. The references to the names here used, the synonyms, &c., will be found in the general list of species given hereafter.

1. *Potsdam Sandstone.*

This is the earliest fossiliferous rock discovered in the United States, where it is of considerable importance; it contains Lingulæ and some supposed fucoids. It thus appears that both in America and England the Lingulæ are among the earliest animal forms yet met with, but the species in the two countries are not the same.

2. *Calciferous Sandrock.*

The organic remains in this bed are more varied than in the preceding; but they are seldom found in a condition which admits of their being identified.

3. *Chazy Limestone, Bird's-eye Limestone and Black-river Limestone.*

Mr. Hall enumerates 77 species of organic remains from these beds, of which the most remarkable are the Orthocerata in the Black-river limestone, which are sometimes above ten feet long. I have seen no specimens of European species, but Mr. Hall gives three:—

Illænus crassicauda?
Columnaria alveolata, *Goldf.*
Lituites convolvens, *Hisinger.*

4. *Trenton Limestone.*
Utica Slate.
Hudson River group.
} *Blue Limestone of Ohio.*

These beds furnish an abundant and interesting supply of fossils, and usually in a condition in which they can be studied with great advantage. We here begin to find many species which are common in Europe, where they characterize the middle part of our Lower Silurian formation, thus giving us the first good term of comparison with the American beds. In Mr. Lyell's collection I have found the following European species, and it is probable that a larger collection would supply more, as the American authors give long lists of British species from those beds:—

Leptæna alternata.
—— depressa.
—— imbrex.
—— sericea.
Orthis parva.
—— testudinaria.
Spirifer biforatus.
Terebratula bidentata.
—— reticularis?
Strophomena grandis.
Bellerophon bilobatus.
Porcellia ornata.

5. *Grey Sandstone.*
Oneida Conglomerate.
Medina Sandstone.
Clinton Group.
Also part of the *Cliff Limestone* of Ohio.

The organic remains in the sandstones are few, and I have not recognized any European species among them. The Clinton group is rich in fossils, but unfortunately Mr. Lyell's cabinet is poorly supplied with them. I have only been able to identify *Pentamerus oblongus* in the Clinton group, and *Pentamerus lævis* in the Cliff limestone: these are regarded in America as one species, but they are clearly distinct. In Mr. Hall's Report the following are added from the Clinton group:—

Atrypa hemisphærica.
—— affinis.
Leptæna depressa.
Spirifer radiatus.

Both in fossils and mineral character the Clinton group forms a passage between the Lower Silurian sandstones below it and the limestone series above it: the latter is clearly referable to the epoch of our

Wenlock beds. Nevertheless, although it may contain a few Upper Silurian species, I think that Mr. Hall has classed it correctly in the Lower Silurian series, which must be taken as ending with the Clinton group.

It is not so easy to state the correct place of the Cliff limestone of Ohio, as it appears from Mr. Hall's Report, p. 519, and from M. de Verneuil's remarks in the Bulletin of the Geological Society of France, vol. iv. p. 12, that the western geologists have thrown together under this name calcareous beds containing both Silurian and Devonian strata. I hope that M. de Verneuil may give us some further remarks on this subject, which is at present in great obscurity*.

6. *Niagara Shale and Limestone.*

These two beds so closely resemble the limestone and shale of Dudley, both in mineral character and in organic remains, that they have been regarded as their exact equivalents: this however is carrying the comparison too far, as it will soon be shown that many of the limestones of the Helderberg series must also be included in the Wenlock formation.

The shells in these beds belong mostly to the Brachiopoda, and the number of species identical with those found in the Wenlock rocks in this country is very remarkable; while none are species found in England exclusively in the Lower Silurian formation. The following are seen in Mr. Lyell's cabinet:—

Atrypa didyma?
Leptæna depressa.
—— transversalis.
Orthis elegantula.
Spirifer crispus.
Spirifer plicatus.
—— radiatus.
Strophomena grandis.
Terebratula cuneata.
—— reticularis.

To which may be added, on Mr. Hall's authority,—

Orthis hybrida.
Spirifer biloba.
Strophomena pecten.

7. *Onondaga Salt Group. Water-lime Group.*

The first of these is a deposit of great extent and thickness, and of great economical importance from its supply of salt and gypsum: the next forms a passage from the Salt group to the calcareous system above. Both beds contain few organic remains; the only European species I have seen is the *Spirifer plicatus.*

8. *Pentamerus Limestone. Delthyris shaly Limestone. Encrinal Limestone. Upper Pentamerus Limestone.*

These four beds form a calcareous series so closely connected in

* These anticipations have been fully realized by the publication of M. de Verneuil's views on the subject in the 'Bulletin de la Société Géologique de France,' t. iv. p. 646.

mineral character, and containing so many fossil species in common, that they must be regarded as one group, however convenient these divisions may be for local examination. A large proportion of their shells correspoud with those of our Wenlock formation, and there can be no doubt that they must be classed with that deposit. But it is not a little remarkable that we find mixed with these species of the Middle Silurian age some forms which we are accustomed to consider of the Devonian, or even of the carboniferous epoch: the most marked of these are *Orthis resupinata,* a small Productus and a large unnamed Spirifer, which if found apart from other known species would have been enough to have caused the beds to be classed in the carboniferous system.

The species identified with ours are the following:—

Avicula naviformis.
Atrypa tumida.
—— didyma.
Leptæna depressa.
Orthis hybrida.
—— orbicularis.
—— resupinata.
Pentamerus galeatus.
Spirifer plicatus.
Strophomena pecten.
Terebratula borealis.
—— reticularis.
—— Stricklandi.
—— n. s. found in Wenlock shale.

9. *Oriskany Sandstone.*
Cauda-galli Grit.
Schoharie Grit.

These beds are locally distributed; the first, of no great thickness in New York, becomes of more importance in Pennsylvania and Virginia: it is however everywhere of great moment geologically, as in entering it we lose all those species which are considered here as peculiar to the Wenlock formation: the species which are common to the Oriskany sandstone and the beds below it are either carboniferous forms, or such species as have as great a range vertically.

Mr. Hall places these beds and the limestone series next to be mentioned as No. 10, in the Wenlock formation, adding, however, that there are many reasons for classing them in the Ludlow formation. The evidence which I have had before me does not justify either of these views, but leads me to class both these and the following beds in the same great formation as the Hamilton and Chemung groups, the whole giving us what appears to be an enormous development of the Devonian system; for I cannot find in any of the New York beds any equivalent of the Ludlow formation of England.

The species from the beds No. 9, identified as European, are,—

Spirifer arenosus.
—— Urii.
Terebratula reticularis.

10. *Onondaga Limestone.*
Corniferous Limestone.

The fossils of the lower bed are mostly corals; in the upper are found the following:—

Leptæna depressa.
Orthis resupinata.
Terebratula reticularis.

11. *Marcellus Shale.*

Hamilton Group. { Moscow Shales. Encrinal Limestone. Ludlowville Shales. }

Tully Limestone.

Genesee Slate.

In a palæontological classification these beds must be arranged together, so many species do they possess in common. There is also a mineralogical accordance in their prevailing argillaceous and shaly character.

We have here some species which were found in the beds below; but with these we find a great variety of new species, belonging mostly to different genera from those common below. In this group of beds the Brachiopoda are less numerous, and the species of Lamellibranchiata far more abundant than we have yet seen them. Among the latter are many species either belonging or allied to the genera Cypricardia, Cucullæa?, Avicula, Inoceramus? &c., which have a general resemblance to shells found in our Ludlow beds; but so few of the species are identical, that we cannot group these beds with the Ludlow formation. The shells which can be specifically identified are, with few exceptions, known here in the Devonian or carboniferous formations, so that we must undoubtedly refer the beds of this group to the Devonian period.

The Hamilton group is perhaps the richest in species of all the New York beds, and its specimens are usually well preserved; still I am not able to identify a large proportion of its species with those of Europe. The following occur in Mr. Lyell's collection:—

Avicula Boydii.
—— quadrula.
Athyris concentrica.
—— lamellosa.
Orthis Michelini.
—— eximia?
—— opercularis.
Strophomena Sharpei.
Spirifer Urii.
—— macronotus.
Productus fragaria?
—— scabriculus?
Terebratula reticularis.
—— aspera.
—— borealis.
—— nucula?
Orthoceras articulatum?

12. *Portage Group.*

This is described by Mr. Hall as an extensive development of shales, flagstones and sandstones, at least 1000 feet thick, with very few organic remains; of these Mr. Lyell's collection contains no specimens: the few species described by Mr. Hall connect the Portage group with the beds both above and below it: the principal character being the negative one, that it is almost bare of fossils, though lying between two beds richly supplied with them: in all these respects it resembles part of our Devonian series.

13. *Chemung Group.*

This group consists, according to Mr. Hall, of "a highly fossiliferous series of shales and thin-bedded sandstones," scarcely less, in the eastern part of his district, than 1500 feet thick. Many of the species are common to the Chemung and Hamilton groups; such as I have been able to identify lead me to class this group in the Devonian system. In fact, but for their separation by the non-fossiliferous beds of the Portage group, the Chemung and Hamilton groups would hardly be divided: thus all the beds of the "Erie division" form a closely connected series well-characterized by common species of organic remains.

The following species are European:—

Avicula Boydii.	Productus plicatilis ?
—— Damnoniensis ?	—— fragaria ?
Athyris concentrica.	Terebratula reticularis.
Strophomena umbraculum ?	—— aspera.
Spirifer Urii.	—— borealis.
—— aperturatus.	—— nucula ?

Old Red Sandstone.

The "New York System" of our American colleagues closes with the Chemung group, which is surmounted by a formation of sandstone, considered identical with our old red sandstone. The arguments in favour of this classification are its position above the great fossiliferous Erie division, which is identified with our Devonian system, and below a series of beds identified by their organic contents with our carboniferous system, and the occurrence in this sandstone series of the remains of fishes stated to resemble those of the old red sandstone of Great Britain. Upon this latter point I can pronounce no opinion, not having examined the evidence; but I see no reason to doubt the soundness of the American classification of the formation. It is however worthy of particular notice, that in New York there is clear stratigraphical evidence for placing this red sandstone formation above the whole of the fossiliferous Devonian series.

Having thus passed in review the separate members of the "New York System," let us now look at its larger features. The whole system divides itself naturally into three great divisions, marked by differences both of mineral character and of organic remains. Owing to the general conformity of the beds and the gradual change of characters throughout, it is difficult to fix on the exact lines where these great divisions should be made, and the geologists who have described the country are not exactly agreed on them; yet the main features are well-marked, and have struck every one nearly in the same light.

Looking at the mineralogical characters of the rocks, we see, 1st, a vast accumulation of sandstones, with occasional beds of limestone reaching from the earliest fossiliferous beds upwards to the Medina sandstone; the Clinton group of beds which lie upon that sandstone being intermediate in character between the lower group and the next above.

2ndly. A great calcareous series, varied with some shales and sandstones, commencing with the Niagara shale, and ending, according to Mr. Conrad, with the Upper Pentamerus limestone inclusive, or, according to Mr. Hall's views, reaching upwards to the top of the corniferous limestone.

3rdly. A series of still greater thickness in which argillaceous matter is the main ingredient, and limestone very rare; the rocks consisting chiefly of shales and argillaceous sandstones. This series reaches upwards to the top of the Chemung group, and is covered by a red sandstone.

The organic remains of these three great divisions are also well-marked, and will help us to a more close classification of the beds.

1st. The shells found in the lowest or Sandstone division present a great accordance with those found in the Lower Silurian formation of Europe: and in this we must include the Clinton group, notwithstanding its containing a few Wenlock species, for the great majority of its fossils are of Lower Silurian types.

In Mr. Lyell's collection there are about 45 species from this lower series of beds, of which 14 are known European species of Lower Silurian age, being near 30 per cent. of the whole.

If our Welsh specimens were in better condition and had been thoroughly examined, it is probable that the agreement would be found still greater; but even at present it justifies the classification of this American series of beds with our Lower Silurian formation.

2ndly. In the calcareous series reaching from the Niagara shales to the Upper Pentamerus limestone inclusive, the agreement of the species with ours is still more remarkable. Out of near 50 species in Mr. Lyell's cabinet, 20 are European, or 40 per cent. of the whole. Of these European species so large a proportion belong to the Wenlock period, that we must class this calcareous series with our Wenlock formation. In this division we first meet some species which in this country belong to the carboniferous and Devonian formations, but they are too few to affect our conclusions.

3rdly. The uppermost of the three great divisions, including the beds from the Oriskany sandstone to the Chemung group, contains a great number of species, of which Mr. Lyell's collection contains above 100 species; among these I can only identify 22 European species, being about 20 per cent. of the whole: these belong for the most part either to the Devonian and carboniferous systems of Europe, or are such species as have a wide range through the older formations; with these are a very few Ludlow species: the conclusion, therefore, from a general examination of the fossil shells, is, that the beds of this division must be considered as an enormous development of what we have called in Europe the Devonian system.

In the preceding arrangement of the New York series of rocks, no part has been classed with the Ludlow formation of this country. The American writers are not agreed upon this part of their series: Mr. Hall places the beds from the Oriskany sandstone to the corniferous limestone inclusive in the Wenlock series, with the remark that there are many reasons for including them in the equivalents of the Ludlow formation*. But as there are no species found in those beds which are known here as peculiar to the Ludlow formation, and they contain some common carboniferous species, it seems fitter to class them in the Devonian system with the beds above them.

* Report on the Fourth district of New York, p. 517.

Mr. Conrad* considers all the beds from the Cauda-galli grit to the Tully limestone inclusive to correspond with our Ludlow formation, leaving for the Devonian system the Portage and Chemung groups and some rocks in Pennsylvania called there Old red sandstone. In favour of this view may be quoted one or two Ludlow species found in the Hamilton beds, and a large number of bivalves found in the same beds of the genera Avicula, Pterinæa, Cypricardia, Sanguinolaria, &c., which have a strong general resemblance to shells found in the Ludlow rocks of Westmoreland: but as very few of these species are identical with ours, and they are associated with many Devonian species, the balance of evidence is strongly in favour of classing the whole as Devonian. Moreover, so great a number of species are common to the Hamilton and Chemung groups, that they must both be classed in the same formation.

It will be found safer to give up the attempt to identify any of the New York beds with our Ludlow formation, and to divide the "New York System" of rocks into three great divisions, equivalent to the Lower Silurian, Wenlock and Devonian systems of Europe; the lines between which can only be drawn somewhat arbitrarily, owing to the gradual passage of all the groups into one another, and their general conformity throughout.

It has just been stated that Mr. Lyell's collection contains the following proportion of known European species of shells, viz.—

The Lower Silurian series........	30 per cent.
The Wenlock series	40 per cent.
The Devonian series	20 per cent.;

but I wish it to be understood that I attach little importance to these or any similar numerical calculations of species. The sources of error in such calculations are numerous and varied, and so little known beforehand, that we can never be enough on our guard against them. Fossils must be collected to a far greater extent, and their comparison must be carried on with more care than has yet been given, before we can rely with safety on any calculations of the proportions of species.

There are many circumstances which should make us mistrust the relative proportion of European species found in the three great divisions of the New York system. In this country the fossils of the Wenlock beds are easily found in good condition; they have in consequence found favour with collectors, and have been more thoroughly described than those of the other palæozoic formations: they offer therefore more extended means of comparison than the Lower Silurian or Devonian species. The Lower Silurian fossils still undescribed are known to be very numerous; but a large proportion of the Welsh specimens are in bad condition, and their determination is very difficult. Large numbers of the Devonian species also have been found in a condition which does not admit of satisfactory comparison with foreign specimens. So that although my tables show in the Wenlock beds of New York a great excess of European species over either the Lower Silurian or the Devonian beds, it is by no

* Journ. of Acad. of Nat. Sciences of Philadelphia, vol. viii. p. 232.

means certain that such a difference really exists, since the means of comparison in the three cases are very different.

Among the European species found in the palæozoic rocks of the United States, the following species are found in Russia or the east of Europe, but are not known in this country :—

Leptæna alternata, Spirifer biforatus, —— var. lynx, chama, &c.,	of the Lower Silurian series.
Spirifer arenosus, —— aperturatus, Orthis eximia ?, —— opercularis, Strophomena umbraculum,	of the Devonian series.
Fusulina cylindrica *,	of the Carboniferous series.

Should further examination discover a larger number of species under these circumstances, we might infer that at these remote periods the ocean was connected round the whole of the northern part of the globe.

The opposite table shows the proportion of species of different genera which are common to the United States and Europe in each of the three great divisions of the New York system, as shown in Mr. Lyell's collections.

Although the results of this table are liable to suspicion for the reasons mentioned at p. 157, they are worthy of some attention: it appears that while hardly a Gasteropode, and but few species of the Lamellibranchiate bivalves, are common to the older formations of Europe and the United States, above two-fifths of the Brachiopoda collected by Mr. Lyell are of European species. Most of the recent Brachiopoda are inhabitants of deep water; and the genera Lingula and Orbicula, which are fond of the coasts, give us no species common to the two continents: therefore the explanation of these facts may be that the inhabitants of deep seas have a wider geographical range than shells which are found near shore. Littoral species may require for spreading themselves a continuous line of coast under a nearly equal climate, which are circumstances rarely likely to occur. But the inhabitants of the deeper waters being less subject to change of climate may be able to travel to greater distances.

The comparison of the palæozoic fossils of Europe and the United States does not bear out the opinion that those species which range through the greatest thickness of formations have also the widest geographical range; for we find in New York European species which are confined here to nearly a single bed as well as those which are common to several formations, and usually the species appear to have nearly the same vertical range in both countries. Thus :—

Terebratula reticularis, Leptæna depressa,
—— borealis,

* De Verneuil, Bull. de la Soc. Géol. de France, vol. iv. p. 12.

Species of Mollusca common to the United States and Europe.

	Lower Silurian.		Wenlock.		Devonian.	
	Total number of species.	Species common to Europe & United States.	Total number of species.	Species common to Europe & United States.	Total number of species.	Species common to Europe & United States.
Brachiopoda.						
Atrypa	1	...	5	2	6	2
Chonetes	2	...	...	...	3	
Leptæna........................	5	4	3	2	3	
Lingula	4	...	1			
Orbicula........................	...	...	...	...	3	
Orthis	5	2	5	4	7	3
Pentamerus	2	2	2	1		
Productus	...	...	1	...	6	3
Spirifer	2	1	8	3	12	4
Strophomena................	2	1	7	2	7	2
Terebratula	4	2	10	5	7	3
Trematis	1					
	28	12	42	19	54	17
Lamellibranchiata.						
Avicula	1	...	2	1	14	3
Cypricardia	1	...	...	...	9	1
Sundry genera	6	...	...	...	25	
	8	...	2	1	48	4
Gasteropoda.						
Sundry genera	2	...	3	...	3	
Heteropoda.						
Bellerophon	1	1	2			
Porcellia	1	1				
	2	2	2			
Cephalopoda.						
Orthoceras....................	5	...	...	...	1	1
Cyrtoceras....................	...	...	...	...	1	
	5	...	...	...	2	1
Total.........	45	14	49	20	107	22

have in both continents nearly the same wide vertical range.

Pentamerus galeatus,
Spirifer plicatus,
—— radiatus,
—— Urii,
Strophomena grandis,
—— pecten,
Orthis orbicularis,

are found both here and in the United States, either in two or three formations.

And a longer list may be formed of shells which are confined in each country to one formation: in this will be found many common species, as

Leptæna sericea.	Terebratula cuneata.
Orthis testudinaria.	—— Stricklandi.
—— parva.	Spirifer crispus.
—— elegantula.	Pentamerus lævis.
Terebratula bidentata.	—— oblongus.

Such instances might be multiplied to a greater extent; but the above are sufficient to show that the vertical range of each species is nearly the same in both these distant countries.

It would be interesting to trace out the first appearance of each species in many countries, and to see whether it is found in one at an earlier period than in another country; and thus learn of what region it was originally native. At present we have slight materials for such an inquiry; but some facts have been met with while following the present investigations, which bear upon the subject.

Spirifer Urii, which in Britain is found sparingly in South Devon, more abundantly in the S. Petherwin and Pilton beds which unite the Devonian and carboniferous formations, and is most common in the shales of the carboniferous period, is in the United States rather a Devonian than a carboniferous species; appearing first in the Oriskany sandstone, a bed which lies next above the Wenlock formation.

Terebratula reticularis is not known here below the Wenlock shale: in New York it is common in the Lower Silurian Clinton group; and if a single doubtful specimen may be trusted, occurs low down in that series in the blue limestone of Cincinnati.

Orthis resupinata is rare with us in the Devonian beds, and common in the mountain limestone: in the United States it is found as low as the Upper Pentamerus limestone, where all its companions belong to the Wenlock epoch. It is impossible to be mistaken about so well-marked a shell; but had this been found alone, or in company only with unknown species, no European geologist would have hesitated to class the bed in the carboniferous series.

All the species just named are found in North America in beds of an older date than those in which we find them here, and must therefore be set down as native Americans which have migrated at a later period to Europe. When we know the American shells better, we may be able to point out European species which had established themselves here before they passed to the United States; perhaps *Leptæna depressa* may be one of them.

Leptæna depressa is abundant in the schists connected with the Bala limestones, and continues throughout all the beds from that to the mountain limestone. The Bala limestone is certainly low down in the Lower Silurian formation; and in Professor Sedgwick's opinion it lies below all the Silurian beds described by Sir R. Murchison. In the United States the *Leptæna depressa* is found but sparingly in the Trenton limestone and blue limestone of Ohio which lie in the middle of the Lower Silurian series, and is first found in any abundance at the top of that series in the Clinton group.

If, without regarding species, we look only to general form, we shall find some groups of shells common in the United States long before we meet them here.

In the genus *Spirifer* some of the sections may be pretty evenly matched in the two continents, while others appear at different epochs. The following are in the former case :—

In the section of *Biforés* of De Verneuil, we find in the Lower Silurian beds

S. biforatus, var. Lynx, Chama, &c., in the United States.

S. dentatus, *Pander*, S. terebratuliformis, *M'Coy* (*crucialis* of Sedgwick's list), } in England.

Among the species with fine striæ, either alone or in addition to strong rays, the following are found in the Middle and Upper Silurian beds of the two countries :—

S. radiatus, S. Niagarensis, S. macropleura, } in the United States. S. radiatus, S. interlineatus, } in England.

And many large-winged, expanded species are found in both countries in the Devonian formation.

But there are several large species of *Spirifer* found in the United States in the equivalents of the Wenlock formation, or in the beds next above them, of forms which we are only accustomed to see here in the carboniferous series. Such are the following :—

S. arenosus, a shell so like the usual carboniferous species, that M. de Verneuil doubted the correctness of the localities marked on specimens sent him from Bogoslofsk with Silurian and Devonian species ('Russie,' vol. ii. p. 164), where the species is named *S. superbus*.

S. undulatus, of Hall, not of Sowerby.

S. (unnamed), a large strongly-marked species nearly allied to *S. crassus*, but with a smooth mesial fold.

In the Upper Pentamerus limestone, a bed belonging to the Wenlock series, there occurs a small spinose species of Productus allied to *P. laxispina, P. Cancrini*, &c. ; such as we only find in Europe in the Devonian and carboniferous formations.

These instances ought to teach us that all classifications of the formations of distant countries are very liable to error when they are only based upon the *generic* resemblances of the organic remains. Had a bed been found containing only the species just mentioned, it would, in the absence of other evidence, have been referred by common consent to the carboniferous system : whereas a preponderance of evidence derived from the identification of species forces us to class these in the Wenlock series. Even when we have one or two identical species to rely upon, we may be easily mistaken in our estimate of the age of a foreign formation : but a classification is of very little value which only rests on finding, in two distant places, shells of the same genus or section of a genus ; or upon what have been called representative species.

List of Published Species of Mollusca *recognised in the Collection of* Charles Lyell, Esq., *from the Palæozoic Rocks of the* United States.

[(1) &c. These numbers refer to the notes which follow this Table of species, p. 171, &c.]

CONCHIFERA.

Species.	References and Synonyms.	Strata.	Localities.	Found in Europe.
Avicula (1).				
Boydii (2)	Conrad, Journ. Acad. Phil. v. 8, t. 12, f. 4.	Hamilton group, Chemung group.	Casenovia, Corning.	Ludlow form., Westmoreland.
Damnoniensis ?	Sow. Geol. Tr. 2, ser. v. 5, t. 53, f. 22; Phillips, Pal. Foss. Nos. 90–92; Hall, Report, p. 263, f. 1.	Chemung group.	Corning.	Devonian syst., N. Devon.
decussata	Hall, Report, p. 203, f. 1 & 2.	Hamilton group.	18-mile Creek.	
flabella	Conrad, Journ. Acad. Phil. v. 8, t. 12, f. 8; Vanuxem, Report, p. 152, f. 3.	Hamilton group.	Schoharie.	
lævis	Hall, Report, p. 180, f. 6.	Hamilton group.		
naviformis (3)	Conrad, Journ. Acad. Phil. v. 8, t. 12, f. 11.	Pentamerus limestone.	Schoharie.	Wenlock and Ludlow form.
pectiniformis ...	Conrad, Journ. Acad. Phil. v. 8, t. 12, f. 14; not of Hall, Report, p. 262. *A. orbiculata*, Hall, Report, p. 202, f. 1.	Hamilton group.		
quadrula (4) ...	Conrad, Journ. Acad. Phil. v. 8, t. 13, f. 5; perhaps variety of *A. Boydii*?	Hamilton group.	....	Ludlow form., Westmoreland.
Cypricardia.				
Chemungensis .	Vanuxem, Report, p. 179, f. 2.	Ludlowville shale.	Genesee.	
Microdon.				
bellastriata......	Conrad, Journ. Acad. Phil. v. 8, t. 13, f. 12; Hall, Report, p. 196, f. 2.	Ludlowville shale.	Ovid.	
Posidonia.				
lirata	Conrad, Ann. Report, 1838, p. 116; 1839, p. 62.	Ludlowville shale.	Schoharie.	
Pterinæa.				
? carinata	Conrad, Ann Report, 1838, p. 114; 1839, p. 63; Vanuxem, Report, p. 65, f. 1; Emmons, Report, p. 402, f. 1; not of Goldfuss?	Blue limestone, Trenton limestone, Hudson's River group.	Cincinnati, St. Croix, Toronto, Turin.	
Athyris, M'Coy.				
concentrica ...	*Terebratula* sp. Von Buch, Tereb. p. 103. *Atrypa* sp. Conrad, Ann. Report, 1838, p. 111; 1839, p. 62; Hall, Report, p. 198, f. 5.	Hamilton group, Chemung group.	18-mile Creek, Corning.	Devonian and Carboniferous formations.
lamellosa	*Spirifer* sp. Leveillé, Mém. Soc. Géol. Fr. v. 2, t. 2, f. 21–23.	Hamilton group.	Ovid.	Devonian and Carboniferous formations.

BRACHIOPODA.

Species.	References and Synonyms.	Strata.	Localities.	Found in Europe.
ATRYPA.				
congesta.........	Conrad, Journ. Acad. Phil. v. 8, t. 16, f. 18; Hall, Report, p. 71, f. 2.	Medina sandstone, Tentaculite limestone.	Medina, Schoharie.	
didyma?.........	Hisinger, Leth. Suec. t. 22, f. 7; Sowerby, Sil. Syst. t. 6, f. 4.	Coralline limestone.	Schoharie.	Ludlow form., Ludlow, Gothland.
elongata.........	Conrad, Ann. Report, 1839, p. 65; Vanuxem, Report, p. 123, f. 2; Mather, Report, p. 342, f. 2; Hall, Report, p. 148, f. 2. *Pentamerus elongatus*?, Conrad, Ann. Report, 1838, p. 113; Vanuxem, Report, p. 132, f. 1; Mather, Report, p. 339, f. 1; Hall, Report, App. t. 34, f. 2.	Oriskany sandstone.	Schoharie, Frostburg, P^a^.	
lævis	Vanuxem, Report, p. 120, f. 2; Mather, Report, p. 343, f. 2.	Pentamerus limestone, Delthyris shaly limestone, Upper Pentamerus limestone.	Schoharie.	
limitaris.........	Hall, Report, p. 180, f. 11. *Orthis* sp. Vanuxem, Report, p. 146, f. 3	Marcellus shale.	Le Roy.	
nitida............	Hall, Report, App. t. 13, f. 5.	Niagara shale.	Lockport.	
peculiaris	Vanuxem, Report, p. 123, f. 3; Mather, Report, p. 342, f. 3; Hall, Report, p. 148, f. 3. *A. singularis*, Vanuxem, Report, p. 120, f. 3; Mather, Report, p. 343, f. 3.	Oriskany sandstone.	Schoharie.	
tumida	Dalman; Hisinger, Leth. Suec. t. 22, f. 5. *A. tenuistriata*, Sowerby, Sil. Syst. t. 12. f. 3.	Pentamerus limestone.	....	Wenlock shale, Walsall, &c.
CHONETES.				
carinata.........	*Strophomena* sp. Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 13; not of Conrad, Ann. Report, 1839, p. 64.	Ludlowville shale.	Genesee.	
? elegantula ...	*Strophomena* sp. Hall, Report, p. 72, f. 1.	Hudson's River group, Trenton limestone.	Toronto, Jacksonburg.	
LEPTÆNA.				
alternata	Conrad, Ann. Report, 1838, p. 115; De Verneuil, Russie, t. 14, f. 6. *Strophomena* sp. Emmons, Report, p. 393, f. 3; Hall, Palæont. N. Y. t. 31, f. 1; t. 31 A, f. 1. *L. deltoidea*, De Verneuil, Russie, t. 14, f. 5.	Blue limestone.	Cincinnati.	Lower Silurian, Reval.

Species.	References and Synonyms.	Strata.	Localities.	Found in Europe.
LEPTÆNA (*continued*).				
deltoidea.........	*Strophomena* sp. Conrad, Ann. Report, 1839, p. 64; Emmons, Rep. p. 389, f. 2; Hall, Pal. N. Y. t. 31 A, f. 3; not of De Verneuil, Russie, t. 14, f. 5.	Hudson's River group.	Quebec.	
? demissa (5)...	*Strophomena* sp. Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 14.	Hamilton group.	18-mile Creek.	
depressa (6) ...	Dalman; Hisinger, t. 20, f. 4; Sowerby, Sil. Syst. t. 12, f. 2. *Strophomena* sp. Vanuxem, Report, p. 79, f. 5; Hall, Report, p. 77, f. 5; p. 104, f. 2. *Strophomena rugosa*, Conrad, Ann. Report, 1839, p. 62. *Strophomena undulata*, Hall, Report, p. 175, f. 3. *L. tenuistriata*, Hall, Pal. N. Y. t. 31 A, f. 4.	Blue limestone, Niagara limestone, Rochester shale, Pentamerus limestone, Delthyris shaly limestone, Corniferous limestone.	Cincinnati, Lockport, Genesee Falls, Cedarville, Schoharie, Vienna.	Lower and Upper Silurian, Devonian and Carboniferous formations.
imbrex ?.........	Pander sp., De Verneuil, Russie, t. 15, f. 3; Davidson, Charlesworth's Geol. Journ. v. 1, t. 12, f. 25–28.	Hudson's River group.	Toronto.	Wenlock shale, Walsall; Lower Silurian, St. Petersburg.
sericea	Sowerby, Sil. Syst. t. 19, f. 1; Conrad, Ann. Report, 1840, p. 201; Emmons, Report, p. 115; Hall, Pal. N. Y. t. 31 B, f. 2. *Strophomena* sp. Emmons, Report, p. 394, f. 1; Hall, Report, p. 30. *L. semi-ovalis*, Conrad, Ann. Report, 1838, p. 115; Vanuxem, Report, p. 47.	Hudson's River group, Blue limestone.	Toronto, Cincinnati.	Lower Silurian, *passim*.
transversalis ...	Dalman; Hisinger, Leth. Suec. t. 20, f. 5; Sowerby, Sil. Syst. t. 13, f. 3. *Strophomena* sp. Conrad, Ann. Report, 1840, p. 202; Hall, Report, p. 104, f. 4.	Rochester shale.	Genesee Falls.	Lower Silurian and Wenlock shale.
LINGULA.				
prima............	Conrad; Hall, Palæont. N.Y. t. 1, f. 2	Potsdam sandstone.	Kelsville.	
cuneata	Conrad, Ann. Report, 1839, p. 64; Hall, Report, p. 45, f. 5; p. 52, f. 10.	Medina sandstone.	Medina.	
ORBICULA.				
grandis	Vanuxem, Report, t. 152, f. 4.	Hamilton group.		
minuta	Hall, Report, p. 180, f. 9.	Marcellus shale, Hamilton group.	Le Roy, Avon.	

Species.	References and Synonyms.	Strata.	Localities.	Found in Europe.
ORTHIS.				
carinata (7) ...	*Strophomena* sp. Conrad, Ann. Rep. 1839, p. 64; not of Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 13; not of Hall, Rep. p. 267, f. 1.	Marcellus shale, Hamilton group, Chemung group.	Le Roy; Moscow, Northville; Orwigsburg, P[a].	
carinata	Hall, Report, p. 267, f. 1; not *Strophomena carinata* of Conrad.	Chemung group.	Chemung, Painted Post.	
eximia ?	Eichwald; De Verneuil, Russie, t. 11, f. 2.	Ludlowville shale.	Genesee.	Carboniferous, Russia.
elegantula	Hisinger, Leth. Suec. t. 20, f. 13; De Verneuil, Russie, v. 2, p. 188. *O. canalis*, Sowerby, Sil. Syst. t. 13, f. 12 A; Conrad, Ann. Report, 1840, p. 202; Emmons, Report, p. 115; Hall, Report, p. 105, f. 6.	Rochester shale, Niagara shale.	Genesee Falls, Lockport.	Wenlock form., Dudley, &c.
fissicosta	Hall, Palæont. N.Y. t. 32, f. 7.	Blue limestone.	Cincinnati.	
hybrida	Sowerby, Sil. Syst. t. 13, f. 11; Conrad, Ann. Report, 1840, p. 202; Vanuxem, Report, p. 94; Hall, Report, p. 105, f. 7. *O. lenticularis*, Vanuxem, Report, p. 139, f. 4. *O. lentiformis*, Hall, Report, p. 175, f. 4.	Delthyris shaly limestone.	Schoharie.	Wenlock form., Dudley, &c.
Michelini	Leveillé, Mém. Soc. Géol Fr v. 2, t. 2, f. 14–17. *O. filiaria*, Phil. York. v. 2, t. 11, f. 3.	Hamilton group.	Ovid.	Carboniferous form.
nitens	Vanuxem, Report, p. 90.	Oneida conglomerate.	Wayne C°.	
orbicularis	Sowerby, Sil. Syst. t. 5, f. 16.	Delthyris shaly limestone.	Schoharie.	Wenlock and Ludlow forms.
opercularis......	De Verneuil, Russie, v. 2, t. 13, f. 2.	Hamilton group.	18-mile Creek.	Devonian form., Russia.
parva (8)	Pander sp., De Verneuil, Russie, t. 13, f. 3. *O. striatula*, Emmons, Report, p. 394, f. 3.	Trenton limestone, Blue limestone.	Jacksonburg, Cincinnati.	Lower Silurian, common.
resupinata	Martin sp. *Terebratula* sp. Sow. Min. Con. t. 325; Vanuxem, Report, p. 122; Hall, Report, p. 215, f. 2.	Upper Pentamerus limestone, Corniferous limestone.	Schoharie, Onondaga.	Devonian and Carboniferous formations.
sinuata	Hall, Palæont. N.Y. t. 32 B, f. 2.	Blue limestone.	Cincinnati, Richmond, &c.	
testudinaria ...	Dalman; Hisinger; Sowerby, Sil. Syst. t. 20, f. 9; Conrad, Ann. Report, 1839, p. 63; Emmons, Report, p. 115 and p. 404, f. 4; Vanuxem, Report, p. 47 and p. 56; Hall, Report, p. 30; Hall, Palæont. N. Y. t. 32, f. 1.	Hudson's River group, Blue limestone.	Quebec, Montreal, Cincinnati.	Lower Silurian.

Species.	References and Synonyms.	Strata.	Localities.	Found in Europe.
PENTAMERUS.				
galeatus (9) ...	*Atrypa* sp. Dalman; Hisinger, Leth. Suec. t. 22, f. 1; Sowerby, Sil. Syst. t. 8, f. 10; t. 12, f. 4; Vanuxem, Report, p. 117, f. 1; Mather, Report, p. 346, f. 1; Hall, Report, App. t. 27, f. 1.	Pentameruslimestone, Delthyris shaly limestone.	Cedarville, Schoharie.	Wenlock and Ludlow formations.
lævis	Sowerby, Sil. Syst. t. 19, f. 9. *P. oblongus*, Hall, Report, p. 71.	Cliff limestone.	Ohio.	Lower Silurian form.
oblongus	Sowerby, Sil. Syst. t. 19, f. 10; Conrad, Ann. Report, 1840, p. 201; Vanuxem, Report, p. 88; Hall, Report, p. 70, f. 1–5.	Clinton group.	Genesee Falls.	Lower Silurian form.
PRODUCTUS.				
fragaria?	*Leptæna* sp. Sowerby, Geol. Tr. 2 ser. v. 5, t. 56, f. 5, 6; Phillips, Pal. Foss. t. 25, f. 100.	Chemung group.	Near Bath.	Devonian form., Devonshire.
plicatilis?	Sowerby, Min. Con. t. 459, f. 2.	Chemung group.	Near Tioga.	Carboniferous form., *passim*.
scabriculus? ...	Sowerby, Min. Con. t. 69, f. 1. *Strophomena lachrymosa*, Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 9.	Hamilton group.	....	Devonian and Carboniferous formations.
SPIRIFER.				
acanthota	*Delthyris* sp. Hall, Report, p. 270, f. 2. *Delthyris inermis*, Hall, Report, p. 270, f. 4. *Delthyris cuspidata*, Hall, Report, p. 270, f. 1.	Chemung group.	Chemung.	
aperturatus ...	Bronn sp. Leth. Geog. t. 2, f. 13.	Chemung group.	Alleghany C°.	Devonian form., Eifel.
arenosus	*Delthyris* sp. Conrad, Ann. Report, 1839, p. 65; Hall, Report, p. 148, f. 1; p. 149, f. 5. *Delthyris arenaria*, Vanuxem, Report, p. 123, f. 1; p. 124, f. 5; Mather, Report, p. 342, f. 1 & 5. *Spirifer superbus*, Eichwald; De Verneuil, Russie, v. 2, t. 5, f. 4.	Oriskany sandstone.	Schoharie.	The Oural.
? biloba	Linnæus sp. *Delthyris cardiospermiformis*, Dalman; Hisinger, Leth. Suec. t. 21, f. 9. *Spirifer sinuatus*, Sowerby, Sil. Syst. t. 13, f. 10; Hall, Report, p. 105, f. 8. *Delthyris varica*, Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 20.	Niagara group.	Wolcot, &c.	Wenlock form.

Species.	References and Synonyms.	Strata.	Localities.	Found in Europe
SPIRIFER (*continued*).				
biforatus (10)...	Schlotheim sp. De Verneuil, Russie, v. 2, p. 135. *Delthyris* sp. Hall, Palæont. N. Y. p. 132; var. *Lynx*, Eichwald; De Verneuil, Russie, v. 2, t. 3, f. 3 & 4; Hall, Pal. N. Y. t. 32 D, f. 1; var. *Chama*, Eichwald; De Verneuil, Russie, v. 2, t. 5, f. 1; Hall, Palæont. N. Y. t. 32 D, f. 1 R. *Delthyris acutilirata*, Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 15.	Blue limestone.	Cincinnati, Richmond, I[a], &c.	Lower Silurian formation, St. Petersburg, &c.
congestus	*Delthyris* sp. Hall, Report, p. 207, f. 2.	Hamilton group, Chemung group.	Ovid, Ludlowville, Oneonta.	
crispus	*Delthyris* sp. Dalman; Hisinger, Leth. Suec. t. 21, f. 5; Sow. Sil. Syst. t. 12, f. 8. *Delthyris staminea*, Hall, Report, p. 105, f. 3.	Niagara shale.	Lockport.	Wenlock form., *passim.*
decemplicatus..	*Delthyris* sp. Hall, Report, p. 105, f. 4.	Niagara shale.	Lockport.	
granuliferus ...	*Delthyris* sp. Hall, Report, p. 207, f. 1.	Hamilton group.	18-mile Creek.	
lævis	*Delthyris* sp. Hall, Report, p. 245, f. 1.	Portage group.	Ithaca.	
macronotus (11)	*Delthyris* sp. Hall, Report, p. 207, f. 3. *S. cuspidatus*, Koninck, Foss. Belg. t. 14, f. 1; Phillips, Pal. Foss. t. 29, f. 124 *b*.	Hamilton group.	Ovid, 18-mile Creek.	Devonian and Carboniferous formations.
macropleura ...	*Delthyris* sp. Conrad, Ann. Report, 1840, p. 206; Vanuxem, Report, p. 120, f. 1; Mather, Report, p. 343, f. 1.	Delthyris shaly limestone.	Schoharie.	
medialis	*Delthyris* sp. Hall, Report, p. 288, f. 8.	Ludlowville shale.	Ovid.	
mesastrialis ...	*Delthyris* sp. Hall, Report, p. 269, f. 1.	Chemung group.	Orwigsburg, P[a].	
mucronatus ...	*Delthyris* sp. Conrad, Ann. Rep. 1841, p. 54; Van. Rep. p. 150, f. 3; Hall, Rep. p. 198, f. 2 & 3; p. 205, f. 3; p. 270, f. 3.	Hamilton group, Chemung group.	18-mile Creek, Phillipsburg, Corning, Tioga.	
Niagarensis ...	*Delthyris* sp. Conrad, Journ. Acad. Phil. v. 8, p. 261; Hall, Report, p. 105, f. 1.	Niagara shale.	Lockport.	
plicatus (12) ...	*Orthis* sp. Vanuxem, Rep. p. 112, f. 1. *Delthyris* sp. Hall, Report, p. 142, f. 1. *S. octoplicatus*, Sowerby, Sil. Syst. t. 12, f. 7; not of Min. Con.	Tentaculite limestone, Pentamerus limestone.	Schoharie.	Wenlock and Ludlow formations.

Species.	References and Synonyms.	Strata.	Localities.	Found in Europe.
SPIRIFER (*continued*).				
radiatus	Sowerby, Sil. Syst. t. 12, f. 6. *Delthyris* sp. Vanuxem, Rep. p. 89; Hall, Rep. p. 75; p. 105, f. 2.	Rochester shale.	Genesee Falls.	Wenlock form., Dudley, &c.
undulatus	*Delthyris* sp. Conrad, Ann. Report, 1838, p. 110; Vanuxem, Report, p. 132, f. 3; Mather, Report, p. 339, f. 3; Hall, Report, App. t. 34, f. 3; not of Sowerby, Min. Con.	Delthyris shaly limestone.	Schoharie.	
Urii	Fleming, Brit. Anim. p. 376. *S. unguiculus*, Phillips, Pal. Foss. t. 28, f. 119. *Orthis unguiculus*, Hall, Report, p. 267, f. 5. *Orthis nucleus*, Hall, Report, p. 180, f. 8. *Orthis umbonata*, Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 4; Vanuxem, Report, p. 154.	Oriskany sandstone, Marcellus shale, Hamilton group, Ludlowville shale, Chemung group.	Schoharie, Le Roy, Seneca Lake, Genesee, Painted Post, Corning.	Devonian and Carboniferous formations.
zigzag............	*Delthyris* sp. Hall, Report, p. 200, f. 5.	Hamilton group, Chemung group.	Moscow, Phillipsburg, Corning.	
STROPHOMENA (13).				
arcto-striata ...	Hall, Report, p. 266, f. 3.	Hamilton group, Chemung group.	18-mile Creek, near Tioga.	
bifurcata	Hall, Report, p. 266, f. 2.	Chemung group.	Corning.	
Chemungensis .	Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 12.	Chemung group.	Phillipsburg, Mansfield.	
grandis	*Orthis* sp. Sowerby, Sil. Syst. t. 19, f. 6; t. 20, f. 12, 13. *Orthis leptænoides*?, Emmons, Report, p. 396, f. 1.	Trenton limestone, Blue limestone, Rochester shale.	Jacksonburg, Cincinnati, Genesee Falls.	Lower Silurian form., Wenlock shale.
pecten	Linnæus sp. *Orthis* sp. Hisinger, Leth. Suec. t. 20, f. 6; Davidson, Charlesworth's Geol. Journ. v. 1, t. 13, f. 18–23. *S. subplana*, Conrad, Journ. Acad. Phil. t. 8, p. 258; Hall, Report, p. 104, f. 1.	Pentamerus limestone, Delthyris shaly limestone.	Schoharie.	Lower Silurian and Wenlock formations.
planumbona ...	*Leptæna* sp. Hall, Palæont. N. Y. t. 31 *b*, f. 4.	Blue limestone.	Cincinnati, Richmond.	
radiata	Conrad; Vanuxem, Report, p. 122, f. 6; Mather, Report, p. 343, f. 6; Hall, Report, App. t. 28, f. 2. *S. punctilifera*, Conrad; Vanuxem, Report, p. 122, f. 5; Mather, Report, p. 343, f. 5; Hall, Report, App. t. 28, f. 1.	Pentamerus limestone, Upper Pentamerus limestone.	Schoharie.	

Species.	References and Synonyms.	Strata.	Localities.	Found in Europe.
STROPHOMENA (*continued*).				
Sharpei	De Verneuil, Russie, v. 2, p. 181.	Hamilton group.	Moscow.	Carboniferous limestone, Kendal, &c.
striata	Hall, Report, p. 104. f. 3.	Tentaculite limestone, Pentamerus limestone, Upper Pentamerus limestone.	Schoharie.	
syrtalis	Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 1.	Hamilton group.		
umbraculum ?...	*Orthis* sp. Von Buch, Delth. &c. t. 1, f. 5 & 6.	Chemung group.	Tioga.	Devonian form., Eifel.
varistriata	Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 6.	Tentaculite limestone, Pentamerus limestone.	Schoharie.	
TEREBRATULA, subgenus *Hypothyris*.				
aspera (14) ...	Schlotheim, Pet. t. 18, f. 3. *Atrypa* sp. Dalman; Hisinger; Phillips, Pal. Foss. t. 33, f. 144; Conrad, Ann. Report, 1839, p. 62. *Atrypa squamosa*, Sowerby, Geol. Trans. 2 ser. v. 5, t. 57, f. 1. *Atrypa dumosa*, Hall, Report, p. 271, f. 1. *Atrypa spinosa*, Hall, Report, p. 200, f. 1, 2.	Hamilton group, Chemung group.	18-mile Creek, Moscow, Chemung Creek.	Devonian form., Devonshire, Eifel, &c.
bidentata	Hisinger, Leth. Suec. t. 23, f. 7; Sowerby, Sil. Syst. t. 12, f. 13 *a*. *Atrypa dentata*, Hall, Palæont. N. Y. t. 33, f. 14.	Blue limestone.	Cincinnati, Richmond, I[a].	Lower Silurian formation.
borealis	Schlotheim. *T. lacunosa*, Sow. Sil. Syst. t. 5, f. 19. *Atrypa lacunosa*, Vanuxem, Report, p. 117, f. 3; Mather, Report, p. 346, f. 3; Hall, Rep. App. t. 27, f. 3. *Atrypa laticosta*, Hall, Rep. App. t. 66, f. 1 & 2. *Atrypa eximia*, Hall, Rep. App. t. 66, f. 4.	Upper Pentamerus limestone, Chemung group.	Schoharie, Tioga.	Wenlock, Ludlow and Devonian formations.
capax	*Atrypa* sp. Conrad, Journ. Acad. Phil. v. 8, t. 14, f. 20. *Atrypa increbescens*, Hall, Palæont. N. Y. t. 33, f. 13.	Blue limestone.	Cincinnati; Madison, I[a]; Richmond, Ind[a].	
cuneata	Dalman; Hisinger, Leth. Suec. t. 23, f. 5; Sowerby, Sil. Syst. t. 12, f. 13. *Atrypa* sp. Hall, Report, App. t. 13, f. 2.	Niagara shale.	Lockport.	Wenlock form.

Species.	References and Synonyms.	Strata.	Localities.	Found in Europe.
TEREBRATULA, subgenus *Hypothyris* (*continued*).				
hystrix	*Atrypa* sp. Hall, Report, p. 271, f. 3.	Chemung group.	Corning, Tioga.	
modesta.........	Hall, Palæont. N. Y. t. 33, f. 15.	Blue limestone.	Cincinnati.	
nucula	Sowerby, Sil. Syst. t. 5, f. 20.	Hamilton group, Chemung group.	Oneonta.	Ludlow form., *passim*.
reticularis	Linnæus sp. Hisinger sp. *T. affinis*, Sowerby, Min. Con. t. 324, f. 2. *Atrypa affinis*, Sow. Sil. Syst. t. 6, f. 5; Vanuxem, Report, p. 88, f. 12; Hall, Report, p. 77, f. 8; p. 108, f. 37; p. 215, f. 4. *Atrypa prisca*, Mather, Report, p. 337, f. 5; Vanuxem, Report, p. 88, f. 12; p. 139, f. 5; Hall, Report, p. 175, f. 5; p. 198, f. 4. *Atrypa tribulis*, Hall, Report, p. 271, f. 3. *Hipparionyx consimilaris* ?, Vanuxem, Report, p. 132, f. 2; Mather, Report, p. 339, f. 2; Hall, Report, App. t. 34, f. 2.	Blue limestone ? Niagara shale, Rochester shale, Pentamerus limestone, Scutella limestone, Oriskany sandstone, Corniferous limestone, Hamilton group, Chemung group.	Cincinnati ? Lockport, Genesee Falls, Cedarville, Schoharie, Schoharie, Williamsville, Moscow, &c., near Bath.	Wenlock, Ludlow and Devonian formations.
Stricklandi......	Sowerby, Sil. Syst. t. 13, f. 19.	Pentamerus limestone, Delthyris shaly limestone, Upper Pentamerus limestone, Scutella limestone.	Schoharie.	Wenlock formation.
unguiformis (15)	*Atrypa* sp. Conrad; Hall, Report, p. 149, f. 1. *Hipparionyx proximus*, Vanuxem, Report, p. 124, f. 4; Mather, Report, p. 342, f. 4.	Oriskany sandstone.	Schoharie.	
TREMATIS, *Sharpe*.				
terminalis	*Orbicula* sp. Emmons, Report, p. 395, f. 4; Hall, Palæont. N.Y. t. 30, f. 11.	Blue limestone.	Cincinnati.	

GASTEROPODA.

NATICA.				
lineata	*Platyostoma* sp. Conrad, Journ. Acad. Phil. v. 8, t. 17, f. 7.	Corniferous limestone.	Williamsville.	

HETEROPODA.

Species.	References and Synonyms.	Strata.	Localities.	Found in Europe.
BELLEROPHON.				
bilobatus	Sowerby, Sil. Syst. t. 19, f. 13; Emmons, Report, p. 392, f. 6; Hall, Palæont. N. Y. t. 40, f. 3.	Blue limestone.	Cincinnati.	Lower Silurian formation.
profundus	*Euomphalus* sp. Conrad, Ann. Report, 1839, p. 62; Vanuxem, Report, p. 117, f. 2; Mather, Report, p. 346, f. 2; Hall, Report, App. t. 27, f. 2.	Pentamerus limestone.	Schoharie.	
PORCELLIA.				
ornata (16) ...	*Cyrtolites* sp. Conrad, Ann. Report, 1838, p. 118; Emmons, Report, p. 402, f. 2.	Hudson's River group, Blue limestone.	Salmon River, Cincinnati.	Lower Silurian form., near Capel Cerrig.
CEPHALOPODA.				
ORTHOCERAS.				
articulatum ...	Sowerby, Sil. Syst. t. 5, f. 31.	Hamilton group.	....	Ludlow form.

Notes on some of the species contained in the preceding list.

(1) AVICULA.—The palæozoic species of this genus cannot be determined easily: their horny shells have suffered much from a scaling off during decay, which has frequently altered their outline and thus added to the difficulty caused by their original variations of form: moreover the rocks in which they are most common do not admit of their perfect preservation. From want of attention to these circumstances the species have been extravagantly multiplied. Mr. Conrad has described as species many which it is impossible to distinguish, and in some instances has increased the number by describing separately each valve of the same species*. It would require a larger collection of specimens than is at my command to enable us to limit all the species properly. The following species are found both in England and in America, and have not yet been published here:—

(2) AVICULA BOYDII, Conrad.—"Subrhomboidal, compressed, lower valve with numerous radii, disposed to be interrupted by concentric lines, which are fimbriated, or have numerous angular indentations; anterior wing short, sinuous, truncated; posterior wing ample; posterior extremity of the valves acutely rounded†."

This species has some resemblance to *A. rectangularis*‡, from which it differs in a less development of the anterior part of the shell and in being more oblique; moreover it is a true *Avicula*, and the *A. rectangularis* is probably of the genus *Pterinæa*. Found abun-

* Journal of the Acad. Nat. Sciences of Philadelphia, vol. viii.
† Conrad, Journ. Acad. Nat. Sci. Phil. vol. viii. p. 237, and t. 12. f. 4.
‡ Sil. Syst. t. 3. f. 2.

dantly in the Hamilton group of New York and in the Ludlow formation of Westmoreland.

(3) Avicula naviformis, Conrad.—"Lower valve subrhomboidal, slightly ventricose, obscurely radiated; summit of umbo much above the cardinal line; anterior wing triangular; posterior wing elongated; angulated at the extremity, which extends beyond the line of the posterior extremity of the valve; umbonal slope rounded, not suddenly depressed, except on the umbo*."

Perhaps this shell may be only a variety of *A. retroflexa* of Hisinger, to which it is closely allied. It is one of the commonest forms of this genus in the Ludlow rocks of Westmoreland, and is found in New York in the Pentamerus limestone at Schoharie.

(4) Avicula quadrula, Conrad.—"Subquadrate, length and breadth equal, compressed; lower valve plano-convex, with distinct radii of equal size crossed by concentric lines; posterior wing rather shorter than the width of the shell; anterior wing triangular, beneath which the margin is direct before rounding to the base†."

This is closely allied to *A. Boydii*, but is thinner and flatter: perhaps they may be only varieties of one species. *A. emacerata*‡ cannot be separated from this.

From the Hamilton group of New York and Ludlow formation of Westmoreland.

(5) Leptæna demissa, Conrad sp.—"Length and width nearly equal; inferior valve ventricose; superior valve deeply concave; radii sharp, prominent, subtuberculated, much more prominent on the upper than on the lower half of the valves, where they greatly bifurcate and become fine and very numerous; umbo convex, the summit slightly elevated; hinge-angles slightly salient§."

The specimens of this shell are not perfect, but as far as can be seen they have no trace of any foramen whatever. The convex or dorsal valve has a rather broad hinge-area strongly marked by lines parallel to the hinge which continue without interruption along the whole area: the ventral valve has a narrower area which is also continuous. Both areas are also striated in a direction perpendicular to the hinge.

The absence of any foramen at the hinge is very rare among the Brachiopoda and deserves particular notice. It will probably be found to indicate a distinct genus, as it must be accompanied with a peculiar internal arrangement. Until this can be ascertained this species may remain in *Leptæna*, the genus to which it is most nearly related.

(6) *Leptæna depressa*. Many well-preserved specimens of this shell, from the blue limestone and the Niagara shale, have a circular foramen in the beak of the dorsal valve, just above the point of the triangular deltidium. I find a similar foramen in some young specimens of the same species from the Wenlock shale of this country: and on several old specimens a trace of such an opening may be seen on the outside

* Conrad, Journ. Acad. Nat. Sci. Phil. vol. viii. p. 240, and t. 12. f. 11.
† Conrad, loc. cit. p. 243, and t. 13. f. 5.
‡ Conrad, loc. cit. t. 12. f. 15.
§ Conrad, loc. cit. p. 258.

of the shell, which has been completely closed up by fresh layers of shelly matter deposited within the shell. The foramen attains a very different size in different individuals, and is larger in the American specimens than in any which I have seen here. Probably in the young state the shells of this species were always attached by a ligament passing through this foramen, and at a later stage of growth the connection was broken and the opening closed by the deposition of new layers within the shell; the period at which this change took place depending on local or accidental circumstances. Mr. King has observed a similar foramen in the closely allied species *L. analoga** ; and M. de Verneuil has pointed it out in the American *L. alternata*†. It also occurs in *L. scabrosa* of Davidson, and may sometimes be seen in our *L. euglypha*.

A similar opening will probably be found, on farther examination, throughout the whole genus *Leptæna*; and it may be conjectured from the analogy of their structure, that all the Brachiopoda which have in their adult state a triangular deltidium covering up a slit in the hinge-area, had, when young, an open foramen at the apex of the dorsal valve admitting the passage of a ligament for the attachment of the shell. We should thus explain the cause of the break of continuity of the hinge-area in *Leptæna, Chonetes, Strophomena* and *Thecidia*, and we should find the deltidium in these genera analogous to that of *Terebratula*, both in its position below the foramen and in its use, which is to circumscribe the opening of the foramen to the space required for the passage of the ligament. Should this conjecture be verified, we shall be able to show some mode of attachment in some stage of growth of nearly all the Brachiopoda, except those belonging to the genus *Productus*, and perhaps *Calceola*.

(7) ORTHIS CARINATA, Conrad sp.—Mr. Conrad has described this species in the Annual Report for 1839, p. 64, under the name of *Strophomena carinata*, as follows:—"Shell suborbicular, with from sixteen to eighteen angular radiating ribs; superior valve with a sinus in the middle; inferior valve angulated in the middle, slightly flattened on the sides; base prominent and subangulated in the middle; basal margin sinuous. Length three-fourths of an inch‡."

The same name has since been applied to another species by the same author without any explanation of the circumstance, and Mr. Hall has added an *Orthis carinata*, so that much confusion arises between them.

The original species presents an unusual combination of characters connecting closely *Orthis* with *Strophomena* and *Leptæna*: it has the open triangular foramen, which helps to define the genus *Orthis*, accompanied with broad simple plaits, such as are common in the species of *Orthis* from the Lower Silurian formation; but with these characters it has the concavo-convex form of *Leptæna*, with the dorsal valve convex and the ventral valve concave. The following may serve for a description:—

* Annals of Natural History for July 1846, vol. xviii. p. 38.
† Russie, vol. ii. p. 225, and pl. 14. f. 6.
‡ Conrad, Annual Report of the Geological Survey of New York, 1839, p. 64.

Orthis carinata; shell transversely semi-oval, concavo-convex; hinge-line hardly equal to the width of the shell; hinge-area, on the dorsal valve narrow and slightly triangular, with a broad open triangular foramen; on the ventral valve very narrow. Dorsal valve convex, with the two sides sloping away from the middle rib, which is larger than the rest, giving it a roof-shaped or keeled form; covered by strong simple plaits, separated by rounded hollows twice the width of the plaits; plaits narrow and rounded at top, diminishing gradually in size from the middle keel towards the hinge-margin, near thirty in all. Ventral valve concave with broad rounded plaits, separated by narrow deep furrows, of which the middle one is the largest and deepest.

The surface of both valves is covered by minute, irregular, concentric wrinkles left by the growth of the shell: in old specimens these wrinkles form a rough scaly margin to the shell.

Very common in the beds of the Hamilton group of New York.

In general form this shell resembles *Orthis semicircularis* of Eichwald, as figured by M. de Verneuil*; but in its plication it is more like *O. calligramma*. It is however very distinct, and cannot be confounded with any other species.

(8) *Orthis parva* has been confounded with the *O. elegantula* by all English geologists under the name of *O. canalis*: the differences between them have been clearly pointed out by M. de Verneuil†.

In *O. elegantula* a narrow stripe down the middle of each valve is occupied by finer striæ than those which cover the rest of the shell: by this character it is easily recognized; besides this distinction it has the dorsal valve deeper than the other species. *O. parva* has its striæ somewhat fasciculated, those striæ which have had a common origin running together in a sort of cluster. *O. argentea* of Hisinger has this last character strongly marked, and is probably the young of the same species. *O. parva* and *elegantula* are found in different formations, both in this country, in Russia and in the United States; the former belonging to the Lower Silurian beds, the latter to the Wenlock series.

(9) Pentamerus galeatus.—The American specimens do not exactly agree with any of the European varieties of this most variable species, and yet they present no characters which justify our separating them as a distinct species. The principal difference consists in a greater flatness of form, caused in part by the slighter elevation of the ventral valve, and partly by the lowness of the mesial ridge on the dorsal valve. The ribs are nearly equal in size, about fifteen in number, and commence near the beak, so as to cover the greater part of the shell: there are also specimens on which the ribs are very faint, and the shell is nearly smooth. The interior characters agree with those of our Upper Silurian specimens: the two plates which enclose the middle chamber of the ventral valve are entirely detached along their bases, and only meet at the beak; in this respect they differ from a smaller species found in the Eifel, in which the two plates are united together along the whole of their base, so as to ap-

* Russie, vol. ii. t. 13. f. 12. † *Ib.* vol. ii. p. 188.

pear on the worn outside of the shell like a single plate; while in the true *P. galeatus* two plates are seen on the worn surface of the shell forming a fork at the beak.

The small Eifel species has not yet received a name, having been confounded with the *P. galeatus*. M. de Verneuil has unfortunately taken an Eifel specimen, with the plates of the ventral valve united, as the type of the Silurian species*, although the Russian specimen figured at pl. 8. f. 3 *c*. shows the two ventral plates quite distinct; and from this circumstance he has confounded together the characters of the two species in describing *P. galeatus*.

Both species here alluded to are found in the Eifel, but only the true *P. galeatus* has been found in the Silurian rocks of Europe or the United States.

(10) Spirifer biforatus.—Few shells present so many variations of form as this elegant species; yet there are certain characters common to all its varieties which give them a marked general resemblance, and should prevent our subdividing the species, or confounding it with any other. The principal variations are well-described, and its more important characters shown in Mr. Hall's 'Palæontology,' p. 132, &c.

Mr. Hall has pointed out that in the young state there are invariably two plaits on the mesial fold of the ventral valve, and one plait raised in the middle of the deep sinus of the dorsal valve. I can confirm the accuracy of this remark after examining above a hundred specimens. Each of these plaits may either continue simple, or bifurcate once or twice, forming the three principal varieties which have been described. 1st, where the plaits are simple, the shell is the *Spirifer chama*, Eichwald, with one plait in the sinus, and two plaits on the mesial fold. This is a rare form of the full-grown shell in the United States.

2. *Spirifer lynx* has each of the two original plaits on the mesial lobe increased to two by bifurcation, making four plaits in all; while to correspond with these, the original plait in the sinus has branched into three. This is the common American variety, which varies almost indefinitely in the number of the side plaits and in the length of the hinge-line. The most remarkable variety is that which Conrad has named *Delthyris acutilirata*†, which has sometimes twenty plaits on each wing.

3. *Spirifer biforatus*, having six plaits on the mesial fold and five in the sinus, arising from a double bifurcation of the original plaits. This form is only seen in very old shells, and is rare everywhere.

The side plaits, although varying in number from four to twenty, are usually simple: if a bifurcation is seen it is a rare accident, probably arising from injury to the shell during its growth, and is as common in the forms with few as with many ribs. It sometimes happens that one of the plaits on the mesial fold bifurcates while the other remains entire, or that one bifurcates once and the other twice,

* Russie, vol. ii. p. 121.

† Journ. Acad. Nat. Sciences of Phil. vol. viii. t. 14. f. 15.

producing either three or five plaits on the elevation; but notwithstanding this irregularity, the division of the mesial fold into two equal or nearly equal parts by a sharp deep sinus is never lost, and the additional plait remains smaller than its fellows.

M. de Verneuil has united to the *S. biforatus* a species which appears to differ from it essentially in the points just described; the *S. dentatus** has three equal plaits on the mesial fold and two equal plaits in the sinus: it thus wants the most important and constant character of the American species, the division of the mesial lobe into two equal parts by a deep sinus, and it must in consequence be regarded as a distinct species; in fact M. de Verneuil himself seems to have some doubts of the propriety of uniting them†.

The shell given by Mr. M'Coy for *Spirifer lynx*‡ is figured with three equal plaits on the mesial fold, and must therefore be considered as the *S. dentatus*.

The *S. terebratuliformis* of M'Coy§, which has been given in Professor Sedgwick's lists of Coniston and Welsh species under the manuscript name of *S. crucialis* without description, is closely allied to the *S. biforatus*, but is easily distinguished; it has an elevated plait along the middle of the mesial fold, forming a striking contrast to the deep sinus which occurs in the same situation in the *S. biforatus*: this plait is accompanied in *S. terebratuliformis* by a pair of lateral plaits which usually bifurcate while the central one remains simple, so that the mesial fold has either three or five plaits. Besides this difference, the *S. terebratuliformis* has its plaits on the wings bifurcated.

I have not been able to find any sufficient evidence of *S. biforatus* having been found in this country. Professor Sedgwick quotes it from Pwllheli in Carnarvonshire‖, but I have learnt that the shell there referred to is the *S. terebratuliformis*. Mr. M'Coy states that the *S. lynx* is common in the county of Kildare, but his figure as above explained appears to represent the *S. dentatus*: the latter species has also been found in the Wenlock limestone of Dudley, &c., where it has been called *S. lynx*.

(11) Spirifer macronotus, Hall sp.—Mr. James Hall has published a species of *Spirifer* under this specific name, which "is readily distinguished by the broad area, the narrow aperture, and the numerous small plain ribs and strong concentric laminæ of growth¶." We have the same species in Europe, but have confounded it with the *S. cuspidatus*, from which it is easily distinguished by a greater number of ribs and a less elevated hinge-area terminating in a more obtuse angle; moreover it never reaches the size of *S. cuspidatus*. In old and well-preserved specimens of *S. macronotus* about thirty ribs may be counted on each side of the mesial line, but in younger specimens from fifteen to twenty only can be distinguished (while the oldest specimens of *S. cuspidatus* have only about sixteen ribs on

* Russie, t. 3. f. 5.
† Russie, vol. ii. p. 138.
‡ Sil. Foss. t. 3. f. 25.
§ Sil. Foss. t. 3. f. 26.
‖ Journ. Geol. Soc. vol. iii. p. 149.
¶ Hall, Report, pp. 206, 207, f. 3.

each side); the ribs are simple but rather irregular; they decrease in size towards the extremity of the wing, at first slowly, so that the twelve or fifteen ribs on each side of the middle are nearly equal; beyond those they decrease rapidly and the exterior ribs are very small and indistinct. The mesial fold is plain and produced in front, the sinus is also plain. The concentric lines of growth are strongly marked and very irregular and give a coarse appearance to the shell. The hinge-area is large and triangular and marked irregularly with strong lines parallel to the hinge; the angle at the apex varies from 100° to 110° (in *S. cuspidatus* this angle is about 80°), the apex bends over backwards very slightly. The foramen occupies about a fourth of the length of the hinge-area in English specimens, but only about one-fifth in those from New York.

Breadth at the hinge $2\frac{1}{4}$ inches; length of the dorsal valve $1\frac{1}{4}$ inch; length of the ventral valve 1 inch; height of hinge-area 1 inch.

Found at Moscow and on the shores of Seneca Lake in the state of New York in rocks of the Hamilton group. In England we find this species in the lower beds of the mountain limestone at Kendal, and at Barton and S. Petherwin in the Devonian system.

The small shell figured by Mr. Phillips as *S. cuspidatus*, f. 124 β. of the 'Palæozoic Fossils of Devon and Cornwall,' appears to belong to the *S. macronotus*, with which it agrees in proportion. I refer also to the same species M. de Koninck's *S. cuspidatus* from the mountain limestone of Tournay, pl. 14. f. 1, 'Fossiles de Belgique': the general form and size of the shell and the obtuse angle at the apex of the hinge-area correspond with *S. macronotus*, from which it only differs in having fewer ribs, less strongly marked concentric lines, and a neater and more regular aspect.

(12) SPIRIFER PLICATUS.—Two species have been confounded in this country under the name of *S. octo-plicatus*; the original one, figured in the 'Mineral Conchology,' t. 562. f. 4, is from the carboniferous limestone; this must of course retain the name: the other, from the Wenlock limestone of Dudley, figured in the 'Silurian System,' t. 12. f. 7, requires another specific name.

The latter species is common in the limestone of the Wenlock period in the state of New York, where it has been published by Mr. Vanuxem under the name of *Orthis plicatus*, which has been corrected by Mr. Hall to *Delthyris plicatus*. Under these circumstances we cannot hesitate to adopt the specific name of *plicatus* for our Silurian species, which may be described as follows:—

Spirifer plicatus; globose, with a produced and incurved beak; from four to six simple, rounded ribs on each side of the mesial fold, which is broad, flattened and divided by a slight longitudinal furrow or depression; mesial sinus broad and rounded. Surface entirely covered with fine concentric undulating laminæ. Hinge-line hardly equal to the width of the shell. Hinge-area large and triangular.

Width $\frac{5}{8}$ths of an inch; length of dorsal valve $\frac{5}{8}$ths of an inch; of ventral valve $\frac{3}{8}$ths of an inch.

Found in England in the Wenlock limestone at Dudley, Wenlock, Woolhope, &c., and in the Ludlow formation near Kendal. Found in New York in the Tentaculite limestone, and in the Pentamerus limestone at Schoharie, &c.

(13) Strophomena.—Most of the American geologists have included in this genus all the species usually placed in the genus *Leptæna*, and such species of *Orthis* as are related to the *Leptænæ*. By this arrangement they have left a natural group of shells in the genus *Orthis*, but have created a heterogeneous assemblage in *Strophomena*. European writers have usually run into the opposite difficulty, for in defining *Leptæna* neatly, they have thrown into *Orthis* species variously characterized, many of which do not agree with any definition of the genus. Both difficulties may be avoided by dividing into three genera the species hitherto included in *Orthis* and *Leptæna*, retaining each of those genera as most strictly defined, and throwing into the third genus the intermediate species which have been placed sometimes in one, sometimes in the other of those groups. For this third genus we do not require a new name, as *Strophomena* was originally instituted by Rafinesque for one of the species of this intermediate group.

Orthis is defined by Dalman and Hisinger as having "margo cardinalis rectilineus, latus, foramine deltoideo sub nate valvæ majoris. Valva major dentibus duobus subcardinalibus internis, longitudinalibus, compressis." These characters describe the genus exactly as I wish to see it limited, excluding all the species which have the foramen covered by a deltidium, as in *O. umbraculum* and its allies. All Dalman's species agree with this definition except his *O. pecten*, and perhaps *O. striatella*, which have the foramen closed.

M. de Verneuil in his excellent account of the Russian fossils has added, as a distinguishing character, that in *Orthis* the ventral valve is convex and does not follow the curve of the dorsal valve, while in *Leptæna* the two valves have a similar curvature and are, as it were, parallel, the ventral valve being concave (Russie, vol. ii. p. 41). But M. de Verneuil has not adhered to these characters in separating the species of the two genera, as in the greater part of his division of *Orthides recto-striatæ uni-areæ* the curvature of the two valves is exactly similar, and the dorsal is the concave valve. We are indebted to M. de Verneuil for calling attention to the curvature of the valves in these groups, as it has hitherto been nearly overlooked; but we can hardly adopt it as a distinctive generic character, as in each genus there are a few species which differ in this respect from the majority of their congeners.

Strophomena: not knowing where to find Rafinesque's original description of this genus, I can only refer to it in the 'Dictionnaire des Sciences Naturelles,' where the description is rather vague; but the characters, "Coquille équilatérale, régulière, subéquivalve, ayant une valve plate et l'autre un peu excavée," added to that of the original species, *S. rugosa*, having the dorsal valve concave, limit us to the group of which *Orthis umbraculum* may serve as the type, and distinguish *Strophomena* from both *Orthis* and *Leptæna*.

In a very instructive paper on the arrangement of the *Brachiopoda*, published in the 'Annals of Natural History' for July and August

1846, Mr. King proposes to limit the genus *Leptæna* to the species which are wrinkled transversely, as *L. depressa* and *rugosa*, and to include in *Strophomena* the rest of the species now classed in *Leptæna*, as *L. euglypha, transversalis*, &c. There is here hardly difference enough to warrant a division into two genera, for with the exception of the transverse wrinkling of the valves, there is no distinguishing character between them ; and the name of *Strophomena* also is applied to a group not intended by its author, who had a flat, regular, sub-equivalve shell in view, and not such produced, irregular forms as *Leptæna euglypha*, &c. : so that we cannot adopt this classification.

Confining the genus *Orthis* as here proposed to the species with an open triangular foramen, we have a well-marked character which distinguishes it from the other two genera ; but we still require characters to divide *Strophomena* from *Leptæna*. These will be found in the regular form and striation of *Strophomena*, with the valves nearly flat or regularly curved, in contrast to the irregular curving and striation of *Leptæna*, with the valves strongly and suddenly bent over and produced in front. But there are more important internal characters connected with the hinge-processes and the muscles of attachment which distinguish them. In *Leptæna* the dental lamellæ of the dorsal valve unite with an elevated ridge, which curves round and encircles the base of the muscles ; the space devoted to the attachment of the muscles is nearly circular, and is completely surrounded by this elevation ; the inclosed space is divided longitudinally by a broad plate or ridge, from which a minor pair of muscles take their rise : in the ventral valve the bases of the muscles are equally confined by two elevated ridges encircling them. In *Strophomena* the dental lamellæ of the dorsal valve are produced in a straight line, marking the limits of the muscles towards the sides of the shell, but there is no ridge or enclosure round the fore part of the muscular impressions, and a straight plate starting from the apex separates the bases of the two muscles : thus there are three straight plates in the interior of the valve which converge at the apex. The arrangement of the plates on the ventral valve is nearly similar.

These distinctive internal characters are well exhibited in Mr. Davidson's beautiful illustrations of the Brachiopoda, pl. 12 & 13 of Charlesworth's 'Geological Journal,' vol. i., where the interior arrangement of *Leptæna* is fully shown in the figures of *L. depressa* and *euglypha*, and that of *Strophomena* in those of *Orthis pecten*, which belongs to that genus.

The differences of internal structure above described appear the consequences of the following peculiarities in their respective animals ; that in *Strophomena* the base of the great pair of muscles covers a much larger proportion of the surface of each valve than in *Leptæna*, and thus their attachment is less distinctly marked. On the other hand, there is a greater thickening of the shell in *Leptæna* during the growth of the animal ; and as this deposit of shelly matter takes place less under the base of the muscles, in old shells their place is marked by a deep depression.

In *Strophomena* the dorsal valve is usually slightly elevated near the apex, and then bent back, so as on the whole to be concave; in such species the ventral valve is convex, being flat near the apex, and then curving down regularly. But there are many species where both valves are nearly flat, and a few, as *S. crenistria*, where both valves are convex.

In the large majority of *Leptænæ* the dorsal valve is convex, but the reverse is the case in *L. euglypha* and a few other species.

We find the same irregularities in *Orthis*; the majority of the species have the dorsal valve strongly convex, and the ventral valve less convex or flat; but there are many species with both valves equally convex; *O. resupinata* and a few others have the dorsal valve concave and the ventral convex, and *O. carinata*, described above, p. 173, has the ventral valve deeply concave. Thus, though in each genus a certain form prevails, we cannot take these forms as generic characters, as there are a few aberrant species in each.

(14) Terebratula aspera.—This species appears to be common in the Hamilton and Chemung groups, and is frequently found with the ribs produced into spines, one of which rises at each intersection of the ribs by the laminæ of the shell, which occur at intervals of a tenth or a twelfth of an inch: the spines themselves are nearly a quarter of an inch long. This tendency to produce laminæ projecting beyond the shell appears the strongest when the animal lived in very still water, as we find it best exemplified in specimens from fine clay. Thus *T. reticularis* is often found in the Wenlock shale covered with projecting laminæ, but these never run into spines.

The variations in appearance arising from the different degree of development or preservation of the scales has led to a sad multiplication of supposed species; thus the young shell of *T. reticularis* with the laminæ slightly projecting formed the *Atrypa aspera* of the Silurian system; the preservation of the scales on the true *T. aspera* supplied the *A. squamosa* of Sowerby; and the spinose development of them has led to two more names in America, the *A. spinosa* and *A. dumosa* of J. Hall.

Another American species of the same group, *A. hystrix*, Hall, has also the ribs produced into long spines; it is distinguished from *T. aspera* by having only about eight or ten large rounded ribs with larger and stronger spines; but it may perhaps prove to be merely a variety of that species.

(15) Terebratula unguiformis, Conrad sp.—Mr. Conrad and Mr. James Hall have shown the true relations of this species by placing it in the genus *Atrypa*, which with those authors contains all the *Terebratulæ* found in the palæozoic formations. Mr. Vanuxem has attached an undue importance to it by using it as the type of a new genus *Hipparionyx*. But as no description nor figure of the exterior of the shell has been published, and we have only been shown the cast of the interior of one valve, there has been no opportunity given to European students of understanding its characters.

As far as I can judge from Mr. Lyell's imperfect specimens, the *T. unguiformis* is closely related to the *T. reticularis*, from which it differs in its greater size, coarser striation, and in the flatness of the ventral valve. In casts of old specimens of *T. reticularis* the muscular impressions are seen to be analogous to those of the American shell, but from a difference in the proportions of the various parts, our shell does not present the strong resemblance to the base of a horse's hoof to which the *T. unguiformis* owes its celebrity and name.

(16) PORCELLIA ORNATA, Conrad sp.—Shell consisting of two or three whorls wholly exposed and increasing very rapidly in size; whorls sharply carinated, ornamented on each side with a row of 12 or 15 tubercles, which expand laterally into short ribs, occupying about half the width of the shell; back crossed by elevated rows of minute tubercles arranged in straight lines nearly at right angles to the keel: opening irregularly quadrangular.

Found in the Hudson's River group on the Salmon River, and in the blue limestone of Ohio at Cincinnati.

I have no doubt that this is the *Cyrtolites ornatus* of Conrad and Vanuxem, although the specimens I have seen do not show the whorls detached in the manner represented in Mr. Vanuxem's figure. The species is so nearly related to *Porcellia Puzo* of Léveillé, and *P. armata* of De Verneuil, that I could not hesitate to place it in the same genus, without having seen its true generic characters.

A shell found in the Lower Silurian beds of North Wales near Bettws-y-Coed cannot be distinguished from the American species, although the specimen is hardly perfect enough to give a certain identification. The *Euomphalus Corndensis*, Sowerby, Sil. Syst. t. 22. f. 16, may perhaps be also related to the genus *Porcellia*, and has some resemblance to this species.

DECEMBER 15, 1847.

John North, Esq., and Thomas F. Gibson, Esq., were elected Fellows of the Society.

The following communications were then read:—

1. *On the Mineral Character and Fossil Conchology of the Great Oolite, as it occurs in the neighbourhood of* MINCHINHAMPTON. By JOHN LYCETT, of Minchinhampton.

MY principal design in this paper is to exhibit the organic remains of a district small in area, but peculiarly rich in fossil testacea. These likewise occur in a better state of preservation than is common in rocks of a similar geological character, the external ligaments of the bivalves, and coloured markings of the univalves, being not unfrequently visible. Of the remains of reptiles, fishes, crustacea, insects and plants of the oolitic period, the slates of Stonesfield have afforded good illustrations; but the shells are comparatively few as to species.

Mr. Lonsdale's list from the vicinity of Bath, at the south-western extremity of the formation, is equally scanty. A few species may be found in the 'Mineral Conchology of Great Britain;' and recently

Messrs. Buckman and Strickland have made additions to the Stonesfield slate shells in their work on the Geology of Cheltenham. These are all the authorities relating to the course of the great oolite in the middle and south of England. The testacea of these rocks in the north of England have been more fully illustrated, and the lists of Messrs. Phillips, Bean and Williamson contain a considerable number of species; but unfortunately the oolitic series of rocks beneath the Oxford oolite in Yorkshire constitute a great carboniferous deposit, which differs essentially both in its natural subdivisions and mineral character from the presumed parallel series in the middle and south of England. On this account the Yorkshire lists of shells have little more than a local value, inasmuch as the particular stratum to which they are referred cannot with certainty be placed as the equivalent of a stratum whose position in the series is elsewhere determined. Further information respecting the shells of this epoch can only be obtained by referring to the works of Roemer, Goldfuss, Bronn, Dunker, D'Archiac, Deslongchamps, &c., where a large number of foreign oolitic shells are figured and described. It would seem that there attaches a degree of reproach to us that the shells of a formation which engaged the attention of the fathers of geology in the earliest infancy of the science should still remain perhaps less generally known than those of any other fossiliferous series in the kingdom. In the hope that this little memoir may somewhat assist in remedying this defect, I have ventured to submit the accompanying list of species and observations. The district to which these remarks apply is very small, having a radius of only three miles. Nevertheless within this limited space, very many species, and even several genera, are found which are new to science. Possibly some few of these may be described in foreign authorities with which I am not acquainted; it is not likely, however, that their number is considerable. In fact, when collating foreign oolitic forms, it is remarkable how few are found identical with our own;—there is so strong a family resemblance that at first we feel confident that we shall establish a specific relationship; but a closer scrutiny undeceives us, and eventually we feel surprised at the small number which we can call our own. In some instances errors are corrected into which others have fallen from describing imperfect specimens, or from unacquaintance with the hinges of the bivalves; nor is it unlikely that here also similar errors are committed from the same causes. The smallness of area has at least one advantage,—it enables us to exhibit the grouping or assemblage of contemporaneous species free from the doubt which must sometimes exist with regard to fossils collected over a more extensive tract of country. The results of this examination, it is trusted, are such as will afford some curious information with respect to the proportion and diffusion of the Zoophagous tribes. Until very recently an opinion has prevailed that we might in vain look for the carnivorous Trachelipods in rocks of such antiquity as the great oolite, or that they were extremely few, and that it was only on the extinction of those two great families of Cephalopods, the Ammonites and Belemnites, that this class of mollusks first appeared, and have continued down to the recent period to perform the office of those extinct races. It will here, however, be seen that out of 142 species of univalves, exclusive of Cephalopoda and Radiaria, no less than forty-one are carnivorous, and five others belong to a genus (*Phasianella*) the recent species of which are both phytophagous and carnivorous, thus presenting a proportion of species in the Zoophagous tribes not very different from that which obtains in warm seas of the recent period. The unusual paucity of Cephalopoda, taken in connection with this fact, is worthy of notice;—of Belemnites there is only one small species, and the number of individuals is but few; so also with the Nautili, of which only two species occur; and an Ammonite is decidedly a "rara avis;" six species, with less than forty individuals, are all which have fallen under my notice. The inquiry naturally follows: Was this peculiar distribution of families characteristic of the great oolite generally over large areas, or was it merely local, and dependent upon conditions found only within certain limited spaces, so that it ceased when these conditions no longer existed? We know that both before and after this period the Cephalopoda reigned supreme among the molluscous tribes, a fact favouring the existence of a local cause to account for such an unusual assemblage. Even a cursory glance at our largest sections of the great oolite suggests the idea that the beds were deposited from a shallow sea where strong currents prevailed; where the surface and mineral character of the deposit were continually changing. A closer view confirms the first impression; heaps of broken shells, piled in irregularly laminated beds, are intermixed with occasional rounded boulders of rock foreign to the neighbourhood, with fragments of abraded madrepores, dicotyledonous wood, crabs' claws, &c. Other portions of the shelly beds have suffered denudation, and the removed portion has been filled with clay. These, together with false stratification and nonconformity of certain beds in juxtaposition, are conclusive upon this point; and the effect is not lessened by the occurrence of other beds, barren or less fossiliferous, but of more uniform character. May not these circumstances suffice to account for a paucity of Cephalopoda, and for the absence of species fitted for such conditions over large and more tranquil areas where a similar littoral surface could not be expected? As a contrast to these conditions, the mineral character and fossils of the same formation in the vicinity of Bath may be cited. The rock has there the oolitic structure for its prevailing character; corals are large and abundant, but testacea scarce, and those chiefly Brachiopoda,—denizens, it may be presumed, of a deep and tranquil sea. In Mr. Lonsdale's list of thirty-one species of testacea from the Bradford clay, great oolite and Fuller's earth of that locality, there are upwards of eight Terebratulæ, and a Crania has since been discovered,—a larger number in proportion than will be found in the 300 species here tabulated.

Geological features of the district.

The beds of the great or Bath oolite within the limits of this sketch consist of forest marble, great oolite and Fuller's earth; but it is chiefly the lower 30 or 40 feet of the great oolite which will engage our attention, inasmuch as the testacea of the other divisions are unimportant with respect to number of species, and rarely contain any which are not likewise found in the testaceous portion referred to.

The general geological features of the neighbourhood are already sufficiently known; all the exposed sections are artificial, the quarries are openwork, and nearly the whole are situated in the parishes of Minchinhampton and Bisley, near escarpments of the oolite, caused by the two deep valleys of Chalford and Woodchester, with their lateral ramifications. These valleys of denudation have cut through the series of rocks from the forest marble to the lias, having a mean depth of 500 feet, and have produced a combination of circumstances eminently favourable for bringing the valuable beds of oolite into use at a small comparative expense, and of transporting it by water-carriage.

The rocks have the same general dip to the south-east, at a small angle, which usually prevails over this part of England. Many sections indeed exhibit a dip at variance with this general position, and one lateral valley (Toadsmere) has an anticlinal axis producing considerable upthrow of the beds on each side. These variations however from the general rule are local only, and do not affect the inclination of the beds when viewed on a large scale.

Joints (*lissens* of the quarrymen) are for the most part parallel in their direction and frequently widely separated. In one curious instance a large Nautilus was severed by a joint, and the divided portions remained a yard apart on opposite sides of the chasm. Our sections, though numerous, are but of small extent, and have not disclosed any fault or displacement of importance, nor is there any reason to suspect the occurrence of such within the limits here chosen.

The compound great oolite, irrespective of the Fuller's earth, has an aggregate thickness of about 130 feet, and will admit of the following general subdivisions:—

1. Forest marble beds with bands of clay and marl representing the Bradford clay.
2. Thin-bedded sandstones, not shelly.
3. Weatherstone, being the portion quarried for building purposes. This subdivision is distinguished from the one above by the superior thickness of the beds, their shelly structure and frequent diagonal lamination, thereby approaching in general aspect the uppermost or forest marble beds. The two former subdivisions occupy the surface to the east of the town of Minchinhampton; the latter is exposed to the west and north.

The forest marble series consists of many very irregular thin beds of oolitic sandstone more or less shelly, and frequently separated by bands of brown or grey marl or clay; these latter are the probable representatives of the Bradford clay; the *Terebratula digona* however does not occur in them, although they contain many bivalves, the most conspicuous of which is the *Cardium Beaumonti*, d'Archiac. Some of the shelly beds are very hard, split into thin laminæ, and are extensively used for roofing. In the preparation of the tiles no exposure to frost is necessary, light dressing with the hammer being all that is required: they form a covering more durable than the Stonesfield slate, but heavier and less neat. These laminated tile-stones are sprinkled over with small oysters, pentacrinal remains, spines of Echini, ossicula of Ophiura, &c.

Connected with the forest marble a local deposit occurs of a curious character; it consists of a bed of thin, brashy, but very hard calcareous stone, full of irregular holes, forming masses sometimes very large. One of these has been placed erect, about a mile from the town, and is known by the name of Longstone, a sepulchral monument it is supposed of great antiquity. The extent of this stratum is unknown, but it certainly covers very many acres, and is extracted for out-of-door ornamental purposes, on account of the grotesque forms which it assumes. Unlike other oolitic stones, the only change which it experiences by exposure to the weather is that it becomes somewhat whiter. Its singular structure would appear to be owing to the forcible escape of gases from beneath while the stratum was of a soft or pasty consistence.

No positive line of separation can be drawn between the forest marble and great oolite; the shelly beds of the former gradually change to thin-bedded sandstones nearly destitute of organic remains; stems of Apiocrinites, however, may be traced throughout the middle subdivision. At the upper part of this series, or about 90 feet above the Fuller's earth, is a bed from 1½ to 2 feet in thickness, emphatically termed the '*limestone bed*'; which is distinguished from all the associated strata by a remarkable uniformity of thickness and mineral character over a large area. It may be described as a very hard, homogeneous, cream-coloured rock, occasionally containing shells which agree specifically with those of the uppermost beds of building stone or planking. It has been traced from the town of Minchinhampton on the west to a deep section made by the Swindon and Gloucester Railway, close to the east entrance of the smaller of the two Sapperton tunnels, a distance of five miles; where it appears near the middle of the section. It is sometimes burned for lime, which is moderately good, though more impure than that obtained from the carboniferous limestone.

The third subdivision or weatherstone is exposed in many openwork quarries situate to the west of the town and on the northern side of the vale of Brimscombe or Chalford; the whole of the beds are extracted down to the Fuller's earth. The mineral character of the weatherstone beds is found to vary considerably within a short distance, a change being sometimes observable even on opposite sides of the same quarry. The description of any one section will therefore afford only a very general and distant notion of a similar section in another locality. Taking for example the largest quarry on Minchinhampton Common, one mile west of the town, we there find the upper part to consist of thinly-laminated stone, the laminæ being irregular and often rising at a high angle, 5 or 6 feet in thickness; this should probably be referred to the middle subdivision.

A. Planking, 10 feet, usually consists of several beds; a shelly, coarse calcareous sandstone, having oolitic globules in particular layers, but upon the whole sparingly distributed. These beds are sometimes very hard and barren of organic remains; in other situations again they are distinguished by a profusion of relics, including many zoophagous Trachelipods, which seem peculiar to the great oolite. The partings of the beds frequently exhibit a remarkable appearance; the shells, for the most part broken, are piled in diagonal layers, so as frequently to constitute a large proportion of the mass of the rock, together with rounded fragments of harder sandstones, coralline bodies, crabs' claws, palates and teeth of fishes, remains of Pentacrinite, Ophiura, spines of Cidaris, &c. Other blocks will be found strewed with small spiral univalves belonging to the genera *Cerithium* and *Nerinæa*. The structure of the shells consists of pure crystalline carbonate of lime, and their internal cavities are frequently filled with the same substance. From this crystalline structure the stone appears to derive its superior hardness and durability; when once dried by exposure to the sun it does not readily absorb water and consequently resists the action of frost. The largest blocks are worked into pillars, gate-posts, trough-stones, and other uses where much exposure is required.

Beneath the planking sometimes succeeds a few inches of sand or brown clay, and it may be remarked that the bivalve shells in this and other clay seams, unlike the stony beds, have usually both valves in apposition, though for the most part in the form of casts.

B. Soft, yellowish sandstone, thin-bedded, 12 to 14 feet, divided occasionally by sandy partings. These beds are worthless for economical purposes, the absence of shells and crystalline lime rendering it liable to destruction from frost, which, together with its small masses and tendency to lamellar separation, preclude its employment for building; it is accordingly suffered to disintegrate on the banks of the quarries.

C. Soft yellowish sandstone, shelly, 6 feet, much more coherent than B, and advantageously worked for purposes where hardness is not necessary; it is therefore sawn into ridge-tiles and coping for walls. The shells increase in quantity downwards; both this bed and B exhibit numerous holes bored by the Lithophagidæ, in some of which Lithodomi may still be found. 'Oven-bed' is the workmen's term for these strata.

D. Weatherstone, 6 feet, separable into two or three beds; greyish-brown sandstone, abounding with shells and carbonate of lime; the hardness increases downwards until we arrive at the lowest bed.

E. Lowest weatherstone, 6 to 9 inches; a coarse, grey, shelly limestone. The superior hardness of this bed is due to the valves of small oysters, chiefly *O. acuminata*; these in fact constitute the greater portion of its mass; it strikes fire with the tools of the workmen; the lowest two or three inches are frequently blue.

Of the Fuller's earth which underlies the last stratum a brief notice will suffice; its thickness in this neighbourhood varies from 60 to 80 feet. Northwards in the parish of Bisley, somewhat beyond the limits of this sketch, it rapidly thins out, and at Throughham and Lypiatt, where the Stonesfield slate in mass begins to occupy its position, the thickness is reduced to about 9 or 10 feet. It consists of stratified blue and brown marls and clays, traversed by three or four bands of hard brown argillaceous rock called "clay rag." The uppermost of these is a lamellar argillaceous slate having all the characters of the Stonesfield slate, and judging from the number of places where it occurs, would appear to be continuous over the whole district. Occasional traces of various organic remains may be observed, but rarely sufficiently distinct to be recognised. The shells distributed through the Fuller's earth, though abundant in certain layers, belong to few species; Terebratulæ predominate. One or two bands of stone and the neighbouring clays are nearly made up of the valves of *Ostrea acuminata.*

The soil over the Fuller's earth is the best in the neighbourhood; and when properly drained constitutes good pasturage and orchard land. The springs which burst out at the base of the superincumbent oolite frequently afford the means of ministering to domestic purposes; accordingly its course may usually be traced in populous districts by a zone of cottages and gardens girdling the hill-sides, and affording a strong contrast to the barren slope of the inferior oolite beneath.

From the occurrence of a series of clay beds between two rock formations in a single hill-slope, it may be conjectured that landslips are of frequent occurrence, and accordingly we sometimes find the steep slope of inferior oolite rendered fertile by a coating of the marls of the Fuller's earth.

In illustration of the diversity of mineral characters which may exist in the great oolite within a small area, I will mention that at the Box, one mile from the large section which I have quoted, the beds A, B and C are absent, and their place is occupied by a thick stratified deposit of brown clay containing several bands of argillaceous rock and nodules; in fact, a repetition of the Fuller's earth as far as mineral character is concerned. From this uncertainty it follows that the success of opening and working a quarry in this formation somewhat resembles the risk of a mining speculation; a slight accidental circumstance will sometimes defeat the project by rendering the quarryman unable to compete with others more favourably situated.

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Conchifera.

Macrodon Hirsonensis (*Cucullæa*), Archiac; *C. elongata*, Phillips; *C. rudis*, Sow.; *Arca elongata*, Goldfuss.
Cucullæa Goldfussii, Roemer.
—— *minuta*, Sowerby.
—— *oblonga*, Phillips.
Arca lata, Dunker.
—— *pulchra*, Sow.
—— *æmula*, Phill.
—— n. sp.
Nucula variabilis, Phill.
—— *lachryma*, Sow.
—— *acuminata*, Goldfuss.
—— *elliptica*, Phill.
Pectunculus ooliticus, Archiac.
Corbula curtansata, Phill.
—— *involuta*, Goldf.
Corbis Lajoyei, Archiac.
—— *lævis*, Roemer.
Mya margaritifera, Young and Bird.
—— *æquata*, Phill.
—— *dilata*, Phill.
Anatina undulata (*Sanguinolaria*), Phill.
Pholas, n. sp.
Pholadomya ventricosa, Goldf.
—— *orbiculata*, Roemer.
—— *truncata*, Goldf.
—— *nana*, Phill.
—— *Murchisoni*, Goldf.; *Cardita deltoidea*, Sow.
Pholadomya ambigua, Sow.
—— 2 n. sp.
Donax, 3 n. sp.
Capsa oblita (*Pullastra*), Phill.
—— n. sp.
Mactra gibbosa, Roemer.
Mactromya, 2 n. sp.
Hiatella, n. sp.
Lucina lirata, Phill.
—— *cardioides*, Roemer.
—— *despecta*, Phill.
Astarte cuneata, Sow.
—— *lucida*, Sow.
—— *squamula*, Archiac.
—— *excavata*, Sow.

Astarte minima, Phill.
—— *similis*, Goldf.
—— *elegans*, Phill.
—— *orbicularis*, Sow.
—— *rotundata*, Roemer.
—— 3 n. sp.
Venus ovalis, Sow. ??
—— *isocardioides*, Roemer.
—— n. sp.
Cytheræa deltoidea, Goldf.
—— *dolabra*, Phill.
—— *lamellosa*, Goldf.
—— n. sp.
Cyrena nuculiformis, Roemer. ??
Opis lunulatus (*Cardita*), Sow.
—— *similis* (*Cardita*), Sow.
—— *extensus*, Goldf.
—— 2 n. sp.
Cardium striatulum, Phill.
—— *Beaumonti*, Archiac.
—— *globosum*, Bean.
—— *acutangulum*, Phill.
—— *pes-bovis*, Archiac.
—— 2 n. sp.
Isocardia truncata, Goldf.
—— *striata*, Sow.
—— *nitida*, Phill.
Ceromya v. scripta (*Cardita*), Buckman.
—— *excentrica* (*Isocardia*), Roemer.
—— *concentrica* (*Isocardia*), Sow.
—— n. sp.
Cypricardia solida (*Venus*), Buckman.
—— n. sp.
Sphæra Madridi (*Cardium*), Arch.; *C. incertum*, Phill.
Lutraria concentrica, Goldf.
Trigonia gibbosa, Sow.
—— *quadrata*, Sow.
—— *cuspidata*, Sow.
—— *muricata*, Goldf.
—— *costata*, Sow.
—— *litterata*, Goldf.
—— *angulata*, Sow.
—— *striata*, Sow.
Lysianassa v. scripta, Goldf.
Myoconcha crassa, Sow.
Mytilus Hausmanni, Goldf.
Mytilus obtusus, Buckman.
—— *sublævis*, Sow.
—— *pectinatus*, Sow.
—— n. sp.
Modiola subæquiplicata, Goldf.
—— *plicata*, Sow.
—— *pulcherrima*, Roemer.
—— *cuneata*, Sow.
Lithodomus inclusus (*Modiola*), Phill.
—— n. sp.
Pinna ampla, Sow.
—— 2 n. sp.
Lima duplicata, Sow.
—— *rigida* (*Plagiostoma*), Sow.
—— *ovalis* (*Plagiostoma*), Sow.
—— *gibbosa*, Sow.
—— *substriata*, Goldf.
—— *notata*, Goldf.
—— *Cardiiforme* (*Plagiostoma*), Sow.; *L. læviuscula*, Goldf.
—— 3 n. sp.
Pecten abjectus, Phill.
—— *vagans*, Sow.
—— *annulatus*, Sow.
—— *lens*, Sow.
—— *clathratus*, Roemer.
—— *arcuatus*, Sow.
—— *personatus*, Goldf.
—— *fibrosus*, Sow.
—— 2 n. sp.
Hinnites tuberculatus (*Spondylus*), Goldf.
—— *velatus* (*Spondylus*), Goldf.
Plicatula, 3 n. sp.
Placuna? *Jurensis*, Roemer.
Monotis, n. sp.
Perna mytiloides, Goldf.; *P. quadrata*, Phill.
—— *rugosa*, Goldf.
—— n. sp.
Gervillia lanceolata, Goldf.; *G. acuta*, Phill.
—— *siliqua*, Deslongchamps.
—— *Costatula*, Deslongchamps.
—— n. sp.
Avicula ovata, Sow.
—— *echinata*, Sow.
—— *Munsteri*, Goldf.
—— *pygmæa*, Dunker.
—— n. sp.

Ostrea Marshii, Sow.
—— *costata*, Sow.
—— *gregarea*, Sow.
—— *acuminata*, Sow.
—— n. sp.
Several other species undetermined.
Terebratula orbiculata, Roemer.
Terebratula perovalis, Sow.
—— *media*, Sow.
—— *intermedia*, Sow.
—— *ornithocephala*, Sow.
—— *bullata*, Sow.
—— *concinna*, Sow.
Crania, n. sp.

MOLLUSCA.

Patella rugosa, Sow.
—— *nana*, Sow.; *P. cingulata*, Goldf.
—— *Aubentonensis*, Archiac.
—— *tenuistriata*, E. Deslongchamps.
—— 3 n. sp.
Metoptoma, n. sp.
Rimula clathrata (*Emarginula*), Sow.; *R. Goldfussii*, Roemer.
Emarginula scalaris, Sow.
—— *tricarinata*, Sow.
Fissurella, n. sp.
Pileolus plicatus, Sow.
—— *lævis*, Sow.
Nerita costata, Sow.
—— *minuta*, Sow.; *N. pulla*, Roemer.
—— *decussata* (*Natica*), Goldf.
—— *sulcosa*, Archiac.
—— 5 n. sp.
Monodonta Lyellii, Archiac.
—— *lævigata*, Goldf., (*Nerita*) Sow.
—— n. sp.
Turbo clathratus, Roemer.
—— *obtusus*, Sow.
—— *Meriani*, Goldf.
—— *capitaneus*, Goldf.
—— *muricatus*, Sow.
—— *pyramidalis*, Archiac.
—— *princeps*, Roemer.
—— 5 n. sp.
Bulinula olivæformis (*Bulla*), Dunker.
—— n. sp.
Rissoa acuta, Sow.
—— *duplicata*, Sow.
Phasianella Leymeriei, Archiac.
—— 4 n. sp.
Chemnitzia lineata (*Melania*), Sow.
—— *undulata* (*Melania*), Deslong.
—— 2 n. sp.
Natica Verneuili, Archiac.
—— *grandis*, Goldf.
—— *Michelini*, Archiac.
—— *adducta*, Phill.
—— *elegans*, Sow.
—— *globosa*, Roemer.
—— 7 n. sp.
Trochus plicatus, Archiac.
—— *glaber*, Dunker.
—— *obsoletus*, Roemer.
—— 5 n. sp.
Pleurotomaria, 5 n. sp.
Trochotoma affinis, Deslong.
—— *acuminata*, Deslong.
—— *conuloides*, Deslong.
—— 2 n. sp.
Cirrus nodosus, Sow.
—— n. sp.
Solarium polygonum, Archiac.
—— 4 n. sp.
Delphinula coronata (*Euomphalus*), Sow.
—— n. sp.
Bulla suprajurensis, Roemer.
—— *Hildesiensis*, Roemer.
Cylindrites acutus (*Actæon*?), Sow.
—— *cuspidatus* (*Actæon*), Sow.
—— *bullata*, *Conus*? *minimus*, Archiac.
——, 3 n. sp.
Cerithium muricato-costatum, Goldf.
—— *Dufrenoyi*, Archiac.
—— *limæforme*, Roemer.

Cerithium quadricinctum, Goldf.
—— *Portlandicum* (*Terebra*), Sow.
—— *pentagonum*, Archiac.
Nerinæa Roissyi (*Turritella*), Archiac.
—— *fasciata*, Roemer.
—— 13 n. sp.
Buccinum sublineatum, Roemer.
—— *parvulum*, Roemer.
Pleurotoma, n. sp.
Rostellaria composita, Phill.
—— *trifida*, Phill.
—— *bispinosa*, Phill.
—— *atractoides*, Deslong.
Rostellaria paradoxa, Deslong.
—— 6 n. sp.

Note.—All the species in this group are characterized by the absence of a siphon on the spire.

Murex, 3 n. sp.
Purpuroidea nodulata (*Murex*), Young and Bird; *Murex tuberosus*, Sow.
—— 2 n. sp.
Fusus unilineatus (*Buccinum*), Sow.
—— *obliquatus* (*Rissoa*), Sow.
—— n. sp.

CEPHALOPODA.

Belemnites hastatus, Orbigny.
Nautilus truncatus, Sow.
—— (species undetermined).
Ammonites Herveyi, Sow.
Ammonites Parkinsoni, Sow. (var.)
—— *coronatus*, Brug.
—— *Lalandeanus*, Orbigny.
—— (2 sp. undetermined).

RADIARIA.

Clypeus sinuatus, Parkinson.
Pygaster patelliformis, Agassiz.
Nucleolites clunicularis, Phill.
—— (species undetermined).
Acrosalenia coronata (*Cidaris*), Goldf.
Acrosalenia Hoffmanni (*Cidarites*), Goldf.
—— (species undetermined).
Cidaris subangularis, Goldf.
Echinus germinans, Phill.

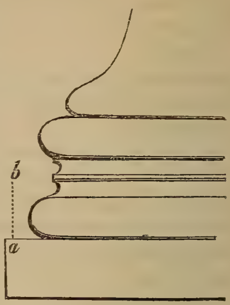
Numerical proportion of species obtained from the Great Oolite of Minchinhampton.

Conchifera	109
Monomyaria	44
Brachiopoda	8
Gasteropoda	142
Cephalopoda	9
Radiaria	9
	307

2. *Extract of a Letter to* J. CARRICK MOORE, Esq. *from* COLONEL MACINTOSH, F.G.S.

Florence, June 15, 1847.

. . . . When at Naples I visited Pozzuoli twice; the first time on the 27th of May 1847, at seven o'clock P.M. The tide was still flowing slowly out of the Temple of Serapis. The water was then exactly on a line with the angular base of the northern column (*a*), the surface of which, as well as the first ring (*a b*), was at the time wet, and covered with short green weeds resembling moss, clearly indicating the water-mark of the ordinary tide. A dark dry mark without weed reached about 6 inches higher, seeming to point out the water-mark in high tides; and similar marks corresponded with these on every other part of the building reached by the sea-water. I returned on the 6th of June at five o'clock P.M., and found the water reaching about half an inch above the point (*b*), and therefore entirely covering the first or lowest ring (*a b*). I placed the end of my foot-rule on the upper surface of the angular base (*a*), and found the depth of water above it (expressed by a dotted line) to measure exactly 6½ inches.



I therefore presume that the water now reaches 6 inches higher on the column than when measured by Mr. Smith of Jordan Hill*.

The shape of this part of the column must be noticed: there are, it will be perceived, *two* rings, which are 6 inches in diametrical thickness, separated by a *double concave* ornament (*see sketch*).

The bay was quite smooth on the 27th of May; on the 6th of June a slight north-westerly breeze was blowing; but that part of the bay was still and smooth, and is seldom rough, unless the wind is strong from the south.

It is very difficult to obtain correct information respecting the tides at Naples. I applied to the superintending officer at the Ammiragliato, as it is called, who stated that their variation is so trifling as not to affect navigation, and that therefore no tide-tables are kept. He said the ordinary tide was about a palm—nearly 10 inches—and that the state of the wind causes more variation than the state of the moon.

On the Naples side of Pozzuoli, just below its entrance, there are, I think, more marked appearances of the sinking of the land than on the opposite side, where the Temple of Serapis stands. The spot I allude to is at the Convent, or rather Hospice of Capuchins (for their principal habitation stands higher up in the direction of the Solfatara). They inhabit the Hospice during the warm months only; and the oldest monk, a man of about sixty, showed me over the premises. The water stands so high as frequently to enter the lower story of the building, covering the floor. The refectory, kitchens, &c., which were there, are therefore entirely abandoned, and the monks reside altogether in the upper story, and have done so for some time. The side of the convent next the sea (now under water) was a vineyard; and the old monk informed me that he had for many years eaten grapes grown on a spot which he pointed out, and which I then saw covered with about three feet of water, and tra-

* Colonel Macintosh does not mention the exact state of the tide when he made his observation, but merely that the tide was still ebbing. The level observed by him is intermediate between the high and low water observations of Mr. Smith of Jordan Hill.—See Journal, vol. iii. p. 234. J. C. M.

versed by boats. Vestiges of the walls of the vineyard were to be seen standing in the water.

The Hospice at present literally stands in the water, and a wooden bridge has been made to keep up the communication over the remains of a pavement on the land side (and more than a foot under water) which was passed over a few years ago *dry-shod* by persons entering the convent. Last winter several miles of the high road between it and Naples were undermined and totally destroyed, though very strongly built and faced with solid masonry. This was attributed solely to stormy weather; but an unsound and sinking foundation was most likely an assisting cause. A new road a little further back from the sea is at present under formation by the government at immense cost, by cutting into the face of the rocks of old lava, which there advance close to the sea, and forming breakwaters at other places of enormous blocks of that stone. The sinking of the hospital is stated to have been very gradual and progressive.

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3. *A Description of a New Species of* Nautilus (*Nautilus Saxbii*) *from the Lower Greensand of the* Isle of Wight. By John Morris, Esq., F.G.S.*

This species is referred to in Dr. Fitton's Memoir on the Section at Atherfield (Quart. Geol. Jour. vol. iii.) under the name of Nautilus Saxbianus (*vide* Table, p. 289). Its general form is like that of *Ammonites Fittoni* (d'Archiac), and *Am. splendens* (Sow.). It also closely resembles the *N. mesodicus* (Quenstedt), but differs from it in being of less breadth, having a smaller umbilicus, and in the greater number of the septa.

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4. *On the Land-Slip at the* Lizard. By the Rev. C. A. Johns, (Helston).

[Communicated by the President.]

The face of the cliff between Mullion Cove and the Blackhead (a line of coast which includes the Lizard Point and other places of interest) is remarkable for being pierced in numerous places by deep caverns, most of which appear to have been formed at a remote period by the washing away of lodes of steatite in serpentine, mica-slate, or hornblende-slate, softer than the adjacent rock. Some of these are accessible only by a boat, others may be entered by a pedestrian at low-water, some few are beyond the reach of the tide except during a storm; but I am not aware of any which are elevated much above high-water mark. They are usually called by the people living in the neighbourhood "Hugoes," with the adjunct of the name of the birds observed to frequent them, as "The Daws' Hugo," "Ravens' Hugo," "Pigeons' Hugo." Near the fishing village of Cadgwith, about three miles east of the Lizard, there is a natural archway which may be entered by a boat, and which terminates in a pebbly beach,

* Withdrawn by the Author.

bounded on the land side by a circular shelving cliff thickly covered with vegetation. From the top it presents an appearance not unlike that of the upper part of an enormous funnel. It is known by the name of "The Frying Pan," and is deservedly visited by strangers as an object of curiosity. During the present year a geological incident has occurred which beautifully illustrates its formation. Between the Bumble and Ladmakeen Points, the ground gradually slopes down from the lighthouses till it abruptly terminates in a cliff, which is perhaps 70 or 80 feet high. Here on the night of February 19th, 1847, without having shown any previous symptom of insecurity, a portion of turf, in shape an irregular ellipse, about 120 feet in circumference, suddenly subsided to the depth of 30 or 40 feet. The appearance presented next morning was that of a pit with precipitous sides and an overhanging edge of turf, the bottom being level and composed of loose stones and earth. It was known that the base of the neighbouring cliff was pierced by a cave (the Daws' Hugo), which extended in the direction of the new cavity, and as the outer edge of the latter was only 56 feet from the cliff, it was natural to suppose that the roof of the cave had fallen in. The discoloration of the water for more than a mile round proved that this opinion was correct. The appearance presented at the latter end of June was the same as that described, except that several deep cracks had been formed in the turf on the land side of the hole, showing that the walls, on that side at least, were not sufficiently compact to preserve their perpendicular character, but that they would in time shelve like the sides of the Frying Pan. After the July spring-tides the bottom of the pit presented an altered appearance; it was no longer level, but sloped suddenly down towards the sea, so that a sounding line would not rest at a depth of 70 feet. On the 15th of July, at low-water, I descended the face of the cliff with the intention of exploring the Daws' Hugo, when I found that a communication had actually been established between the mouth of the cave and the orifice of the pit. The late high tides had washed away so much of the loose rubbish, that the floor of the pit had subsided towards the sea; the cave had become an archway, leading by a sloping ascent composed of loose stones to the level of the former floor, and through the pit light was pouring in on recesses which had never seen the sun. Most probably all the stones and earth which have fallen will soon be washed away, the pit will become funnel-shaped, its orifice enlarging proportionately with its increasing depth; and as the roof of the archway is composed of solid rock, the whole will eventually become a counterpart of the Frying Pan. But if the archway itself be destroyed, we shall have a striking example of the formation of one of the little coves which are so numerous on the coast. It is now proceeding in the direction of the lighthouses, but whether it will endanger those structures must depend upon the nature of the soil between them and the growing mischief.

January 5, 1848.

The following communication was read:—

On the Geology of the Silurian Rocks in the Valley of the Tweed.
By James Nicol, Esq., F.R.S.E., Assistant Secretary Geol. Soc.

There is perhaps no extensive formation in the British Islands of which we possess less certain geological knowledge, than of the rocks constituting the great mountain-chain which crosses the southern counties of Scotland from east to west. These deposits have indeed been long ascertained to be of far more ancient date than the old red sandstone and carboniferous rocks with which they are in contact; and from this and their mineralogical characters have usually been classed in the transition series of Werner, and more recently placed hypothetically on the parallel of one or other portion of the Silurian rocks of England. This very uncertain determination of their age has in a great measure arisen from the extreme rarity of their fossil remains, which till very lately were scarcely known to exist. Having in the course of last autumn succeeded in procuring a few specimens of organic remains from the central portion of this formation, in the upper part of the valley of the Tweed, I have thought that a notice of these may not be without interest to the Society. With this I shall combine some observations on the mineralogical character and position of the rocks in this district, and the indications which these afford of the geological age of the formation and the conditions under which it has been produced. Though chiefly limited to those districts, with whose structure I have had most opportunity of becoming personally acquainted, these remarks will yet, I believe, be found applicable to the whole of this formation in the south of Scotland.

The most remarkable physical feature of this district is the mountain-chain which extends from St. Abb's Head on the east coast, in a W.S.W. direction, to the vicinity of Port Patrick on the opposite side of the island, a distance of 140 miles, with an average breadth of 25 to 30 miles. This high-land consists less of a single connected chain than of a group of smaller ridges, separated by longitudinal valleys, running parallel to the chief direction of the mass, or from E.N.E. to W.S.W. In these valleys the principal rivers, with the exception of the Tweed, have their course,—often nearly in a straight line. These ridges and valleys are crossed almost at right angles by another system of valleys, in which many of the secondary streams flow, and which is also followed by the Tweed in a considerable part of its upper course. By these two systems of valleys, the high-land is divided into huge oblong mountain-masses, often with steep declivities and flat, or almost tabular, summits. When seen from the low ground the mountains have thus apparently a very complex or irregular arrangement; but wherever a proper view is obtained from the high grounds, their disposal in parallel ridges is distinct.

The whole eastern portion of this extended mass of mountains is composed of greywacke and clay-slate, with a few beds or veins of felspar porphyry and trap rocks. In the south of Scotland these formations cover a space of more than 4000 square miles, or a twentieth part of the whole island, and have thus very considerable geographical importance. In mineralogical character the stratified rocks present no great diversity, by far the larger portion consisting of greywacke, composed chiefly of fragments of clay-slate with rounded grains of quartz and scales of mica; occasionally mixed with a small proportion of chlorite and fragments of white or red crystalline felspar. Taken as a whole, it is very different in aspect from any rock found either in the old red sandstone or carboniferous formations of Scotland, so that there would be no difficulty in distinguishing them, even in hand specimens. The quartz seems in general rounded by long attrition, and the grains are rarely larger than a pea, whilst the clay-slate often forms flat, angular laminæ, occasionally several inches in diameter. Sometimes also the greywacke incloses distinct angular fragments of greywacke, or of a conglomerate rock, similar to itself in structure. As the name implies, this rock is usually of a grey or light bluish colour, and has an uneven, conchoidal fracture and massive structure, with no trace of slaty cleavage. In the coarser varieties also the laminæ of deposition are by no means distinctly marked.

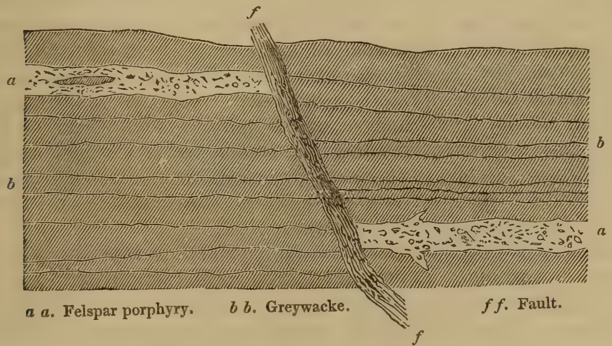
Interstratified with the greywacke are numerous beds of clay-slate,—sometimes apparently only a finer variety of the former with its materials more comminuted by attrition, sometimes it would appear a distinct rock. Its general colour is a light greyish or dark lead-blue, but is occasionally brown, red or yellow, approaching to white. It has a fine laminar structure in a direction parallel to the planes of deposition; a transverse cleavage so common in the slates of Wales and Cumberland being rarely observable in this district, and then confined within short distances, and apparently the effect of local igneous action. The slaty structure is not, however, a result of the mere fineness of the material, as in the same quarry, and in beds which do not differ in mineralogical character, it appears in various degrees, or is even altogether wanting.

The igneous rocks connected with these strata are chiefly felspar porphyries of many distinct varieties. In the channel of a small stream near Innerleithen I counted, in a distance of about one mile, twenty-two distinct beds or veins of felspar porphyry, each with peculiar mineral characters, running W.S.W. parallel to the strata, which in this place are nearly vertical, so that the two formations have a thickness of at least 5000 feet. The more common varieties are, compact felspar rock of a deep brick-red colour and slaty structure; and a true porphyry with a basis of light red felspar often nearly yellow or white, and with numerous disseminated crystals of common or glassy felspar. To these, acicular crystals of green hornblende are often added; and more rarely hexagonal prisms of black mica, or disseminated grains of quartz, and lastly iron pyrites, not in veins, but dispersed as a constituent in the mass. Rarely the rock passes into a distinct granite, of felspar, quartz, and mica, or hornblende. But as a whole these porphyries seem to differ mineralogically both from the granites of the primary mountains, and from the clay-stones of the Pentlands on the north and the Cheviots on the south. They are less crystalline than the former and more so than the latter, which they also far surpass in durability when exposed to the weather. From the trap rocks they differ mineralogically in consisting chiefly of felspar and not of augite or hornblende, and also in position, being generally disposed in beds parallel to the strata, whereas the augitic trap rocks run in veins crossing the strata in all directions.

In the central part of this district true trap rocks, as greenstone and basalt, are rare, compared to their abundance in the secondary formations, both on the south and north, where every square yard almost, as Dr. Macculloch has remarked, must be searched for them. Where they do occur it is in veins seldom above a few feet wide, though often extending for a great distance longitudinally, in one case to twenty-five miles or more*. In this region also they never seem to have overflowed at the surface, forming those large conical or tabular hills which are so numerous in all the secondary formations in Scotland. On the whole, they are in the transition districts far inferior in extent and importance to the felspar porphyries; whilst immediately on entering the secondary formations they begin to form hills and large overlying masses, whilst porphyries, like those imbedded among the greywackes, disappear. This intimate association of certain igneous rocks with certain stratified formations is frequently observable in Scotland, and is one of those facts in geology the cause of which seems but imperfectly understood.

Both these classes of igneous rocks, where in contact with the strata, have considerably modified the character of the latter. Near the trap veins the greywacke is often hardened and the slates converted into a very hard flinty slate; but in other cases they have produced little or no change on the strata, or have only modified their colour. At other times they seem to have partly destroyed the consistence of the slates and rendered them softer, more friable, and more devoid of

Fig. 1.



a a. Felspar porphyry. *b b.* Greywacke. *f f.* Fault.

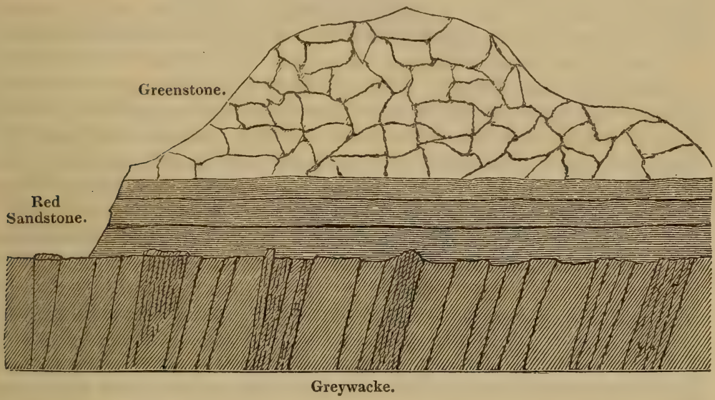
* This remarkable vein occurs in Roxburghshire, and consists of a dark, highly magnetic greenstone. I have traced it almost continuously from Hindhope at the top of the Kale, by Rink, Kirkton church and Hawick, to Whitslaid in Selkirkshire; and on the south-east it is said to extend to the sea-shore near the mouth of the Coquet. It thus traverses the carboniferous formation of Northumberland, the porphyries of the Cheviots, the red sandstone of Roxburgh and the greywacke.

slaty structure. The action of the porphyries is similar, often merely changing the grey colour of the rocks to red or brown; occasionally converting the greywackes into masses of hard flinty slate or clinkstone, with distinct imbedded crystals of felspar; or rarely producing no apparent action. As these porphyries are sometimes considered contemporaneous with the associated strata, the following horizontal section (Fig. 1) may have some interest. It shows the rocks, as exposed on the sides of the mountain-stream above noticed, at Priesthope near Innerleithen, which runs along a fissure or fault, by which both the greywacke and the felspar bed have been shifted horizontally for eight or ten feet. On one side of the section the porphyry incloses a fragment of greywacke, and on the other forms two short veins penetrating the adjoining strata. Similar sections are not uncommon, and from these appearances and the changes produced on the greywacke, I believe that the porphyry in this district has in general been injected among the strata in a state of igneous fluidity. Some of these bedded veins run for considerable distances almost in a straight line parallel to the strata. Thus, one which passes through the hill immediately above the mineral well at Innerleithen, which may be regarded as an additional proof of its igneous origin, may be traced almost continuously for five or six miles in one direction.

The position of these rocks, or the dip and direction of the strata, presents some points of interest. The direction of the beds, with local exceptions, is almost invariably parallel to the direction of the mountain-chain, or nearly east and west by compass (the variation being about 26° west of north). The dip again is almost constantly at a high angle on the northern side of the formation, from 60° to 90°, but as we proceed south becomes lower, till in Roxburghshire it is more often about 30° or 40°. The point to which the strata dip is not thus constant, being in Peeblesshire as often north as south, but in many cases towards the centre of the mountain ridges, or north on their south declivity and south on the north. In Selkirkshire and Roxburghshire again a southerly dip begins to prevail, and becomes more constant near the border of England. From this statement it appears that the direction of the beds corresponds with the great longitudinal valleys formerly mentioned. On the other hand, the direction of the transverse valleys is parallel to a series of transverse lines of division, crossing the strata nearly at right angles to the strike of the beds. In consequence of these divisions the strata are cut into large quadrangular masses, corresponding on the small scale to the mountains on the large.

Such are a few of the more general features of this formation considered as a whole. It however presents some interesting local peculiarities from which several results of considerable importance seem to follow. Before mentioning these, however, we must describe the relations of this formation to the strata with which it is in contact. And first, there are no older formations on which it is seen to rest. It forms the oldest and lowest rock visible in this district, or of whose existence in it any indication appears. Of newer formations it is immediately followed by the old red sandstone, which in this part of Scotland seems to form merely the lower portion of the carboniferous group. Its relation to this deposit is very distinctly seen both on the north and south. On the former it is well-exhibited in a section in the western part of the Pentland Hills, exposed along the channel of the Lyne*, one of the tributaries of the Tweed. Highly-inclined strata of greywacke and clay-slate form the bed of the stream for a considerable distance. On the broken ends of these slate rocks a formation of grey or very light red sandstone rests in a gentle curve, corresponding to the ridge of the mountains, which in this place appear to have been formed by the upheaval of the greywacke and superincumbent sandstones. Similar sections are common in the eastern part of the Pentland chain, but more complex from the intrusion of the clay-stone porphyries and other igneous rocks.

Fig. 2.

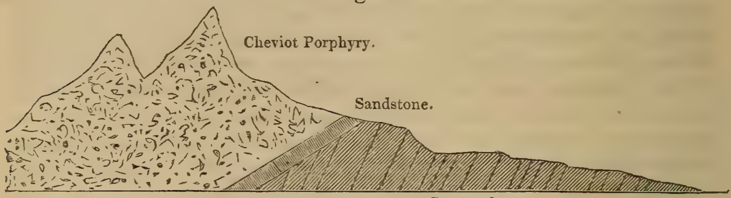


Section Fig. 2 of Southdean hill on the Jed is on the south side of the formation, and forty-five miles distant in a direct line from that just described. In it the greywacke appears in the channel of the river in highly inclined beds covered round the base of the hill by nearly horizontal strata of red sandstone, which is again overlaid by a mass of dark greenstone forming the summit. Lower down the Jed there are several similar sections, one of which near Jedburgh, first described by Hutton, is now well known, having been copied into many popular works on geology. I shall only notice another section in this vicinity, which is interesting as showing the relation of the igneous rocks of the Cheviot mountains to the red sandstone

* This river rises near the ridge of the Pentlands in the old red sandstone, it then passes into the greywacke exposed by the denudation of the sandstone, and lower down again enters the sandstone, which is succeeded by a band of porphyry rocks forming the exterior portion of the Pentlands. Beyond this it runs through a low plane of the old red sandstone, and near Newlands Bridge enters a gorge in the greywacke hills by which it is conducted to the Tweed. Viewing this river as its continuation, it crosses the whole chain chiefly in the transverse valleys, till at Melrose it enters the Roxburghshire red sandstones, and near Kelso the carboniferous formations of Northumberland and Berwick: thus exposing in its course a complete section of all the formations in the south of Scotland.

and greywacke in Teviotdale. In this section (Fig. 3), on the Oxnam Water, about six miles south-east from Jedburgh, the lowest beds are again slate and greywacke, as usual highly inclined. These are overlaid by beds of sandstone of a yellow colour with patches of reddish brown. Above these is porphyry of a light reddish yellow colour, connected with the great mass of this rock in the Cheviot mountains.

Fig. 3.



The facts just stated are of considerable importance in determining the age of the greywacke rocks in the south of Scotland. They are thus shown to be of far higher antiquity than the old red sandstone. Not only have they been previously deposited, but they have also been consolidated and raised up into a great mountain-chain, before this more recent deposit began to form around their margin. This is evident from the highly inclined position of the greywacke, contrasted with the horizontal, almost undisturbed position of the red sandstone, which shows that from the time of the deposition of the latter rock, this region has not undergone any very important general convulsive action. Indeed many facts would induce us to believe that this district had assumed nearly its present physical outline, its characteristic ridges of hills and longitudinal valleys, and even that the existing rivers were flowing in their present directions, at the time when the red sandstone began to be formed. Of these facts I shall only mention two. The first is the prolongation of the red sandstone in bays, or tongues as it were, up the valleys of the present rivers, where they leave the greywacke hills. Had the red sandstone been deposited uniformly over a level surface of the slaty rocks, and both formations at a more recent period eroded by aqueous agents so as to form the present valleys, the features exhibited would have been directly the reverse. Promontories of the older rocks would then have projected along the valleys into the outline of the newer rocks, the higher formations having necessarily undergone the greatest denudation. The second fact is, the prevalence of coarse conglomerates in the red sandstone at the places where the present rivers enter that formation; that is, at the points where they formerly fell into the red sandstone sea. I have remarked these conglomerates especially on the Tweed near Melrose and on the Ale and Teviot. They consist of rounded water-worn boulders of the greywacke and felspar rocks in a basis of red clays, and closely resemble the debris brought down by these streams at the present time. It is, however, right to state, that with these boulders of local origin there are others resembling the primary strata, and which, differing from any rocks observed in the vicinity, must therefore have been derived from a distance. The facts still seem sufficient to prove that at the time of the deposition of the red sandstone, the greywacke mountains were already dry land formed into a system of hills and valleys like those now existing, and traversed by rivers flowing nearly in the channels of our present streams. Hence these facts lend confirmation to the theory, often proposed on other grounds, that these mountains formed the land on which grew part at least of the vegetation entombed in the coal formations of England and Scotland. If we further admit, as many appearances in this district seem to require, that the chief agent in forming the valleys has been running water, the period during which it has continued as dry land, previous to the deposition of the red sandstone, must have been very considerable, and we shall thus be compelled to carry back the formation of the greywacke to a very remote date. This view is confirmed by the great denudation which the red sandstone has evidently undergone, showing that it at one time covered up these mountains to a considerably greater extent.

From the mineralogical character of these rocks, especially as locally developed, some interesting conclusions may be deduced. From the great uniformity of the formation along a space of about 150 miles in length in Scotland, not to mention its continuation in other countries, we may conclude that the greywacke was deposited in the open sea rather than in a limited bay or gulf. But this uniformity is not unbroken. In tracing this formation from its northern border in Peeblesshire and the Lothians, south through Selkirk- and Roxburghshires to the confines of England, or more than forty miles across the strike of the beds, I have observed that the coarser varieties of rock predominate in the north in large irregular masses and with a less distinct stratification; whereas on the south the finer varieties of rock preponderate, in thinner, more regular, and more distinctly stratified beds. The fragments of quartz too are on the north larger and more angular. Hence the conclusion does not seem very remote, that the materials forming this deposit have been derived from the north, and deposited in a sea becoming deeper to the south. The fragments of quartz and the scales of mica would also seem to have travelled farther and to have been longer subjected to attrition, than the clay-slate and imbedded masses of greywacke which have had their origin more close at hand.

Admitting therefore that the formation is composed of materials conveyed from the north, it may be inquired what were the previous rocks from whose destruction these beds were formed and of whose disintegrated materials they consist. The quartz, felspar and mica are evidently the components of granite, and the associated gneiss and mica-slate found in the north of Scotland, so that here it might be supposed was the true source of the materials of the transition rocks. It is, however, a remarkable fact, that whilst, as already stated, fragments of clay-slate and greywacke are not uncommon amongst the conglomerate or coarser varieties, not one of granite or of any of these crystalline schists has ever been observed. There is also a far larger proportion of clay-slate, or fragments of argillaceous rocks, than would be furnished by the decomposition of the primary formations of the

Highlands. This appears not only from the comparison of the two formations, but also from the character of the sandstones in the central district of Scotland, which have undoubtedly been produced by the wearing-down of the primary rocks in the north. It seems thus more probable that these beds have resulted from the waste of formations of clay-slate and greywacke, not much unlike in their general characters to the formation now under review. This is an interesting fact on several accounts. It shows that our present sedimentary deposits were not the earliest rocks of that character on the globe, or rather in this portion of it, but were preceded by other masses, like them produced from the destruction of a still earlier formation. In this district it is therefore possible to intercalate between the oldest existing strata, and the oldest rocks of which any trace remains, another stratified formation, composed of sedimentary materials. The transition rocks in the south of Scotland are thus the third in order of formations, whose existence is established by facts. And it must be observed that these formations do not resemble the separate deposits of the secondary system in England, one of which is regularly superposed on the other, so that both may have derived their materials from the same source, but are formations each of which implies not only the previous existence, but also the consolidation and destruction of that which preceded it. Mineral geology is thus able to carry us a step farther back into the history of the globe, than we can proceed on the evidence of organic remains, and shows that the revolutions which these remains attest were not the first, but the last in a series to which no definite limits can be assigned.

The existence of an earlier series of sedimentary rocks leads to some other conclusions to which, though of a theoretical character, we must shortly allude. So far as we can ascertain, the depths of the ocean are the spots where rocks are deposited and formed, whilst the dry land and the sea-shore are the places where they are destroyed and wasted away. There is not any known process now acting on the globe by which the rocks existing in the depths of the ocean could be disintegrated and their detritus formed again into new rocks. Any ancient sedimentary deposit therefore implies not only the existence of a sea in which its materials were deposited, but of a land from which they were derived, and rivers and currents by which they were carried down to that sea and spread out over its channel. This conclusion is so self-evident that we should not have alluded to it, had not the opposite doctrine been sometimes maintained, and the assumption boldly made, that at the time of deposition of the Silurian formations dry land and consequently land animals and plants did not exist. These beds themselves we now see teach a different doctrine, and show that even then there must have been dry land watered by showers of rain and traversed by rivers; may we not also infer from the analogy of existing nature, clothed with its appropriate vegetation and inhabited by its peculiar tribes of animated and sentient beings?

The cause of the present highly-inclined position of these strata is an inquiry of much interest, but on which little certainty can be obtained. In the beautiful section of this chain of mountains at its extremity on the German Ocean, described by Dr. Hutton and Sir James Hall, the beds are seen to be as it were crushed and folded together. I have observed similar appearances, though on a far less magnificent scale, in many places in the interior. We may therefore conclude that this structure is common to the whole chain, which will thus represent an immense fold or wrinkle in the rocky crust of the globe. This fold cannot be ascribed to any of the igneous rocks now in contact with the strata. The interstratified felspar porphyries are quite inadequate to this effect, even where most abundant; and in many parts of the formation are very rare. The porphyries of the Cheviots and Pentlands are still less capable of having effected this immense change, as they are more recent than the sandstones which rest on the elevated greywacke, and thus cannot be the cause of this elevation. The same facts in like manner exclude the augitic trap rocks, whether on the north or south. These conclusions are chiefly negative, but the following may perhaps lead to some positive conclusion on the question. In the greywacke, we have seen, no fragments of the primary strata in the north of Scotland occur. In the red sandstone in the central district of Scotland such fragments are common, and hence, in the interval between the formation of the greywacke and that of the red sandstone, these northern rocks must have been raised up and subjected to abrading influences. I have thus been inclined to believe, that that invasion of igneous agencies, which hardened and metamorphosed the gneiss and mica-slate in the Scottish Highlands, at the same time crushed up and folded together the transition beds of the southern or border counties. The prevalence of high angles and an irregular dip on the northern margin of the formation gives some confirmation to this theory. We may then believe, that whilst the gneiss and mica-slate of the Grampians were crystallizing in the interior of the globe, the more sedimentary-looking formations of the Lammermuirs were rising up into lofty mountains, which have since been worn down under the action of various external agents.

I have hitherto avoided any allusion to the organic remains occurring in this formation, being desirous that the conclusions deducible from the physical structure and conditions of the mass should stand on their own foundation. It is only very recently too that any organic remains have been found in this district, or indeed in the whole transition formation in the south of Scotland. The first notice of them is by Dr. Hutton in his 'Theory of the Earth,' who states that he found shells in a limestone quarry at Wrae, near Broughton, on the road from Edinburgh to Dumfries, but, as was to be expected at that time, gives no further account of them. The quarry is in a remote and little-frequented part of the country, and seems to have been rarely resorted to by scientific collectors. Some years ago I visited it, but found it wholly forsaken, and the limestone rock so concealed by debris that its very existence seemed problematical. Last autumn I again visited the place, and succeeded in finding some fragments of limestone among the slate debris from which I obtained a few imperfect fossils. The rocks in this place are the usual slates and greywacke, with numerous veins of quartz. The slate has been quarried in one place, about fifty yards distant from the limestone, and there appeared to dip at a high angle to the north. In the limestone quarry the dip is rather to the south, but the beds are much broken and confused. The quarry lies on the side of a steep hill into which the strata run, and the limestone bed being nearly vertical, has been wrought out like a large vein. Of its extent I can give no account from personal observation, it being entirely hid by the rubbish; but an old man who had seen it formerly, stated that the bed was thirty feet thick. It is covered by slate of the common blue colour. In this slate I found irregular masses, or angular nodules of limestone, from an inch, or less, to several feet in diameter: these lie in the slate in no perceptible relation to its cleavage planes, and are accompanied by fragments of slate, the laminæ of which are oblique to those of the inclosing rock. In the slate I saw no traces of organic remains, but the masses of limestone involved in it were quite full of them. They appear indeed little more than a crystalline mass of encrinite stems. From the crystalline structure of the rock the fossils are very imperfectly preserved, and few of them can be certainly determined. Above this bed of slate are beds of light blue greywacke containing much chlorite and quartz; and still higher a fine amygdaloidal rock, unlike any rock that I have seen in any other part of this formation. Where weathered it is of a porous, vesicular texture, but in the interior of the mass these cavities are filled with carbonate of lime. From its general aspect, I have no doubt that this rock is of igneous origin.

This quarry is almost the only place in this district where limestone is found in the greywacke. An impure limestone rock was formerly quarried near Peebles, about twelve miles distant, and nearly in the direction of the former bed, and was also accompanied by an amygdaloidal trap rock, but I have never seen any indications of fossils in it. The only other place in the basin of the Tweed where I have procured distinct organic remains, is at Greiston Slate Quarry near Traquair, about twelve miles, in a direct line, from the Wrae. The fossils at this place are graptolites, and occur imbedded in a single layer of slate or fine greywacke about half an inch thick. The surface of this stratum is almost covered by these remains, but they are not seen in any other bed either above or below. It seems as if they had lived here in great profusion for a single short interval and then been all destroyed, by some sudden catastrophe. In the same bed small fragments of anthracite occur, and elliptical carbonaceous impressions not unlike the leaf of a plant*. In a hill about a mile distant, a bed, or vein, of anthracite was at one time discovered among the greywacke, which may be regarded as furnishing additional evidence of the existence of vegetable life at this epoch. I may also mention that in another slate-quarry in Selkirkshire, I found the surface of some beds marked by impressions apparently of

* In the same quarry there is a hard bluish white rock consisting of argillaceous and calcareous matter mixed up together. It has somewhat of an igneous aspect, but forms thin, very irregular beds interposed among the slates. The occurrence of calcareous matter and of traces of apparent igneous action in the two places where alone fossils have been found, is curious.

annelids, but have mislaid my specimens and have not had an opportunity of procuring others. This paucity of fossil remains does not, however, imply a corresponding paucity of animal existence. The character of the rocks mineralogically is by no means well-adapted to preserve organic remains, and as the formation appears to have been chiefly deposited in a deep sea, where calcareous matter was by no means abundant, this may explain the rarity of testaceous mollusca. There are, indeed, in many parts of the formation, indications of organic bodies, or at least forms in the rocks which may be regarded as such. Thus, in the Pirn Crag, in Peeblesshire, there are numerous ellipsoidal concretions which appear on the exterior surface, where it is beginning to decay, like the letter O distinctly carved in the stone. These concretions do not differ mineralogically from the rest of the rock, except that they are occasionally stained brown by iron, and show no trace of structure; yet it is probable that they occupy the place of some organic body, perhaps of a rolled-up trilobite. In the same place, and indeed throughout almost the whole greywacke formation, numerous concretions of more irregular forms occur. These principally appear when the rock begins to decompose, when they, wasting more readily than the mass in which they are imbedded, leave holes and cavities of various fantastic shapes. To these also I am disposed to ascribe an organic origin, and would regard them as representing the sponges or other soft coriaceous animals of the Silurian seas.

Though there is thus sufficient evidence that animal life was not wholly banished from these ancient waters, and was in some places, probably near calcareous springs, in considerable abundance, yet from the character of the rocks but few species can be specifically determined with certainty, and can scarcely be regarded as positively fixing the true age of the formation. The specimens exhibited are indeed such mere fragments that I despaired of more than one or two species being capable of determination, and valued them chiefly as indications of the existence of animal life at that time, and as holding out hopes of better success in further researches. Mr. Salter, whose great knowledge of Silurian fossils is well known, has kindly undertaken to compare them with the rich collection in the possession of the Geological Survey, and has furnished me with the following list and remarks.

Notice on the Fossils collected by Mr. Nicol *in* Peeblesshire.

In the following list all the forms are noticed, and an attempt made to name them all, however imperfect—as the errors made will be easily corrected from more extended collection in the same localities, and an indefinite reference of them to genera merely would help nothing in provisionally fixing the date of the rocks.

Trilobites.

Asaphus. Tails—very like young *A. megistos,* of the American Lower Silurian rocks.

Asaphus tyrannus. A little differing in the ribs of the tail.
Phacops Odini, Eichwald. Lower Silurian; or a Bala limestone species not yet published.
Illænus Davisii? Lower Silurian.
Cheirurus. Probably portions of the head.

Shells.

Lituites Cornu-arietis, Sow. The straight portion.
Leptæna tenuistriata, Sow., variety.
Spirifer biforatus, Schlotheim, var.
Orthis calligramma, Dalm. Abundant.
———, var. with numerous ribs.
Orthis, broad species, very imperfect.
Orbicula —— sp.

Zoophytes.

Graptolithus Sedgwickii, Portlock.

The aspect of this list is entirely Lower Silurian, and very much what might be found in the Llandeilo flags of Wales. The *smooth Asaphi* are only yet known in Lower Silurian rocks: and it is rather remarkable, as tending to connect this range of hills with the Lower Silurian rocks of Tyrone and Fermanagh, that they have only yet been described in Britain from those counties, and I do not know them elsewhere. The *Graptolithus Sedgwickii* is also abundant in the same schists. *Orthis calligramma* swarms in the slates of Galway; and species of *Illænus* and *Cheirurus* are abundant in Tyrone.

Since these fossils were collected, a very interesting addition to the geology of the Lammermuir range has been made by Lord Selkirk in a collection of fossils from St. Mary's Isle; they are in my opinion Upper Silurian:—

Terebratula semisulcata, Leptæna sarcinulata, Atrypa reticularis, Bellerophon trilobatus, Natica, Turritellæ, Murchisonia, Avicula lineata, Orthonota cingulata, &c., *Phacops caudatus, Beyrichia tuberculata, Graptolites Ludensis.* These characteristic Upper Silurian fossils are accompanied by a *Leptæna sericea,* and *Orthoceras tenuicinctum* of Portlock. On the whole they appear to be of the date of Wenlock shale.—J. W. Salter.

In addition to these remarks of Mr. Salter only a few observations are necessary. 1st. The date of Lower Silurian, indicated by the fossils, would agree well with the high antiquity which, on wholly independent grounds, I have assigned to this formation. At the same time, the number of species is so small, and the specimens so imperfectly preserved, that we must still consider this identification as in some degree uncertain. On the whole, it is probably safer still to retain for these rocks the old name of Transition, or merely class them as Silurian, without attempting any more precise definition. This is the more necessary from the wide interval unoccupied by any deposits, which divides them from the next higher step in the geological series of formations. The red sandstone by which they are immediately succeeded cannot in this part of Scotland be separated, on physical grounds, from the carboniferous sandstones, which rest conformably upon it in unbroken succession. The greywacke, though a much older formation, may thus, from its mere position, belong to any of the great divisions of strata below the carboniferous,—to the Lower Devonian, or Upper Silurian, as well as to the Lower Silurian; and though the probability is in favour of the latter, further evidence from fossils is still required.

2nd. The fossils collected by Lord Selkirk, from the vicinity of his residence at Kirkcudbright, occur on the other side of the ridge or chain of hills, from those found in Peeblesshire. For other reasons I have thought it probable that this is the more recent portion of the formation. Although the want of accurate physical maps, and the frequent interruptions and concealment of the strata, render it very difficult to trace their connection, yet many facts which I have observed indicate that strata, at least mineralogically similar, have a very extended persistence in the line of their direction, or from E.N.E. to W.S.W. It is thus possible that the strata ranging along the opposite sides of the chain may represent different parts of the formation. In that case it is not improbable that the beds from which Lord Selkirk's fossils were derived may be connected with, or underlie, certain greywacke beds in Liddesdale, also on the extreme south side of the formation, in which I have found numerous fragments of plants, not unlike the broken reeds and other imperfect vegetable remains seen on some carboniferous sandstones. The Wrae limestone would then range with certain limestones in Colmonel parish, which Mr. Moore informs me are also fossiliferous.

3rd. It should also be noticed, that the Peeblesshire graptolites (*G. Sedgwickii*) are found in a quarry at a considerable distance from the other fossils, or about twelve miles in a direct line, and on a parallel eight miles distant measured perpendicular to the strike of the beds. They lie more in the centre of the formation, and thus not improbably in a different part of the series. The graptolites, of different species however, found by Mr. Moore on Loch Ryan would also fall in an intermediate and corresponding position, so that we may again infer their connection. It is thus possible that we have already three leading divisions of these formations sketched out, or three geological horizons indicated, by which some order may at length be introduced into this hitherto confused mass of strata. As the rocks, however, form several large folds or convolutions, so that the same bed which in one place sinks down into the interior, may in the continuation of the same transverse section rise again and again to the surface, all reasoning from the mere position of the beds must, in the present state of our knowledge, be very uncertain. It may evidently be mere portions of the same bed, formed at one time, but under diverse local conditions, in distant parts of the Silurian ocean, in which the various fossils have been found. The chief value, therefore, that I would in the meantime attach to these fossils, is as proofs that organic remains do occur in these mountains, and thus as forming an encouragement to further researches, which may at length enable us to classify aright these Scottish rocks and assign them their true position in the great series of Palæozoic formations now so ably and fully wrought out in the sister kingdom.

In conclusion, I would thus sum up the series of geological events in this region, which are attested by existing phænomena. At the earliest period of which any indication remains, this district was a portion of a deep sea, into which detritus of quartzose and argillaceous rocks was conveyed, and spread out by currents probably from the north. In some parts of this ocean animals existed in considerable abundance,—graptolites and soft fleshy animals where mud prevailed; encrinites, orthidæ and trilobites where more calcareous matter was to be found, and probably near the foci of igneous action. After a thick mass of strata had been deposited some power has pressed these beds together into huge longitudinal folds, and raising them above the sea put a stop to the succession of deposits. At the same time it would appear that the veins of felspar porphyry were injected among these beds, hardening the whole mass and more highly modifying particular portions. By means of aqueous agents the formation was then cut into a system of hills and valleys, the eroding action of course being directed chiefly along the lines of fracture caused by the elevation of the mass. A depression of the land must next have taken place when the sea flowed up the valleys and deposited the red sandstone strata in them and around the shores of the greywacke islands. During the whole of the old red sandstone and carboniferous periods, but slight physical changes seem to have occurred in this portion of Scotland. At the close of the latter, however, there has been a great eruption of igneous rocks, forming the chains of the Pentlands on the north, and the Cheviots on the south. It is evident from the relation of the porphyries forming these mountains to the red sandstone, that they are more recent than this deposit. The augitic trap rocks scattered throughout the secondary formations in the Lothians on the north, and Roxburgh and Berwickshire on the south, seem of still more recent date than the porphyries, and probably were conjoined with an elevation of the land, which brought the whole of the secondary deposits in the south of Scotland to a close. No trace of any of the recent secondary formations or of any of the earlier tertiary deposits has certainly been observed in this tract of country. Its geological history is almost an entire blank till the diluvial epoch, when there is evidence that the whole district, even to the summits of the highest mountains, 2000 feet above the sea, has again been under water. But neither this immersion of the land in the ocean, nor its subsequent elevation, appear to have been connected with any important change in its general character or physical outline. The boulders of primary rocks from the Highlands, and of trap rocks from the west coast, especially the very characteristic zeolitic traps of Dumbartonshire, which are by no means rare in the valley of the Tweed, together with the general distribution of the superficial deposits, prove that no great change in these respects can have taken place. Except the gradual erosion and denudation of the superior beds, which has in many places left patches of the red sandstone, lying far from the general mass of this rock, proving that it has at one time covered up the mass of the greywacke to a considerably greater extent, no intermediate geological event can be shown to have occurred. This circumstance leaves the period of the last depression of the land, and the deposition of the diluvium upon it, in a great measure undecided.

JANUARY 19, 1848.

The following communication was read :—

On the Agate Quarries of OBERSTEIN. By W. J. HAMILTON, Esq., Sec. G.S.

IN the autumn of 1844 I visited the agate quarries of Oberstein, and as I believe that no notice of them has been yet offered to the Geological Society, I trust that the following observations, however slight, will not be altogether uninteresting. Indeed it is rather surprising, considering the interest attached to the origin and formation of agates and of other siliceous nodular deposits, and the different views which have been advanced on the subject, and knowing as we do that these quarries have been visited from time to time by some of our most eminent geologists, that no account whatever has yet been given of this locality in any of the publications of the Society.

I allude more particularly to some remarks and opinions contained in a paper by Mr. Bowerbank, read before the Society on the 19th of May, 1841 *, in which he states that he has discovered the existence of remains of sponges in moss-agates from Oberstein, and from which he seems to infer that all agates, as well as chalk-flints and greensand cherts, have originated from sponges and other similar organic bodies. Without stopping however to inquire whether the substances which Mr. Bowerbank calls moss-agates are in any degree essentially different from the agates and other siliceous substances which I found at Oberstein and in the neighbourhood, I shall endeavour to show in the following remarks that the rocks in which the real agates of Oberstein are found are igneous rocks, and that the imbedded masses owe their origin to causes which, to all appearance, preclude the possibility of their containing any remains of organic bodies.

The little village of Oberstein is situated about thirty miles from Kreuznach, up the valley of the Nahe, in a nearly west-by-north direction from the latter place, on the road from Bingen to Saarbruck. Here is the junction of the coarse red conglomerate beds, which form the basis of the sedimentary formations of this district, with the underlying green amygdaloidal trap rocks. This conglomerate may be traced several miles down the valley, overlying and lapping round the various protruding masses of trap and porphyry; the imbedded pebbles appeared to consist exclusively of quartz rock, grits, greywacke and porphyries of various kinds.

* Proceedings of the Geological Society, vol. iii. p. 431.

Near the small town of Kirn, between Oberstein and Kreuznach, coal is found, but of a very inferior and clayey quality. I had no opportunity of visiting the works, or of ascertaining its position with regard to the conglomerate of Oberstein and the New Red or Bunter Sandstein lower down the valley; I am therefore unable to say whether this conglomerate is to be considered as forming the base of the Carboniferous, or of the New Red system; it is however succeeded lower down the valley by overlying sandstones and blue shales, which, being broken through and overturned in various places, particularly between Kirn and Martinstein, by numerous outbursts of porphyry, greenstone and other igneous rocks, extend into the great basin of Mayence, where between Kreuznach and Weinheim they form the base, still penetrated in numerous places by trap rocks and porphyries, of the overlying tertiary formation so abundant in organic remains, attributed to the miocene period.

In the immediate vicinity of Oberstein, this conglomerate, which is cemented together by a hard red matrix, and dips at an angle of 30° to the S.E. or E.S.E., contains several veins of a kind of imperfect agate or chalcedony, which were at first pointed out to me as the agate quarries (Achat Gruben) of Oberstein. These quarries occur low down in the series, near the junction of the conglomerate with the underlying amygdaloid, and are almost on a level with the bed of the river. This agate vein varies in thickness considerably, and runs in a nearly straight direction from N. to S. or N.N.E. to S.S.W., and with a dip of nearly 70° or 80° to the E. or E.S.E., and nearly at right angles with the dip of the strata. This siliceous substance, improperly called agate, being in fact a simple chalcedony, is of a honey-yellow colour, sometimes approaching slightly to red; the vein occasionally separates so as completely to envelope the pebbles of the conglomerate; in other places it spreads out into large irregular masses, and sometimes passes through the pebbles and the red matrix together, thus proving that it must have been deposited subsequently to the consolidation of the conglomerate rock, or Flötz-Gebirge as it is here called; this however can hardly be seen in the hand-specimens which I obtained. In one portion the vein becomes nearly black or bluish grey, and is then apparently more compact. Some specimens occur showing how the original fissure in the conglomerate rock was filled up by the deposition of a thin coating of siliceous matter on each side or wall, leaving a space in the centre where the mammillated surface of the chalcedony is well-exposed.

This stone, when submitted to the artificial processes which I shall presently allude to, and which the agate-workers have learned to apply to these substances from the Italian purchasers and artists who had long possessed the secret, assumes the deep red colour of cornelian. The quantity of it which is obtained is not very abundant, nor are the pits very extensively worked.

But these are not the real quarries where the celebrated Oberstein agates are obtained. These beautiful stones come from the hills in the neighbourhood of Idal, about two miles distant from Oberstein, along the road to Saarbruck. The polishing-mills also are at Idal, and this place must be considered as the real centre of the agate trade.

Before however describing the quarries themselves, I must briefly describe the geological character of the intervening country. All traces of stratified or sedimentary deposits cease with the conglomerate which overlies the amygdaloidal rocks of Oberstein. This rock here forms lofty cliffs, and has, at first sight, a generally greenish hue: it contains numerous small vesicular cavities filled with zeolites, carbonate of lime and other crystalline substances, as well as siliceous deposits. The matrix of the rock, however, is very compact, rather porphyritic, and of a dark brown or chocolate colour, and when exposed to the weathering and atmospheric influences by which the contents of the numerous small cavities have been decomposed, assumes the appearance of a brown vesicular trap rock. The green hue is derived from the exposed surfaces of the imbedded substances. The real agates are not usually found in this amygdaloid; looking at it from a distance there is a faint appearance of general stratification parallel to that of the overlying conglomerate, though on a nearer approach nothing of the kind is visible in the rock itself.

Leaving the town of Oberstein, and proceeding westwards up the valley, the same greenish-brown amygdaloidal trap continues for some distance, but in places becomes more porphyritic or hornstone-like, and is studded with small agates and chalcedonic pebbles or nodules, which appear sometimes to run in lines not unlike flints in the chalk formation, though the nodules are generally at a greater distance from each other.

Proceeding further up the valley, these porphyritic and amygdaloidal rocks are underlaid by others of a more compact and more decidedly igneous character; they are, first, a pale reddish porphyry, very close-grained and compact, with small grains of a white opake substance, or of a transparent siliceous appearance, imbedded in a pale red paste; secondly, a brown, chocolate-coloured, compact, homogeneous rock, resembling hornstone in its fracture; while, thirdly, still further to the N.W. or W., these rocks are suc-

a. Red conglomerate.
b. Green amygdaloid.
c. Porphyry.
d. Greenstone.
e. Trap rock with agate nodules.

ceeded by a highly crystalline greenstone. The precise points of junction between these different rocks are much obscured by the fallen detritus of the hills, and could not be clearly made out during my hasty examination, but the greenstone occurring near the middle of the valley, and the furthest removed from the point from which the red conglomerate beds dipped, was the lowest of these igneous rocks, and therefore probably constituted the nucleus of the volcanic action of this portion of the district.

About a mile further to the N.W., after crossing the valley in a diagonal direction, is the little village of Idal, immediately beyond which the hill rises gradually to the W. and N.W. It is in the upper portion of these hills that the principal agate quarries are found. Near the summit is an escarpment fifty feet in height, facing the W.N.W. The formation of which the hill consists is a greenish-brown trap rock, with a slight appearance of irregular stratification in that portion of it which contains the agates, dipping, if it can be so called, at a very slight angle to the E.S.E., viz. towards Idal. It here consists of two varieties alternating with each other in beds varying from two to four or five feet in thickness, and it is, in fact, this alternation which gives the appearance of real stratification. One of these varieties is much softer than the other, and of a more amygdaloidal character. It contains numerous irregularly-compressed, almond-shaped nodules, varying in size from an inch to a foot in length, most if not all of which, on being broken, prove to be chalcedony or agates. It is worthy of observation, that the length of the nodules corresponds with the inclination of the bed, and that their direction is always parallel, thus suggesting the idea that the lengthening-out of the cavities has been owing to pressure while the mass was still in a viscous state.

The other stratum is of a much harder nature, more compact, and with a more decided cleavage; this however is very irregular, and resembles what may be called wedge-shaped cleavage. The colour, too, is generally browner than that of the former, showing a certain degree of yellow ochreous oxydation on the exposed surfaces, but its most remarkable feature is the total absence of all amygdaloidal character; it contains no nodules whatever, neither agates nor concretions of siliceous or other matter.

The quarries themselves are opened in the escarpment above-mentioned, and penetrate some distance into the rock, keeping as much as possible in the softer beds containing the nodules, and therefore descending slightly with the inclination of the mass. In some of these quarries, where however no work was then going on, I observed several alternations of the two varieties of trap formation which I have just described, but could not distinguish any marked line or separation between them, and they seemed to pass gradually into each other. I was unable to arrive at any satisfactory explanation of this difference of appearance. The igneous character of the rock is too apparent to allow us to conclude that this is real stratification, and the complete union of the beds precludes the idea of their being different *coulées* successively poured forth over each other. Even supposing them to be altered metamorphic rocks, the fusion which they have undergone has been so complete as to have entirely destroyed all trace of stratification, and to have reduced the whole mass to one homogeneous paste. Yet how came this remarkable alternation? It may be owing to some chemical or perhaps electrical causes, by which the siliceous particles have in the softer beds been segregated from the mass and collected together in the vesicular hollows, thus forming the agate nodules, while in the other and harder beds these siliceous particles remained disseminated throughout the whole mass, thus giving them a greater degree of hardness and uniformity.

The agate nodules themselves vary much in character, colour and substance; the smaller ones are generally completely solid, the whole cavity being filled up with the compact chalcedonic mass, generally of an uniform pale ash-grey colour; those of a larger size are more frequently veined with layers or bands of different colours, and are invariably hollow, the outer circumference consisting generally of the same pale grey chalcedony as in the smaller nodules, varying more or less in the coloured bands, which however are not always at once perceptible; this outer portion varies in thickness from a quarter of an inch to about an inch and a half; the interior is generally lined either with botryoidal mammillations, or with imperfect quartz crystals, which sometimes assume a bright amethystine colour. It is only the outer or compact portion of the nodule which forms the real agate, the rest being of too brittle a nature to bear polishing, unless when occasionally perfect crystals are found. Some portions of these chalcedonic agates, which have undergone a slight degree of decomposition from the effects of exposure to the weather, show the original mammillated structure of the successively-formed bands or layers, superimposed on one another in an inverted or contrary order to that in which they were formed. The great proportion of these agate nodules are however unfit for any purposes of trade, in consequence of the thinness of the outer portion.

One remarkable feature of these agate nodules, and which marks an important difference between this rock and the usual class of amygdaloidal traps, including even the neighbouring rocks of Oberstein, is, that in most cases, and particularly when the nodules are of any considerable size, they are found to be compressed, flattened out, and as it were elongated. This peculiarity is important when we come to consider the origin and formation of the agates, inasmuch as, in connexion with the large size which some of them attain, it would seem to preclude the idea of the siliceous particles having been deposited in pre-existing vesicular cavities caused by the expansive power of gases during the consolidation of the igneous rock, in the same manner as the cavities found in some kinds of vesicular basalts and trap rocks are filled up: are we not rather led to the conclusion, that the hollows in which the agates are now found were caused by the molecular aggregation of the siliceous particles compelling the surrounding matter to yield in proportion to the intensity of the attraction of these homogeneous particles?

On the other hand, the still existing hollows in some nodules, and the concentric nature of the bands of siliceous matter which lines the surface of these cavities, bearing such evidence of the deposition of the outer prior to that of the inner layers, prove that at the very period when the deposits were first commenced, the cavities had generally assumed the form and shape which they now retain. Perhaps however the wavy and broken lines which these concentric bands often display, assuming almost the contortions seen in the old altered rocks, may be the evidence that these vesicular hollows *did* undergo very considerable alterations of form, being sometimes contracted in one direction, or expanded in another, after the deposition of the first laminæ, and during the gradual formation of the nodule itself and the deposition of the inner layers.

The alternation to which I have already alluded, of the soft beds containing the agates with the harder compact beds in which no such cellular cavities exist, would seem to point to some important change having taken place subsequently to the consolidation of the beds, and may perhaps tend to the confirmation of the idea that these cavities, if formed during the cooling of the beds, must have been altered in their shape by pressure either previously to the deposit of the chalcedonic matter, or during its gradual formation.

The solution of this difficulty, and of the apparent contradiction which it involves, is well-deserving the attention of geologists, and I am happy in being able to state that Professor Nœggerath of Bonn is now particularly directing his attention to the full examination of all the phænomena connected with the agates of Oberstein.

I have already alluded to the fact of the agate-workers of Oberstein having learnt from Italian artists the means of artificially changing the colour of the agates. In some cases the ash-grey layers of the agates of Idal become, under this treatment, of a dark brown or chocolate colour, and in a few fortunate instances where the arrangement of the strata is appropriate, and the different bands are sufficiently strongly contrasted, the effect of the treatment is to produce alternate black and white, or brown and white layers, resembling the onyx, and even sardonyx. In fact, it appears probable that all the onyxes of the present day are the result of this treatment, and there is good reason to believe that not a few of those which have come down to us from ancient times were produced in the same way.

In confirmation of this view I must refer to an interesting paper by Professor Nœggerath, published in the 'Neues Jahrbuch,' No. 4, for 1847, entitled, "The art of colouring Onyxes, Cornelians, Chalcedonies and other similar stones, in explanation of a passage in Pliny." It is here stated that the present mode of colouring agates, and thereby producing very beautiful onyxes, is an art which has been long known to the lapidaries of Italy, but the knowledge of which has only been introduced into Oberstein within a few years. This agrees with the information which I myself received at Idal. The process is described as follows:—The stones being first well-washed, are placed in honey and water in a clean earthen vessel; this is set in the ashes, or on a warm stone, but must not be allowed to boil, and the agates must be kept always covered by the fluid for a fortnight or three weeks. When taken out they are cleaned and placed in another vessel in sulphuric acid, by which they must also be completely covered. This vessel should be covered over with a slate and also placed amongst hot ashes. Some of the softer and more porous stones or layers are coloured in a few hours, others require several days, while some are not at all affected by the sulphuric acid.

This account nearly corresponds with that which I had already received from Signor Pistrucci, the engraver to the Mint, and one of the most celebrated engravers of cameos and precious stones of the present day; the only difference in the process consisting in the substitution, according to Signor Pistrucci, of olive oil for honey, and that the immersion did not last so long. This remarkable property of the agate appears to be owing to the different degrees of porosity of the different layers of the stone, whereby they are liable to be penetrated by colouring fluids in different degrees, the sulphuric acid carbonizing the vegetable matter already absorbed by the stone.

There is only one further point respecting these Oberstein agates to which I wish to call the attention of the Society. The change of colour being owing to the porosity of the different layers, it is stated by Prof. Nœggerath that some species of chalcedony are found to be so porous that the minute hollows by which the stone is penetrated can be seen by means of a magnifying-glass; they appear like bubbles either round or long, occasionally indeed being drawn out to a considerable length as compared with their breadth, and sometimes running into one another, or as it were anastomosing. In general, however, these hollows are so extremely minute that they are only visible with microscopes of very high power. The real fact is, that under a very powerful microscope, those agates which are generally supposed to be of an amorphous uncrystalline structure, do exhibit a series of concentric rings parallel with the outer circumference, each of which is composed of a congeries of minute radiating fibres at right angles to the rings or bands of colour, the incipient germs of crystallization invisible to the naked eye, and resembling what the Germans appropriately call *faserig,* such as we see in fibrous gypsum and in stalactites. It is no doubt through this fibrous structure that the fluids penetrate by which the colour of these stones is artificially altered.

The running together of the hollow cavities, described by Prof. Nœggerath, is evidently another phænomenon, and closely resembles the anastomosing process of the vascular structure, as described by Mr. Bowerbank in the paper above quoted, where he also describes other specimens from Oberstein without any anastomosing appearances, but exhibiting numerous long and thread-like fibres representing the radiating appearance to which I have just alluded. Many too of the agates so examined under the microscope had no doubt been artificially coloured, and thence may possibly have been derived the colouring matter described by Mr. Bowerbank, if indeed any colour can be fairly distinguished in an object examined with a power of 800 linear.

In concluding these remarks, I do not wish to be understood as denying the possibility of flint stones and chert, or even the red cornelian veins from the conglomerate beds of Oberstein, containing remains of organic structure; but as I cannot agree with Mr. Bowerbank's theory of attributing all flint stones and chert to a spongeous origin, I am bound to protest against its applicability in any degree to the agates of Oberstein.

January 16, 1848.

Since reading the above paper I have had an opportunity of examining what are called the moss-agates of Oberstein through Mr. Bowerbank's powerful microscopes, and am quite willing to admit that they unquestionably contain remains of spongeous structure. How far they are really found at Oberstein, or merely brought there to be polished, is another question. On the other hand, Mr. Bowerbank does not, I find, contend for the spongeous origin of those agates which are found in trap rocks and amygdaloidal formations, but only of those which with chalk-flints and chert may be said to be of aqueous origin. Thus the apparent discrepancy in our views is in a great measure mitigated and removed.

February 1, 1848.

FEBRUARY 2, 1848.

James Hall, Esq., State Geologist for New York, was elected a Foreign Member of the Society.

The following communications were then read :—

1. *On the Organic Remains found in the* SKIDDAW SLATE, *with some Remarks on the Classification of the Older Rocks of* CUMBERLAND *and* WESTMORELAND, *&c.* By the Rev. Professor SEDGWICK, M.A., F.R.S. & G.S., &c.

ALTHOUGH the successive groups into which the rocks of the Lake-mountains of the north of England may be conveniently divided has been the subject of repeated discussions during former meetings of the Society, I think it expedient in the first place (as far as possible suppressing all details) to enumerate these groups in their natural ascending order :—

§ 1. *Successive groups.*

1. Granite of Skiddaw Forest.

2. Immediately over the granite, which is found in the centre of Skiddaw Forest, we have the group of Skiddaw slate, of very great but unknown thickness, and forming hills reaching the height of 3000 feet.

3. The Skiddaw slate is overlaid conformably by the vast group composed of feldstone, feldstone porphyry, trappean breccias, trappean grits, trappean shales, &c., alternating indefinitely with quartzose, and more or less chloritic, roofing-slate, generally of a green colour. This group is more or less regularly bedded ; the trappean rocks, whether erupted or recomposed, being all contemporaneous with the period of the slates, and not protruded at any after-epoch. The igneous rocks end (with a very limited exception) abruptly, and do not reappear, in a similar form, among the upper groups*.

* The whole period is one of nearly continuous plutonic or volcanic action, and the most regularly bedded slates are interlaced indefinitely with recomposed plutonic and erupted matter. The same period of ancient volcanic action is marked

4. Over the preceding rocks, and in a conformable position, comes a group about 1500 feet thick, chiefly composed of slate and flagstone of a dark colour. All parts of this group are more or less calcareous, but the lowest beds contain so much calcareous matter as to pass into a limestone (Coniston limestone).

5. Next comes a group of coarse, hard, light-coloured grit and sandstone. It is of variable thickness, sometimes however much thicker than the preceding group; and it is the commencement of a great physical change in the nature and colour of the deposits.

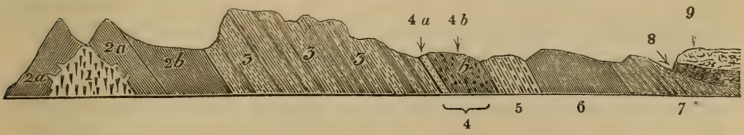
6. The preceding group is followed by a complex deposit containing many thin beds like those last described, but also containing large masses of roofing-slate and flagstone (Ireleth slate). It is of very great thickness, and in its lower division contains in some places a very thin band of impure concretionary limestone.

7. Over the preceding group (and separated from it by beds with a somewhat intermediate type) comes the complicated deposit, composed of sandstone, flagstone, &c., which is developed between the hills immediately north of Kendal and the valley of the Lune near Kirkby Lonsdale. In the upper part of this series are some greenish and reddish flagstones, which mineralogically resemble the tilestone of the Silurian system, and appear to occupy the same place in the series.

8. Old red conglomerate, containing here and there concretions of limestone, and occasionally rolled fragments of limestone derived from the older rocks (Coniston limestone, &c.). As a general rule, this deposit is perfectly unconformable to all the older rocks, filling up the inequalities and hollows on their outskirts in discontinuous masses, and generally at a comparatively low level, reminding us of the shingles of an ancient shore or shallow sea.

9. Carboniferous limestone, sometimes resting conformably on the upper beds of the red conglomerates; and, where they are wanting, resting unconformably upon the older groups. In its long unconformable range it forms a belt about the Cumbrian cluster of mountains, so as to rest near Whitehaven on the Skiddaw slate, and near Kirkby Lonsdale upon the red beds of tilestone.

Ideal section from Skiddaw Forest to the calcareous hills of Westmoreland.



1. Granite-centre of Skiddaw Forest.
2. Skiddaw slate; 2 *a*, metamorphic; 2 *b*, unchanged.
3. Green roofing slate and porphyry, &c.
4. Coniston limestone; 4 *a*, limestone; 4 *b*, calcareous flagstone.
5. Coarse-grained siliceous grits.
6. Ireleth slates, &c.
7. Slaty flagstone ending in tilestone.
8. Old red conglomerate.
9. Carboniferous limestone.

The accompanying section is so far ideal that it leaves out all contortions and dislocations; but it gives the right sequence, and may

by the vast deposits forming the oldest and highest ridges of North Wales. In Cumberland this group (No. 3) is, I think, not less than 20,000 or 30,000 feet in thickness.

therefore assist the memory and help the reader in comprehending the facts here stated, and the inferences which seem to follow from them.

§ 2. *Classification of the preceding groups, &c.*

I would first remark that all the preceding groups are true physical groups; and I may venture to affirm, that any one examining the region in detail would inevitably be led into some arrangement, at least, nearly resembling that given above, and without any reference to the consideration of organic remains. Good physical groups are the foundations of all geology; and are out of all comparison the most remarkable monuments of the past physical history of our globe, so far as it is made out in any separate physical region.

Organic remains are, in the first instance, but accessories to the information conveyed by good sections. But when the successive groups of organic remains are once established, in coordination with actual sections, they then tell us of successive conditions of organic life, which were (as we know by experience, and might perhaps have conjecturally anticipated) of far wider geographical extent than the local physical movements which produced the successive groups of deposits. Hence it follows, that in comparing remote deposits, organic remains become no longer the secondary but the primary terms of comparison. It was plain, at first sight, that the organic remains of the Coniston limestone were entirely different from those of the highest group of the slate series (No. 7). This I saw in 1822. But what was their general place in the old British series? The rocks of Devonshire were considered by all geologists of that day of extreme antiquity, and were of much older aspect than the arenaceous slates and flagstones of Westmoreland; but they contained a series of fossils with several species identical with those of the mountain limestone; whereas the fossils of Coniston and Kirkby Moor had not, so far as was known, one species common to the mountain limestone. Here was the first great difficulty which I encountered so far back as 1822, and which was not solved before 1838. After examining a portion of North Wales in 1831–1832, I felt all but certain that the great mass of slates and porphyries of Snowdonia were coeval with the green slates and porphyries of Cumberland (group No. 3); and this opinion I still retain. At that time my Cumberland and Westmoreland fossils were inaccessible: but on the best evidence I then possessed I ventured to conclude, that the green slate and porphyries were the equivalents of the Snowdonian series—that the Coniston limestone represented the Bala limestone—that the contorted slates of South Wales were the equivalents of the Ireleth slates (group No. 6)—lastly, that the highest group (No. 7) represented the Silurian system in an imperfect and degenerate form. So soon as I had unpacked my fossils in a subsequent year, I revoked this opinion. The Coniston limestone appeared not to represent the Bala limestone, but a higher group (Llansaintffraid limestone); and no traces of Lower Silurian species were found in the higher groups (Nos. 5, 6 and 7). Mr. D. Sharpe soon afterwards published (with many excellent and new details) a nearly similar classification. We now know the true coordination of the groups above described, first taking the rocks of the Silurian system as our type. The lower part only of the group (No. 4), Coniston limestone and flagstone, contains true Lower Silurian species. All the higher parts of the section are, therefore, Upper Silurian till we touch on the red conglomerates. A re-arrangement on fossil evidence only disturbs one great physical group (No. 4) ; the others fall into strict zoological coordination. In like manner the results derived from the Westmoreland section only disturb one of Sir R. I. Murchison's groups ; by teaching us (what indeed would follow from fossil evidence) that the tilestone is to be regarded, not as a part of the old red sandstone, but as the top of the Upper Ludlow series. Surely if a conclusion like this proves the great value of fossil evidence, it also shows the great importance of definite physical groups of deposits ; one set of phænomena running in very near coordination with the other*. In further illustration of what is here stated, I may appeal to the recent labours of Mr. Prestwich in determining the true comparison between the London and Hampshire tertiary basins. It is not by accumulating descriptions of organic remains, or by elaborate sections, that he has worked out his evidence ; but it is by taking and weighing together both species of evidence that he has produced a beautiful coordination between the distant parts of our contemporaneous tertiary deposits.

Taking for granted what has been above stated, viz. that the Coniston limestone and a part of the overlying flagstone represent the Lower Silurian rocks, and that a portion of (No. 4) and all the other overlying groups do in order represent on a noble scale the whole Upper Silurian system,—what are we to say of the green slates and porphyries ? and what of the Skiddaw slate ?

I have before stated my conviction that the great group (No. 3) was the true equivalent of the great Cambrian group (or groups) of North Wales, forming the higher mountains of Carnarvonshire and Merionethshire. But the great Welsh group contains fossils almost to its base, though in the lower part of it they become very rare. The great Cumberland group has not yet been proved to contain a single fossil. This I have endeavoured to explain by referring the negative fact to the enormous masses of contemporaneous igneous products (either direct or recomposed) which have either destroyed the traces of organic life, or prevented the development of organized bodies during the long period of the older Cumbrian slates. Here, then, was an imperfection in the generalization. It was formed partly on hypothesis, and partly on physical development and geological position ; but not on positive identity of fossils. But the Skiddaw slate is not metamorphic, (except in its lower part, which is highly metamorphic, and which I do not profess to describe in this paper,) and contains many arenaceous and earthy beds, in which we might expect to find traces of fossils, had such existed during the period of deposit. I have stated in former papers, that I found no

* If our classification had been based on the Westmoreland sections, I think No. 5 would have been regarded as the commencement of the Upper Silurian series.

traces of organic remains in this group which I could quote with any confidence; but I did (during 1822, when I was first employed on this group) find several traces of carbon, which have often suggested the idea that they must have been derived from some obscure forms of vegetable life, such as fucoids.

In some letters on the Lake district, written about six years since, I mentioned the plumbago found among the slags of our iron-furnaces, and also on the sides of trap dykes traversing the coal strata. Of such appearances, I added, that we could give an intelligible account; and though I did not venture to account for the sublimation of the carbon found in the plumbago mines of Borrowdale, I suggested the possibility of its being derived from the Skiddaw slate, which I believed to contain, here and there, a small proportion of carbon. I mention this to show that the idea of vegetable matter existing during the period of the Skiddaw slate was not a new thought. During the last summer my own engagements prevented me from undertaking the re-examination of the Skiddaw slate; but I examined my old note-book of 1822, and gave a line of march to Mr. John Ruthven of Kendal, requesting him to examine all the most promising localities; devoting his best efforts to the detection of any traces of organic life, vegetable or animal, however obscure. The result of his labours, continued with untired zeal for several weeks, was the discovery of two species of graptolites and two genera of fucoids in the Skiddaw slate. The accompanying catalogue by Mr. M'Coy contains a description of the species, which are now on the table of the Society, with a reference to the localities, and is intended to form an appendix to this paper*.

No fossil shells and no other undoubted organic structures were found in the Skiddaw slate; and it deserves remark, that in the greater part of this slate the beds do not effervesce with acids. By this test we can generally separate the Skiddaw slate from the dark-coloured slates of the groups above the Coniston limestone; a fact first noticed nearly thirty years since by Mr. J. Otley of Keswick, but in no connexion with any speculation on the absence or presence of fossil shells. Here then we have taken away a part of the difficulty, already alluded to, in the comparative arrangement of the older rocks of Wales and Cumberland. The great slate and porphyry group (No. 3), so far as we know, does not contain fossils; but it does contain much calcareous matter, and it does overlie a group with fossils. It is therefore not only possible, but highly probable, that under conditions more favourable to the development of organic life, other contemporaneous deposits (such as the older Cambrian slates) may exist with abundance of fossils. Hence, though the comparison between the older groups of Wales and Cumberland is not yet per-

* The fossils are rather obscure, but of their organic nature there can be no doubt. Some of them were first considered as Annelides: but the graptolites, are well defined. So far as regards my immediate object, the specific character of the fossils is a matter of indifference—my main object being at present only to show that the Skiddaw slate is not below the limits of organic life; and, hence, that the great group, No. 3, must belong to an organic period.

fect, it is more nearly perfect than it was before the discovery of organic remains in the Skiddaw slate.

I will not detain the Society with any account of a second excursion also made by Mr. J. Ruthven, under my direction, during which he found graptolites and other traces of fossils in localities where I should hardly have expected them. During this excursion he examined the lower arenaceous and slaty beds as they descended into the metamorphic group. In these he found no fossils of any species, though among the arenaceous beds impressions of encrinites and shells might have been preserved, had such ever existed.

§ 3. *Concluding Remarks.—Nomenclature, &c.*

1. I believe that the fossils above described belong to the oldest fossil group of the British Isles; nor does it appear that any older fossil group has been found in America, Norway, or any other country yet examined.

2. Does this group mark the descending limit of organic life? My belief is that it does nearly mark the limit. This is no new opinion, as I have often stated my conviction that the traces of organic life disappear in the descending sections, independently of their obliteration from metamorphic action or mineral change. This may be called an hypothesis, and I am willing that it should pass as such, and that it should be withdrawn when it is disproved. But what is the Huttonian view (viz. that there is no descending limit of organic life) but another form of hypothesis? Moreover it is an hypothesis not suggested by fact, but by some supposed analogy between geological and astronomical cycles. And again, this hypothesis appears to me opposed to physical evidence derived from considerations of temperature and of the figure of the earth.

3. The base of the Cumberland series is more perfect and symmetrical than that of Wales, which has no zoological or physical true base-line. On a review of the whole case, I conclude that the Lingula beds (and those beds below them near the Merioneth anticlinal) are all above the greater part of the Skiddaw slate.

4. By what names shall we define the great groups above noticed? The Skiddaw group cannot be correctly coloured as one with the overlying slate and porphyry group, and lose its name. Physical development opposes this view, and organic remains do not confirm it. But it is a matter perhaps of indifference by what name (such as Skiddaw group, Taconic group, protozoic group) we may hereafter please to designate it.

5. If we are to pay any regard to physical development, we cannot regard the vast group of slate and porphyry (No. 3) as only a portion of the group of Coniston (No. 4). It is the equivalent of the great Cambrian slate group, and is out of comparison the most remarkable physical group in the British Isles; and I will venture to assert that no man can describe the older rocks of South Britain without giving this group a prominent place. Its true name may be either the great Cumbrian or Cambrian slate group.

6. All the higher rocks (up to the old red conglomerates) are parts

of the Silurian system, in the true original sense of that term. I have already shown their beautiful coordination to the true Silurian sequence, viz. Caradoc, Wenlock, Lower and Upper Ludlow, ending in Tilestone.

7. But there may arise this question,—May not all the rocks, from the Skiddaw slate to the tilestone, be called the Silurian system? No doubt they may. But then arises another question,—Do all, or the greater part of the rocks below the Coniston limestone belong to the Silurian system, as the words were first used and as they now have currency? Are they the equivalents of any part of the Caradoc or Llandeilo series of that system? To such a question I can only give, as I have done before, a decided negative; and I believe that the assumed identification of beds in North Wales with the Caradoc and Llandeilo groups, because they contained certain fossils described in the Lower Silurian system, has led often to an entire misinterpretation of the sections and the natural sequence presented by the physical groups. My objection to the extension of the term Silurian system to all the lower groups resolves itself into this proposition,—that no geographical name ought to be permanently accepted which does not refer us to a region containing a good typical series of the rocks so designated. Siluria does not contain a good series of the lowest fossil groups; Cambria does.

8. To this remark a reply has been made consisting of two statements: *first*, that the lower Cambrian or Cumbrian groups are without peculiar fossils. This is not quite correct; and supposing it true that every species below the Caradoc group was also found in that group, the fact would only prove that the Caradoc group ought not to have been cut off from the Cambrian series, and that so far the Silurian system was without any zoological base-line. In no sense can it be truly stated that the great Cambrian group is sterile of fossils, and must therefore pass without a name. If it have very remarkable physical characters and a great series of fossils, it must have some designation as a group. We cannot, while describing, in the order of nature, an ascending series of groups, wait for their designation till we reach some higher and much more inconsiderable group, and then give back by reflection a name to the groups of anterior date, and already described. The *second* statement, in opposition to the previous views, is to the following effect: that the older fossil-bearing groups in the Cambrian slates are only the development downwards of the lower parts of the Silurian system. I can comprehend a progressive development from an older formation to a newer, and I believe that the Caradoc sandstone group might correctly be considered as the last development of a vast series of slate rocks, of which the true base is probably to be sought in Cumberland, among the central slates of Skiddaw. But a development downwards is something out of nature, when we speak of geological deposits, and involves a positive solecism both of language and meaning. The application of these remarks to the classification and nomenclature of the older rocks of Wales and Cumberland is too obvious to require any further comment.

Note on the Skiddaw Slate Fossils.

The specimens, both of Fucoids and Graptolites, are as follows, together with the localities in which each is found :—

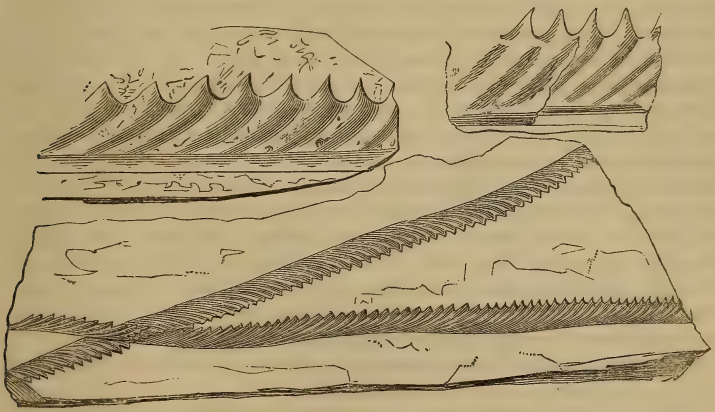
Graptolites sagittarius (His. sp.), Scawgill; Knockmurton.
Graptolites latus (M'Coy), n. s., Scawgill; Knockmurton, near Lamplugh Cross.
Chondrites informis (M'Coy), n. s., Whiteless.
Chondrites acutangulus (M'Coy), n. s., Low Fell.
Palæochorda minor (M'Coy), n. s., Scawgill; Blakefell; Under Crag; Whiteside; Whiteless.
Palæochorda major (M'Coy), n. s., Kirk Fell; Under Crag; Whiteless.

The new species marked above may be described as follows :—

GRAPTOLITES LATUS (M'Coy), n. s.

Spec. Char.—Straight, one edge entire; the other with small, close, conical, very slightly-arched crenulations, touching each other at their bases, and scarcely equalling in length half the width of the undivided portion of the stem, which is 1 line wide.

Compared with the *Graptolites sagittarius, G. Ludensis, G. Sedgwickii, G. distans,* and the other species with the serrations on one side, this is distinguished by the very great width of the smooth, undivided portion of the stem, and the comparatively small, close, little-curved, saw-like character of the serrations themselves. I had previously distinguished the species in the shale of Builth Bridge.



CHONDRITES INFORMIS (M'Coy), n. s.

Spec. Char.—Frond thick, frequently and irregularly branching at short distances; branches short, irregularly elongate fusiform, lateral, unequal, about one-third less than the continuous straight portion, and scarcely half the diameter of the frond before division: average diameter of fronds below a division 5 lines, but varying from 7 to 2.

The above description, when taken in connexion with the geological position, will probably render this species easy of recognition.

CHONDRITES ACUTANGULUS (M'Coy), n. s.

Spec. Char.—Frond irregularly undulato-rugose, cylindrical, rigid, several times dichotomous at a very acute angle (about 20°); diameter throughout, both before and after branching, 2½ lines.

In general habit and appearance this is more simple, rigid and rugose than the ordinary species of *Chondrites*, and, as well as the preceding species, is not unlike *Münsteria*, but the surface is without lineation. The present species differs strongly from the *Fucoides* (*Chondrites*) *rigida* and *F.* (*Ch.*) *flexuosa* of the American *Taconic* slates, and the *F.* (*Chondrites*) *antiquus* of the old Norwegian schists, by the length, rigidity and straightness of its branches, and the acuteness of the angle at which it dichotomises. Specimens 5 inches long show only two branchings, and are nearly uniform in diameter throughout.

PALÆOCHORDA (M'Coy), new genus (*παλαιὸς*, *antiquus*, and *χορδὴ*, *chorda*).

Gen. Char.—Frond very long, cylindrical, cord-like, very slowly tapering at each end; surface smooth (? rarely dichotomous).

That the many long, worm-like fossils to which I give this name really belong to the vegetable kingdom, I think cannot be reasonably doubted if we compare them with such sea-weeds as the common *Chorda filum* of our coasts. The naturalist who described the *Nemertites* for Sir Roderick Murchison's work, does not seem to have thought of the cord-like sea-weeds just mentioned, or it is possible he might have referred that genus also to the vegetable kingdom, a view which seems to be supported by a specimen identical with *Nemertites* in the Cambridge Museum, one end of which seems rooted to a small pebble in the slate. There is no reason for considering either the present fossils, or the closely-allied *Gordia marina* figured by Mr. Emmons from the Taconic rocks of North America, as belonging to the animal kingdom. In neither of them is there any trace of feet, cirri, or any other organs; nor even of annulations (although this latter character of worms might even be in some measure represented in a deceptive manner by the diaphragms of the recent plant to which I have alluded).

The specimens were no doubt at one time cylindrical, but are now more or less compressed. There seem to be two species, distinguished by their difference of diameter and rigidity, as shown in the complexity of their folds.

PALÆOCHORDA MINOR (M'Coy), n. s.

Spec. Char.—Diameter of subcompressed fronds 1 line; length unknown (no perceptible change of diameter in 13 inches), generally coiled in numerous, complex folds.

It is in a fragment apparently of this species that I think I have observed dichotomy, but neither the fact nor the identity of the species can in this instance be clearly ascertained. This is a much more abundant species than the following, from which it is constantly distinguished by its much smaller diameter, the greater complexity of its folds, indicating a less rigid frond; there is also a slight subnodulous irregularity of the frond, which we do not see in the other species.

PALÆOCHORDA MAJOR (M'Coy), n. s.

Spec. Char.—Diameter of subcompressed fronds 2 lines; length unknown (no perceptible change of diameter in a length of 9 inches), generally coiled in a few large simple folds.

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2. *On the Fossil Remains of Birds collected in various parts of* NEW ZEALAND *by* MR. WALTER MANTELL, *of* WELLINGTON. By GIDEON ALGERNON MANTELL, Esq., LL.D., F.R.S., Vice-President of the Geological Society.

IT is not a little remarkable that one of the most interesting palæontological discoveries of our times, namely the former existence of a race of colossal Ostrich-like birds in the islands of New Zealand, though made in a British colony, and announced to the scientific world by an eminent British physiologist, has not hitherto been brought under the immediate notice of the Geological Society of London. I therefore consider myself particularly fortunate in having the opportunity, through the researches of my eldest son, Mr. Walter Mantell, of submitting for the examination of the Fellows of this Society, perhaps the most extraordinary collection of the fossil remains of struthious birds that has ever been transmitted to Europe, and which contains the crania and mandibles, egg-shells, and bones, of several genera and species, most, if not all of which have probably long been extinct.

The first relic of this kind was made known to European naturalists by Professor Owen, in 1839. It consisted of the shaft of a femur or thigh-bone, but a few inches long, and with both its extremities wanting; and this fragment so much resembled in its general appearance the marrow-bone of an ox, as actually to have been regarded as such by more than one eminent naturalist of this metropolis. And if I were required to select from the numerous and important inductions of palæontology, the one which of all others presents the most striking and triumphant instance of the sagacious application of the principles of the correlation of organic structure enunciated by the illustrious Cuvier,—the one that may be regarded as the *experimentum crucis* of the Cuvierian philosophy,—I would unhesitatingly adduce the interpretation of this fragment of bone. I know not among all the marvels which palæontology has revealed to us, a more brilliant example of successful philosophical induction—the felicitous prediction of genius enlightened by profound scientific knowledge.

The specimen was put into Professor Owen's hands for examination, with the statement "that it was found in New Zealand, where the natives have a tradition that it belonged to a bird of the Eagle kind which had become extinct, and to which they gave the name of Movie;" and from this mere fragment, and with this meagre history, the Hunterian professor arrived at the conclusion, "that there existed, and perhaps still exists in those distant islands, a race of struthious birds of larger and more colossal stature than the Ostrich or any other known species." This inference was based on the peculiar character of the cancellated structure of the bone, which differs from that of mammalia, and most closely resembles that of the Ostrich. And so confident was Professor Owen of the soundness of his inductions, that he boldly added, "so far as my skill in interpreting an osseous fragment may be credited, I am willing to risk the reputation for it on this statement;" and he further remarks, "The discovery of a relic of a large struthious bird in New Zealand is one of peculiar interest, on account of the remarkable character of the existing fauna of those islands, which still includes one of the most extraordinary and anomalous genera of the struthious order, the *Apteryx*; and because of the close analogy which the event indicated by the present relic offers to the extinction of the Dodo of the island of the Mauritius. So far as a judgement can be formed of a single fragment, it seems probable that the colossal bird of New Zealand, if it prove to be extinct, presented proportions more nearly resembling those of the Dodo, than of any of the existing *Struthionidæ*." In 1843 the correctness of these views was confirmed in every essential particular by a large collection of bones obtained by the Rev. W. Williams and transmitted to the Dean of Westminster; and still further corroborated by another interesting series brought to England in 1846 by Percy Earl, Esq.; and by the collection which forms the immediate subject of this communication.

My eldest son, who went to New Zealand in 1839, and settled at Wellington, in one of his earliest letters to me after his arrival, mentioned that a tradition was prevalent among the *Maories* or natives, that gigantic birds, taller than a man, were formerly abundant throughout the islands; and that some of the oldest of the natives averred that they had seen such birds; and that although much reduced in numbers, some of the race still existed in the unfrequented and inaccessible parts of the country. They called these birds *Moa*, and affirmed in proof of their statement, that enormous bones were occasionally met with in the mud and silt of the streams and rivers; but my son was unable to obtain any of the bones in question.

Upon learning from me of the discovery of the bone described by Professor Owen, he endeavoured to obtain further information on this interesting subject; but until 1846, when he resigned an official situation, he was unable to follow up his inquiries with success. In the meanwhile the collections of the Rev. W. Williams, Mr. Percy Earl, and of other gentlemen, had furnished the materials from which Professor Owen drew up his two celebrated memoirs on the *Dinornis*, an extinct genus of tridactyle Struthious Birds, which were published in the third volume of the Transactions of the Zoological Society.

In 1846, and the commencement of 1847, my son explored every known locality of these relics in the North Island within his reach, and went into the interior of the country and located with the natives, for the purpose of collecting specimens of the then unknown parts of the skeletons, and of ascertaining whether any of these gigantic birds were still in existence; resolving, if there appeared to be even a remote chance of this being the case, to penetrate farther into the interior and obtain one alive. The information he gathered from the natives offered no encouragement to follow up the pursuit, at least in that part of the country, but tended to confirm the idea that the gigantic struthious birds had become extinct, the last of the race having, like the Dodo, been destroyed by man within a comparatively recent period; and that if any of the species whose bones are found in a fossil state are still living, it is probable they will be those of small size, and related to the *Apteryx*, the living diminutive representative of the colossal bipeds that once trod the soil of New Zealand.

With these introductory remarks, which appeared to me necessary to place the history of the discovery in a clear point of view, I propose, first, to notice the geological conditions under which these fossil bones appear to have been accumulated; secondly, to describe in general terms the most remarkable features of the collection before us; and lastly, to offer some observations on the bearing of these facts on that difficult problem, that "*mystery of mysteries*," as it has been emphatically termed by Sir John Herschel, the appearance and extinction of certain types of organic beings on the surface of the globe.

I. *Geological position of the deposits in which the bones occur.*—In attempting to arrive at a correct knowledge of the relative geological age of the deposit in which the bones sent to this country were found imbedded, I have experienced considerable difficulty, in consequence of the unsettled state of the orthography of the various localities, and also from the indefinite manner in which the collectors describe the places whence they obtained the specimens. Unfortunately the letter from my son containing details of this nature, and to which in his subsequent correspondence he refers me for the necessary information, has not reached me. I endeavoured to mark on a map of New Zealand all the localities whence bones had been obtained, but several places mentioned by the collectors are not inserted. I will therefore briefly state the circumstances under which the bones are described as occurring by the gentlemen who have transmitted them to this country.

The Rev. W. Williams, in his letter of Feb. 1842, states, "that none of the bones have been found on dry land, but are all of them from the beds and banks of freshwater rivers, buried only a little distance in the mud. The largest number are from a small stream in Poverty Bay, the river Wairoa, and from many inconsiderable streams, all of which are in immediate connection with hills of some altitude."

A mutilated cranium, described by Professor Owen*, was obtained by Mr. Williams from the bed of a mountain-stream descending to the coast at Poverty Bay in the North Island. Another, sent over by W. Swainson, Esq.†, is from the vicinity of the Bay of Islands. "Both of these have a ferruginous tint and great weight, arising from an infiltration of peroxide of iron; but the cancelli of the bone contain only a little of the dry powdery alluvium of the stream into which the specimens have been washed‡."

The Rev. W. Colenso, who in 1841–1842 accompanied Mr. Williams in search of the Moa, has given a very interesting account of the circumstances under which the bones were procured in the bed of the Waiapu river by the natives, by whom they were sought for to make fish-hooks §. He states, that travelling southward from Poverty Bay, he came within sight of *Wakapunake*, the mountain celebrated among the natives as the residence of the surviving Moas; but no bones were obtained from thence. "The Maories affirmed that Moas lived there, but admitted that no one had seen any of these gigantic bipeds. The Moa's bones were only to be found after the floods occasioned by heavy rains, when they were to be seen after the waters subsided, washed up on the banks of gravel and mud on the river-side; but none were then to be procured. I offered large rewards for any that should be met with, and directed them to be taken to Mr. Williams in Poverty Bay. At the base of the mountain is the river *Wangarao*, which is a branch of the Wairoa, which runs into Hawke's Bay; and down this we paddled for some distance, but perceived no bones. Finding that we were willing to pay largely for specimens, a hundred persons set about hunting for them, and brought those they collected to Mr. Williams." Mr. Colenso states, that hitherto (in 1842) bones have only been found within the waters and channels of those rivers which discharge themselves into the southern ocean between the East Cape and the south head of Hawke's Bay, on the east coast of the North Island. They only occur on the banks of gravel, &c. in the shallowest parts of the rivers after floods occasioned by heavy rains, and when the waters have subsided to their usual level.

"These rivers are in several places at a considerable depth below the present surface of the soil, often possessing a great inclination, as is at once perceived by the rapidity of their currents. They have all a delta of greater or less extent at their mouths, from an inspection of which it is obvious that their channels have considerably

* Zool. Trans. vol. iii. p. 308, pl. 38. † Ibid.

‡ Prof. Owen in Zool. Trans. vol. iii. p. 308.

§ See Annals of Nat. Hist. vol. xiv. New Series, p. 81.

changed. The rocks and strata in these localities indicate generally both secondary and tertiary formations; the former consisting of argillaceous schist, sandstone, conglomerates, greensands, &c.; the latter of clay, marly *calcareous tufa*, sand, gravel, and alluvial deposits." The true situation of the Moa bones is not known with certainty, but Mr. Colenso infers that they are found in the lowermost tertiary deposit. The localities mentioned by Mr. Colenso lie to the east of the volcanic chain of Tongariro, and the rivers probably have their origin on the flanks of that volcanic region.

The collection formed by Dr. Mackellar was from the Middle Island, from a superficial turbary formation on the coast, which was submerged at high tide, and is near the settlement at *Waikawaite*. Mr. Percy Earl, who obtained his specimens from the same locality, mentions that this deposit, which is overflowed by the sea at high tides, had been covered by a layer of sand and shingle; but this covering had been swept away by storm-waves a short time before his arrival, and a bed of black peat was exposed, from the surface of which bones projected; these and other specimens were procured by digging close to the surface, or at a moderate depth in the peat; they were all Dinornis' bones *.

The account given by the Rev. Mr. Taylor of Wanganui, a settlement on the western coast of the North Island, near the embouchure of the river of that name, lying to the south of Cape Egmont, as New Plymouth does to the north, is, in substance, as follows:—

In 1843 he procured a collection of bones during a journey to Turakina (?), from having observed a fragment of large bone, which induced him to inquire of the natives if such relics were to be met with. The Maories pointed out to him several little hillocks of bones, scattered here and there over the valley at the mouth of the river Whaingaihu (?) where the sand had drifted. Mr. Taylor describes these heaps as being composed of bones of several kinds of Moa, as though the flesh of the birds had been eaten, and the bones thrown indiscriminately together. The bones were in so friable a state that only the large ones would bear removal; the smaller ones pulverized in the hand, and below the surface the whole was a mass of decomposed bone. "The subsoil was a loamy marl, beneath which was a stratum of clay that chiefly forms the cliffs of this part of the western coast; it contains numerous marine shells, and closely resembles in appearance the *galt* of the south-east of England. I have no doubt it was when that loamy marl formed the surface-soil that the Moa lived; for although it is laid bare by the river-side, yet in other parts *it is wholly covered by several strata of marine and freshwater deposits*. I have found the bones of the Moa in this bed, not only in other parts of the western, but also in the eastern coast, at the East Cape, and at Poverty Bay. I have not heard of this deposit having been noticed north of Turakina (?) †."

All the specimens sent from the localities above-mentioned, with the exception of those from the South or Middle Island, are in the

* Zool. Trans. vol. iii.

† See Prof. Owen's Memoir on the Dinornis, Zool. Trans. vol. iii. p. 327.

state of the mammalian bones that occur in the ancient alluvial deposits of England. They are permeated and coloured more or less deeply by a solution of iron, and the cancelli are filled by the mud or silt in which they were found imbedded. They are but little water-worn, and have not suffered much abrasion; having, probably, been protected by the muscles and soft parts during their transport to the places where they were deposited. In short, their state of fossilization corroborates the accounts given of the nature of the alluvial bed from which they were procured; they strikingly resemble in this respect the bones of the Irish Elk, Mammoth, &c. of our diluvium.

But the bones collected by my son present a very different appearance from any previously received from New Zealand; instead of being of a dark colour, heavy, and permeated by silt and iron, they are, on the contrary, light and porous, and of a delicate fawn-colour; the most fragile processes being entire, and the articulating surfaces as smooth and uninjured as if prepared by the anatomist: *egg-shells, mandibles,* even the *bony rings of the air-tubes* are preserved. In their general aspect these bones most resemble those from Gaylenreuth and other ossiferous caverns. The state of preservation of these specimens is evidently due to the material in which they were imbedded, which is a loose volcanic sand, containing magnetic iron, crystals of hornblende and augite, &c., the detritus of augitic rocks and earthy tuff. This sand has filled all the cavities and cancelli that have external openings, but is in no instance consolidated or aggregated together; it is easily removed from the bones by shaking, or by a soft brush. A very few water-worn pebbles of volcanic rocks were the only extraneous bodies found in the sand: there are no vestiges of shells of mollusca of any kind; but there is in the collection a small *Arca* imbedded in a sandy clay, and an ammonite coated with pyrites, so like a specimen of *A. biplex* from the Kimmeridge clay of England, as not to be distinguishable from a genuine British fossil.

The name of *Waingangoro*, the locality which my son mentions as that where he dug up the greater part of his collection, does not appear in the maps of New Zealand I have inspected; but from some incidental remarks in his letters, I have reason to infer that it is situated in the higher part of the valley of the Wanganui, a river which has its source in the volcanic regions of Mount Egmont. It was at the embouchure of the Wanganui that Mr. Taylor obtained the bones in his possession. It will be remembered that the streams which yielded the relics procured by Mr. Colenso and Mr. Williams, lie to the east of Tongariro, and probably originate in that elevated volcanic chain, many parts of which are above the line of perpetual snow. The specimens collected by my son were found imbedded in and filled with loose sand, at a considerable distance from the bed of the river; in no instance do they exhibit any traces of silt or fluviatile mud. My son mentions having on one occasion obtained bones from a potato-pit sunk by a native remote from any stream*.

* Wonders of Geology, 6th edition, p. 129.

With the view of elucidating these remarks, and the inferences I shall presently venture to suggest, I will here concisely describe the geological structure of New Zealand, on the authority of Dr. Dieffenbach. This country, which is situated between 30 and 50 degrees of south latitude, forms a group of mountainous islands nearly as large as England and Wales. Its geological structure is with difficulty determined, owing to the primæval forests which fringe the coast; and where these have been destroyed, by impenetrable thickets of esculent fern. The fundamental rock is everywhere clay-slate, which is frequently traversed by greenstone dykes, as at Port Nicholson, Queen Charlotte's Sound, and Cloudy Bay. On the banks of the rivers Eritonga, Waibo, and along some parts of the sea-coast, *there are horizontal terraces of boulders of trap-rocks* 50 *feet high*. Anthracite coal crops out in the harbour of Wangarua; and there is a seam of the same mineral intercalated in the hard grey sandstone on the east coast of the Northern Island. On the west coast of the same, the limestone contains a few shells, as pecten, ostrea, terebratula, and an *Echinus spatangus*. The coasts are in many places fringed with recent horizontal sediments, consisting of loam with fragments of wood and fern, &c. The small rocky islands of trachyte off the coast of the Northern Island also *bear marks of wave-action to the height of* 100 *feet above the present sea-level*. In the interior of the Northern Island there is a lofty central group of volcanic mountains, some of the volcanos being still in activity: the ancient lava-streams appear to have been principally erupted from the base of the craters. The highest mountains are Tongariro, which is 6000 feet, and Mount Egmont, 9000 feet high. The loftiest summits are covered with perpetual snow. There are many lakes, which appear to occupy ancient craters*.

The occurrence of terraces of loam and gravel of comparatively recent date, at an elevation of from 50 to 100 feet above the sea, along the coasts of New Zealand, prove that a considerable change in the relative level of the land and water has taken place since those terraces were deposited, and at no very remote period. The present rivers of the country are described as now cutting deeply the beds of volcanic detritus and silt in which the birds' bones are contained; and the latter are in some places covered by marine and freshwater deposits. The facts adduced appear to me confirmative of the opinion advanced by Mr. Colenso (in 1842), that the true situation of the ossiferous deposit is beneath the surface-soil of the fluviatile beds formed by the present rivers. In the more elevated regions the bone-deposit consists of pure volcanic sand and detritus; while in the low districts and along the coasts it is composed of fluviatile mud or silt, which in many places is covered by modern beds of shingle and gravel.

II. *Description of Mr. Walter Mantell's Collection.*—I will now describe in general terms the most interesting specimens in the collection formed by my son; the anatomical details, and the important physiological inferences resulting therefrom, will be laid

* British Association Reports for 1845.

before the Zoological Society by Professor Owen; to whom, as a tribute of respect due for his masterly interpretation of the bones previously transmitted from New Zealand, I have offered the examination and description of every object in the series that he may consider worthy his attention.

The specimens amount to between seven and eight hundred, and belong to birds of various sizes and periods of growth; some evidently of aged individuals, and others of very young animals, in which the epiphyses of the long bones are still distinct from the shaft. They were catalogued by my son as follows:—

Birds' bones.—*Crania and mandibles*, 19; vertebræ, 250; sterni, portions of, 7; pelves, more or less complete, 30; femora, 37; tibiæ, 42; fibulæ, 35; tarso-metatarsal, 40; phalangeal, 200; ungueal or claw-bones, 30; ribs, 30; *egg-shells*, fragments, 36 specimens.

Seals.—Jaws with teeth, portions of crania, vertebræ, ribs, scapulæ, bones of the extremities.

Terrestrial mammalia.—One femur.

The specimens received exceeded the number above specified, and with the exception of a few of the most fragile (and unfortunately the most precious, as, for example, the mandibles, pelves, sterni), arrived in an excellent state of preservation.

The birds' bones, so far as they have been hitherto examined by Professor Owen, are referable to five genera; the crania and mandibles of three of which were previously unknown.

1. *Dinornis*.—This name is now restricted by Professor Owen to the birds which possessed a skull and beaks essentially different from any form either recent or fossil. Of this genus there is a nearly perfect cranium, with the upper mandible, and portions of two other skulls. The form of the cranium, especially of the temporal and occipital regions, is wholly unlike any hitherto observed in the class of birds, and approaches that of reptiles. It is characterized by the nearly vertical occipital plane, the elevated position and form of the foramen magnum, and the great development below the occipital condyle, and the strong ridges which border the basi-occipital, and indicate a most extraordinary power in the muscles that moved the cranium. The temporal fossæ are very deep, and are strengthened by a prolongation of the mastoid process, which is united to the frontal, and forms what may be termed a lateral zygomatic arch. The tympanic bone has two distinct cusps for articulation with the double condyle of the os quadratum. The configuration of the upper mandible or beak (the lower one is unknown) is very peculiar, and has been aptly compared by Professor Owen to a cooper's adze; and is considered by him to have been especially adapted for grubbing up roots and tubers; and we have evidence, in the powerful muscles attached to the occipital region, of its having been an instrument capable of being used with great force. There is a portion of the articular part of a large lower jaw, that probably belongs to *D. giganteus*.

To this genus belong many vertebræ of enormous size; ribs, bones of the pelvis, and hinder extremities, and some portions of sterni;

they are referable to six or seven species, respectively named from their size and osteological character, *D. giganteus*, *D. robustus*, *D. ingens*, *D. casuarinus*, *D. geranoides*, *D. curtus*, *D. didiformis*.

Among the bones of the extremities of the large species, I would especially direct attention to the femur, tibia and fibula of a young bird. The femur is 14 inches long, 9 inches in circumference round the shaft, and 16 inches round the condyles. The tibia, in which the union of the epiphysis of the proximal extremity is still incomplete, is 30 inches long, 6 inches in circumference at the shaft, and 14 at the condyles. The tibia of a much younger bird gives still more colossal proportions; for it measures 12 inches in circumference at the condyles, and yet the distal epiphysis, which is always rapidly anchylosed to the shaft in birds, is still distinct. The proximal extremities of other tibiæ are 17 inches in circumference; and there are fragments of shafts 8 inches round.

2. *Palapteryx*.—In this genus the skull differs essentially from that of the Dinornis; the occipital region is narrower; the foramen magnum is situated in the centre, which in the Dinornis is occupied by the condyle; the basi-occipital is not so much developed; and there are other osteological peculiarities which I need not detail. The rostral part of both mandibles is preserved, and shows an approach to the Dromaius or Emeu. The ethmoid cavities, or upper nostrils of the skull, are very large, as in the Apteryx, a peculiarity denoting a remarkable development of the organs of smell.

Of this genus there are imperfect crania, mandibles, vertebræ, bones of the extremities, &c.

3. *Aptornis*.—Among the bones of small size, those for example that are comparable in magnitude to the skeletons of the Bustard and Apteryx, there are several tarso-metatarsals, femora, tibiæ, pelves, &c., which indicate a new tetradactyle genus, very closely allied to the living struthious bird of New Zealand, the Apteryx. Some of these bones are referable to the *D. otidiformis*, or Bustard-like Moa, of Professor Owen's second memoir: I believe the name of *Aptornis* will be assigned to this genus.

The other birds' bones belong to genera and species of which there are still living forms in New Zealand and Australia.

4. *Notornis*.—This genus is established by Professor Owen from the skulls, and upper and lower mandibles, vertebræ and bones of the extremities, of birds belonging to the *Rallidæ* or Rails; and closely allied to the living *Brachypteryx*, a species of Coot or Water-hen peculiar to New Zealand. The mandibles are sharp like those of the Raven, but are more compressed laterally; the cranium presents some interesting anatomical characters. The original was of the size of a bustard.

5. *Nestor*.—The collection contains two upper mandibles of a species of *Nestor*, a genus of nocturnal owl-like parrots, of which only two living species are known. One of these (*Nestor hypopolius* of Mr. Gould) is restricted to New Zealand; and the other (*N. productus*) to Philip Island, which is not more than five miles in extent; and Mr. Gould remarks that " so exclusively is the *Nestor productus*

confined to this isolated spot, that many persons who have resided in Norfolk Island for years have assured me that its occurrence there is unknown, although the distance from one island to the other is not more than three or four miles*."

Such is a brief account of the birds' bones that have been accurately examined by Professor Owen; but it is probable, when the vertebræ and other specimens that have as yet been only cursorily inspected are carefully compared with recent skeletons, other species and genera will be detected. Some of the vertebræ appear to belong to the existing species of *Apteryx, A. Australis.*

Egg-shells.—The fragments of egg-shells imbedded in the ossiferous deposits had escaped the notice of all previous observers, which is not surprising, for they are of small size and of very rare occurrence. My son, in all his wanderings, only procured between thirty and forty pieces. As these precious relics will shortly be described by Professor Owen, I will only mention that the edges of most of them are rounded, as if water-worn. They belong to different species, or perhaps genera: some of them are smooth, but others have the external surface marked with short interrupted linear grooves, resembling the eggs of some of the Struthionidæ, but still presenting very characteristic peculiarities.

No vestiges of the bones of the wings have been detected.

SEALS.—The remaining part of the collection consists of jaws with teeth, scapulæ, vertebræ, ribs, femora, and other bones, of a species of large seal; whether distinct from the two kinds (*Phoca leptonyx* and *P. leonina*) that inhabit the southern seas, and occasionally visit the shores of New Zealand, I have not yet been able to determine. The bones were found mixed indiscriminately with those of the birds, and are filled with volcanic sand.

Femur of a Carnivore.—One other relic must be specified, *the femur of a dog*; the sole fossil bone of a terrestrial quadruped that has hitherto been discovered in the ossiferous deposits of New Zealand.

Burnt Moa, and Human bones.—I must not omit to mention a very remarkable incident. In one spot the natives pointed out to my son some little mounds covered with herbage, as containing bones, the refuse of feasts made by their ancestors; and upon digging into these hillocks they were found to be made up of burnt bones. These consisted of *Moas', dogs' and human bones* promiscuously intermingled. These bones, which have evidently been subjected to the action of fire, contain no traces whatever either of the earthy powder or ferruginous impregnation so constant in the fossil bones from the fluviatile silt, nor of the volcanic sand with which all the bones collected by my son are more or less permeated. Mr. Taylor (*ante* p. 229) mentions having found similar heaps of bones in the valley of the Whaingaihu, "*as though the flesh of the birds had been eaten, and the bones thrown indiscriminately together.*" If such was the origin of these heaps of bones, and they are to be regarded as the rejectamenta of the feasts of the aborigines, the practice of cannibalism by

* Mr. Gould's Birds of Australia.

the New Zealanders will appear to have been of very ancient date, and not to have originated from the want of animal food on account of the extinction of the Moas, as Professor Owen so ingeniously and indulgently suggested in extenuation of this horrid practice by so intelligent a race as the Maoris.

III. *General Conclusions.*—From the scattered facts which I have thus brought together in order to throw some light on a question of such deep palæontological interest—upon the principle that the feeblest rays, when concentrated into a focus, will produce some degree of illumination—I think we may safely infer that the islands of New Zealand were densely peopled at a period geologically recent, by tribes of gigantic ostrich-like birds, of species and genera which have long since been obliterated from the face of the earth; and that subsequently to this "*Age of Struthionidæ,*" the land has undergone those physical changes, by which the areas occupied by the ornithic ossiferous deposits, and the beds of shingle and loam, which now form terraces from 50 to 100 feet above the sea-level, were elevated to their present positions. This inference seems to be corroborated by the fact that the existing mountain-torrents and rivers flow in deep channels which they have eroded in these pleistocene deposits ; in like manner as the rivers of Auvergne have excavated their course through the mammiferous tertiary strata of that country.

The accounts given by Mr. Colenso, the Rev. H. Taylor and others, of the exposure of the bone-bed in the channels of the mountain-streams, and of the bones being left on the river-shoals after heavy floods, remind us of the conditions under which the mammalian fossils of the Sub-Himalayas were first brought under the notice of our eminent countrymen, Major Cautley and Dr. Falconer. And in New Zealand, as in India, the fossil remains of extinct animals are associated with those of existing genera ; and the land is still inhabited by diminutive representative forms of the colossal beings which flourished in the pleistocene, or early human epoch ; for the Apteryx and the Porphurio may be regarded as the living types of the Moa and the Notornis.

I do not deem it necessary to enlarge on the question whether the Dinornis and Palapteryx still exist in New Zealand ; on this point I would only remark, that Mr. Colenso, who was the *first* observer that investigated the nature of the fossil remains with due care and the requisite scientific knowledge, (having determined the struthious affinities of the birds to which the bones belonged, and pointed out their remarkable characters, ere any intelligence could have reached him of the result of Professor Owen's examination of the specimens transmitted to this country,) has given, in his masterly paper before quoted, very cogent reasons for the belief that none of the true Moas exist, though it is probable the last of the race were exterminated by the early inhabitants of these islands.

But whatever may be the result of future researches as to the relative age of the ossiferous deposits, or the existence or extinction of the colossal bipeds whose relics are before us, this fact cannot be questioned—the vast preponderance of the class of birds which prevailed (and still prevails) in the fauna of New Zealand, to the almost entire exclusion of mammalia and reptiles. Any palæontologist who saw the entire collection formed by my son alone could not but feel surprise at its extent and variety. I may venture to affirm that such an assemblage of the fossil bones of birds was never before seen in Europe—nearly one thousand specimens collected from various parts of the country, with scarcely any intermixture of those of any other class: it is a phænomenon as marvellous as the exclusively reptilian character of the fauna of the Wealden epoch. In fact, New Zealand at the present time, as Dr. Dieffenbach observes, offers the most striking instance of an acknowledged fact in every branch of natural history, namely, that different areas of dry land are endowed with peculiar forms of animal and vegetable life; centres or foci of creation, so to speak, of certain organic types. And this organic law, with the effects of which, in the palæozoic and secondary ages, our geological researches have made us familiar, appears to have continued in unabated energy to the present moment. In fact, the most remarkable apparent anomalies in the terrestrial faunas and floras of the secondary epochs are not without modern parallels.

Thus New Zealand, with its peculiar flora, characterized by the predominance of ferns, club-mosses, &c., to the almost entire exclusion of the graminaceæ,—and its fauna, comprising but two or three mammals and reptiles,—and the enormous development of the class of birds,—presents a general correspondence with the lands of the carboniferous and triassic epochs.

Australia and Van Diemen's Land possess a flora equally peculiar and extraordinary, and a fauna unlike that of any other part of the world, including some of the most anomalous of existing forms, as for example that marvellous creature the Ornithorhynchus. These countries, in the abundance and variety of the Cycadeaceæ, Araucariæ, &c.—in the marsupial character of the great proportion of the mammalia—and in the Terebratulæ and Trigoniæ, and the Cestraciont fishes which swarm in the seas that wash their shores, approximate in their organic relations more nearly to those ancient lands of which the Stonesfield oolites are the debris, than to any of the present regions of the earth.

Lastly, we have a reflected image, as it were, of the "*Age of Reptiles*" of the secondary formations, in the exclusively reptilian character of the quadrupeds of the Galapagos Islands, one species of mouse being the only indigenous mammalian. This Archipelago is a group of volcanic islands situated under the equator, between five and six hundred miles westward of the American coast. "It is," observes Mr. Darwin in his delightful Journal, "a little world within itself; most of the organic productions are aboriginal creations found nowhere else. Seeing every height crowned with its crater, and the boundaries of most of the lava-streams still distinct, we are led to believe that within a period geologically recent, the unbroken ocean was here spread out." These islands swarm with herbivorous marine and terrestrial reptiles allied to the Iguanidæ, which are known in no other part of the world; and they are as completely distinct from all other existing reptiles, as are the extinct Iguanodon and Hylæosaurus. The flora too contains more than a hundred plants unknown elsewhere. There is not a fauna or flora in any of the ancient geological periods that presents greater anomalies. Mr. Darwin emphatically remarks, that "when we consider the well-beaten paths made by the thousands of huge tortoises with which these islands are traversed,—the many turtles,—the great warrens of the terrestrial Amblyrhynchi, and the groups of marine species basking on the coast-rocks of every island of this Archipelago,—we must admit that there is no other quarter of the world where the Order of Reptiles replaces the herbivorous mammalia in so extraordinary a manner. The geologist on hearing this will probably refer back his mind to those Secondary Epochs, when saurians, some herbivorous, some carnivorous, and of colossal dimensions, swarmed on the lands and in the seas. It is therefore worthy his especial observation that this Archipelago, instead of possessing a humid climate and a rank vegetation, must be considered as extremely arid, and for an equatorial climate remarkably temperate*."

I have endeavoured to express in the annexed table the organic relations between the countries above-mentioned and their geological analogues.

Modern Epoch.	Secondary Epochs.
New Zealand. Predominance of Ferns, Lycopodiaceæ and other Cryptogamia. Gigantic Birds. Mammalia absent.	Countries of the Carboniferous and Triassic periods as indicated by fossil remains.
Australia. Cycadeaceous Plants. Marsupial Mammalia.	The lands whence the Stonesfield and Carboniferous oolitic strata were derived.
The Galapagos Islands. Predominance of Reptiles. Herbivorous, terrestrial and marine Saurians and Chelonians.	The country of the Iguanodon, and the regions that supplied the detritus that formed the fluvio-marine secondary strata.

In this point of view the "*Age of Reptiles*" may be considered as merely disclosing an exaggerated effect of the organic law of creation, which imparted to the fauna of the Galapagos Islands its reptilian character. In Australia, and in the Oolitic lands, the mammalian fauna assumed the marsupial type. In New Zealand, and in the Triassic countries, the ornithic vertebrata predominated.

If the ancient philosophers, ere the discoveries of Columbus had opened the New World to the European mind, had found in a fossil state such collocations of the remains of animals and plants as are presented by New Zealand, Australia, and the Galapagos Islands, how impossible would it have been for them, by any comparison with existing nature within their circumscribed geographical boundary, to have conceived the possibility of such assemblages of animated beings existing contemporaneously with themselves! In fact, the present geographical distribution of peculiar types of terrestrial animals and plants, affords as many anomalies in the relative predominance of different classes and orders, as are to be found in the vestiges of the earlier ages of our planet.

* 'Journal of a Voyage round the World,' chap. xvii.

From these considerations I think we must conclude, that throughout all geological time the changes on the earth's surface, and the appearance and extinction of peculiar types of animals and plants, have been governed by the same physical and organic laws; and that the paroxysmal terrestrial disturbances, though apparently in the earlier ages involving larger areas, and operating with greater energy than the volcanic and subterranean action of modern times, did not affect the established order of organic life upon the surface of the globe; and that throughout the innumerable ages indicated by the sedimentary formations, there was at no period a greater anomaly in the assemblages of certain types of the animal and vegetable kingdoms than exists at the present time.

February 23, 1848.

W. Talbot Aveline, Esq., was elected a Fellow of the Society.

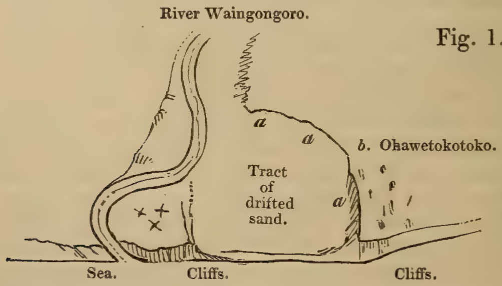
The following communications were then read:—

1. *Additional Remarks on the Geological Position of the Deposits in* New Zealand *which contain Bones of Birds.* By Gideon Algernon Mantell, Esq., LL.D., F.R.S. &c.

Since I had the honour of communicating to the Geological Society a notice of the collection of fossil bones of birds from New Zealand, I have received a letter from Mr. Walter Mantell, dated Wellington, June 18, 1847, containing some details respecting the bone-deposits and the strata with which they are associated, which are of considerable interest, and confirm in every essential particular the conclusions suggested in my former communication. The following are extracts from my son's letter:—"The principal part of the best specimens I have transmitted to you I obtained from near the embouchure of a stream called Waingongoro, which lies about a mile and a half south of Waimate in the Ngátirúanúi district. The country hereabout is an elevated table-land, with deep tortuous gullies, through which the torrents and streams take their course to the sea. That of Waingongoro, which is as tortuous as any of them,

Ground plan of the embouchure of the River Waingongoro.

Fig. 1.

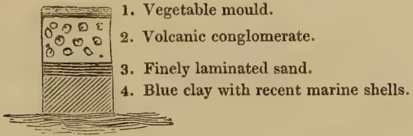


a, a, a. Indicate excavations made in the tract of drifted sand containing the birds' bones.
b. The Pa Ohawetoktoko.
*** The Pa or village of Tukikaii.

appears to rise in Mount Egmont (the volcanic ridge which is 9000 feet high); indeed it must have its source there, or in the short chain of hills which lies between that mountain and the coast in a westerly direction; for in returning to New Plymouth by the mountain road—a forest-track at the back of the volcanic ridge—I must have crossed it, did it rise elsewhere. The Waingongoro evidently discharged itself at some distant period into the sea, far from its present embouchure, as is proved by the existence of a line of cliffs which extends inland, and has clearly been produced by the eroding action of the river. Driven from its course, probably by a change in

Fig. 2.

Vertical Section of the Cliff.

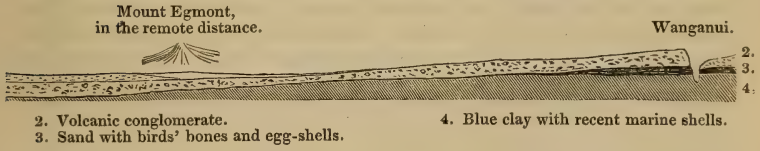


the relative level of the land and sea, it has formed its present channel, which cuts through a hundred feet of loose conglomerate, overlying a bed of finely laminated sand, and containing wood in a very recent state,—so recent as to bear cutting with a knife.

"The conglomerate is composed of an infinite variety of volcanic rocks, with numerous immense rounded masses of the same kind. The following sketch will give you a general idea of the structure of the coast from Wanganui to Taranaki; but the distances are of course merely approximative and very incorrect, and so also is probably the

Fig. 3.

Section of the Coast from Waimati to Wanganui.



highest point of the clay, but I know you will understand my meaning better by this rough diagram than by mere description. The clay abounds in marine shells, all of existing species (?); the upper layers contain but few shells, but the lowermost abound in them, and they are in a perfect state—not drifted shells. In a stratum of sand at Wanganui the shells of a sandy-bottomed sea are found, with some fragments of large Nautili.

"Between Takikau and Ohawetokotoko there is a wide flat of undulating sand, about two hundred yards across (Fig. 1, *a*, *a*, *a*). On my first visit the surface was covered with bones of men, moas and seals, &c., which had been overhauled by the Rev. R. Taylor. I had some deep openings made near the base of the ancient cliffs, under the Pa Ohawe (at *a, a, a,* &c. ; see also No. 3) ; and at the same level as

Fig. 4.

2. Volcanic conglomerate.
3. Finely laminated sand.
4. Blue clay, with recent marine shells.
a. Bone-bed exposed at the foot of the cliffs, on which is the Pa Ohawe.
h. Part dug away.

that on which were the strewn fragments of bones I have mentioned, I came to the regular bone-deposit. The bones were mostly perfect in shape, but so soft, that if grasped strongly they would change, as if by magic, into clay. Unfortunately the natives soon caught sight of my operations, and came down in shoals, trampling on the bones I had carefully extracted and lain out to dry. My patience was tried to the utmost, and to avoid blows I was obliged to retreat and leave them in full possession of the field ; and to digging they went in right earnest, and quickly made sad havoc. No sooner was a bone perceived than a dozen pounced upon it, and began scratching away the sand as if for their lives ; and the bone was of course smashed to pieces. I am only surprised that I ultimately succeeded in getting any entire.

"The natives affirm that this sand-flat to Rangatapu was one of the places first dwelt upon by their ancestors ; and this seems not unlikely, for in digging in various places I found small circular beds of ashes and charcoal and bones, very ancient, and such as are generally left by the native fires that have been long lighted in the same spot. Fragments of obsidian, native flint, two fishing-line stones and a whalebone *meri* (a sort of weapon) were also dug up. The natives told me, and their assertion was borne out by the appearance of the place, that within their memory the entire area had been covered by drift-sand ; in fact, the bones seemed always to be imbedded on or beneath an old surface-level. Columns of vertebræ when uncovered were lying *in situ* and perfect, with, in rare instances, skull and pelvis ; but to preserve these precious relics was impossible while beset with the hordes of Maoris ; and I could not drive or bribe them away.

"The largest femur, tibia and fibula were lying in their natural connection—the leg slightly bent at the knee ; a chain of vertebræ of the largest size was discovered near them, and I doubt not the whole belonged to the same colossal bird. You will readily imagine how exasperating it was to me to see specimen after specimen destroyed before my eyes, with no possibility of preventing it. From your ignorance of the excessive obstinacy and mulishness of the natives, I fear your indignation will be directed against me ; but if so, let me assure you, you are indeed in error. All that man could do I did to dissuade them from turning oryctologists or palæornithists ; but to no purpose. Men, women and children resolutely dashed at every bone that appeared when the sand was removed; and if they listened for a moment to my entreaties and remonstrances, it was but to return with renewed vigour to the work of destruction. Although I am of a forgiving disposition, yet I cannot but hope Mr. Hawkins will place these Maoris in the same category with the Vandals who destroyed the Alexandrian library, and the Somersetshire 'varmint' who mistook a Cheiroligostinus for a 'viery zarp'nt.'

"Mixed with the bones, but exceedingly rare, were the fragments of egg-shells, of which I sent you my then best specimens by post last April. I have also found six oval rings and one broad circular ring of the trachea. In coming down from Ngamotu I discovered a few more remains of eggs; one fragment is four inches long, and gives a good chord by which to estimate the size of the original: as a rough guess, I may say that a common hat would have served as an egg-cup for it: what a loss for the breakfast-table! And if native traditions are worthy of credit, the ladies have cause to mourn the extinction (?) of the Dinornis: the long feathers of its crest were by their remote ancestors prized above all other ornaments; those of the White Crane, which now bear the highest value, were mere pigeons' feathers in comparison."

I have given these extracts without correction or comment, as they were written by my son for my private information, that I might not weaken the graphic description of the exhumation of the bones exhibited and described at the last meeting of the Society. There are still some details required to render it certain that the bone-bed is always intercalated, when not laid bare by modern denuding causes, between the blue clay with recent marine shells and the conglomerate of volcanic pebbles and boulders which forms a bed of from fifty to a hundred feet thick; but so far as I can interpret my son's meaning, and upon comparison of his statements with those of Mr. Colenso and others, I conclude that such is its true geological position. There is also some doubt whether in the heaps of ancient native fires which contain bones of man, dog, and moa, those of the colossal birds may not have been introduced by accident, and their charred appearance have been occasioned by drying, from exposure to the air and sun; but it must be remarked that these specimens never contain any of the sand in which they were imbedded, as the other examples do. These and other points will, I doubt not, be satisfactorily elucidated ere long, now that the collecting of the bones of the extinct birds of New Zealand is so earnestly and systematically pursued. In the meanwhile, the imperfect and hasty sketches of my son which I have placed before the Society, will not, I trust, be deemed altogether unworthy attention.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

January 1st to March 31st, 1848.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Académie Royale des Sciences de Paris, Comptes Rendus de l', tome xxv. Deux. Sem.

Agricultural Magazine, December 1847.

American Journal of Science. Second Series, vol. v. no. 13.

Athenæum Journal.

Berwickshire Naturalists' Club, Proceedings. Vol. ii. no. 5.

Cornwall, Royal Geological Society of, Annual Report, 1847.

Indian Archipelago, Journal of the, Supplement to nos. 5 and 6.

Leeds Philosophical Society, Annual Report, 1847.

Linnean Society, Transactions. Vol. xx. part 2. Proceedings, nos. 30 to 33; and List of Members, 1847.

London Library, Catalogue of the. Second Edition, 1847.

Museum of Practical Geology, First Report on the Coals suited to the Steam Navy, by Sir H. De la Beche and Dr. Lyon Playfair.

Neuchatel, Société des Sciences Naturelles de; Mémoires, tomes i. ii. et iii.; Bulletin, tome i. 1844–46.

New York, State of, the Natural History of New York. Vols. i. and ii.; part 2, Botany, by J. Torrey; part 5, Agriculture, by E. Emmons.

Palæontographical Society, Monograph of the Crag Mollusca, by S. V. Wood. Part I. Univalves. (Two Copies.)

Philosophical Magazine. *From R. Taylor, Esq., F.G.S.*

West Riding of Yorkshire, Geological and Polytechnic Society of the, Reports, 1845–46.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Anonymous, a new Universal Etymological, Technological and Pronouncing Dictionary of the English Language. Vol. i. *From the Author, Proprietors and Publisher.*

Brongniart, Alex. Discours de M. Élie de Beaumont (and others), prononcé aux Funérailles de. *From M. Adolphe Brongniart, For. M.G.S.*

Corbaux, Fanny. On the Comparative Physical Geography of the Arabian Frontier of Egypt.

Daubeny, Charles, M.D. Description of Active and Extinct Volcanos. Second Edition.

D'Archiac, Vicomte. Histoire des Progrès de la Géologie de 1834 a 1845. Tome i.

———————. Notice sur les Travaux Géologiques, de.

De Koninck, L. Notice sur Quelques Fossiles du Spitzberg.

———————. Notice sur deux Espèces de Brachiopodes de Terrain Paléozoique de la Chine.

———————. Notice sur la Valeur du Caractère Paléontologique en Géologie.

———————. Réplique aux Observations de M. Dumont sur la Valeur du Caractère Paléontologique en Géologie.

De Waldheim, G. F. Notice sur Quelques Sauriens de l'Oolithe du Gouvernement de Simbirsk.

Fitton, W. H., M.D. Stratigraphical Account of the Section from Atherfield to Rocken-end, Isle of Wight.

———————. Inquiries respecting the Geological Relations of the beds between the Chalk and Purbeck Limestone in the South-east of England, 1824.

———————. Notes on the Progress of Geology in England 1833.

Frapolli, L. Réflexions sur la Nature et sur l'application du Caractère Géologique.

———————. Quelques Mots apropos d'une Carte Géologique des Collines subhaercyniènnes.

———————. Faits qui peuvent servir à l'Histoire des Dépôts de Gypse, de Dolomie et de Sel Gemme.

Frapolli, L. Mémoire sur la Disposition du Terrain Silurien dans le Finistère.

Gibbes, R. W., M.D. Memoir on the Fossil Genus Basilosaurus.

Guyot, A. Note sur la Distribution des Espèces de Roches dans le Bassin Erratique du Rhone.

———. Note sur le Bassin Erratique du Rhin.

———. Note sur la Topographie des Alpes Pennines.

Hausmann, J. F. L. Handbuch der Mineralogie, Zweiter Theil.

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Keyserling, A. v., and P. v. Krusenstern. Wissenschaftliche Beobachtungen auf einer Reise in das Petschora-Land. With Maps and Plates.

Logan, W. E. Geological Survey of Canada. Report of Progress for the year 1845–46.

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Mitchell, Lieut.-Col. Sir T. L. Journal of an Expedition into the Interior of Tropical Australia.

Pictet, F. J. Description des Mollusques Fossiles qui se trouvent dans les grès verts des environs de Genève.

Ramsay, A. C. Passages in the History of Geology.

Rouquairol (Saint-Romain). Le Globe Terrestre reconnu vivant ou Physiologie de la Terre.

Smith, Rev. J. Pye, D.D. The Relation between the Holy Scriptures and some parts of Geological Science. Fourth Edition.

Von Buch, L. Über Ceratiten, besonders von denen die in Kriedebildungen sich finden.

Yolland, Capt. W. Account of the Measurement of the Lough Foyle Base in Ireland. *From the Hon. Board of Ordnance.*

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

February 23, 1848 (*continued*).

The following communication was then read :—

2. *On the Geology of* Ridgway, *near* Weymouth. By Charles Henry Weston, Esq., Barrister-at-Law, B.A. Cant., and F.G.S.

During the last summer I directed my attention to the geological features of the country in the neighbourhood of Weymouth, not with the idea of adding any fresh information to that which we already possessed of this district, but rather from the desire of working out for myself in the field what had so often interested me in the closet. While examining however this district generally, and those localities where the strata were so considerably exposed by the operations of the Wilts, Somerset and Weymouth Railway, I particularly studied the supposed point of junction of the Portland stone and the chalk of Ridgway Hill. At this spot I saw much to excite my surprise, and what, with my preconceived notions of the theoretic structure of the district, I found difficult to understand.

Having, from a close and rigid examination, come to a conclusion in my own mind respecting the character of the formations disclosed in this locality, I was anxious to communicate my thoughts to Professor Sedgwick ; and in a letter addressed to him in September last, I drew his attention to the peculiarly interesting nature and extent of the geological stratification which I had found existing between the base and apex of Ridgway Hill. I simply stated the new features in its geology, reserving a fuller statement until I had received my fossils from Dorsetshire. These new features were—

1st. The existence of another member of the Wealden formation.

2ndly. The apparently anomalous position of what I deemed to be the Oxford clay; and

3rdly. The existence of the Tertiary system.

The section, which I was not then prepared to send to Cambridge, but which is now appended to this paper, shows also what may be considered as another new feature,—I mean the fact that the Purbeck beds really dip in their natural order between the Portland stone and the Hastings sands.

It will now devolve upon me to detail more fully those facts from which I have considered myself authorized to draw the conclusions I have thus briefly stated. But in doing this it will be expedient previously to point out the geological character of the district generally, and then to state in particular those views which have hitherto been held with respect to the locality.

Ridgway Hill is situate about midway between Dorchester and Weymouth. The high road passes over it, and the railway now in progress is to go right through it by tunneling the upper and deeply cutting the lower parts. The hill must attain the average height of about 500 feet above the level of the sea, and is a portion of the escarpment of chalk, which ranging from the fine bluff and wave-worn cliff of White Nore on the east to its inland termination at Chilcombe on the west, forms a very important feature in the geology of the Weymouth district.

From Messrs. Conybeare and Phillips (pp. 182 and 192), and the elaborate paper of the present Dean of Westminster and Sir H. de la Beche in the Geological Transactions (vol. iv. 2nd series, part i.), we learn the *general structure* of the country between Ridgway Hill and the Isle of Portland, and the *great faults* which in times long anterior to the present have taken place in this part of the coast. Both these characters must be borne in mind whenever we are considering the geological phænomena of this locality.

Respecting the *general structure*, it will be remembered that this arises from the protrusion of the forest marble on the north-west of Weymouth. Its anticlinal line ranges about east and west, and the several superior strata, up to the Purbeck formation inclusive, lie on its inclined sides and conformable to them in regular succession.

The importance of the great Ridgway fault will appear when we state, in the words of the authors of the paper referred to, that it extends "without interruption nearly fifteen miles, passing along the great escarpment of chalk at various elevations from the top to the bottom of it*."

The geological views hitherto entertained respecting this district

* This paper must be the manual of every student of the geology of the neighbourhood of Weymouth. It takes enlarged views of the whole subject. For myself, I am bound to acknowledge deep obligation to its authors.

will be better understood by a few extracts from the same paper. It is stated that "the great Ridgway fault is an *upcast* fault, elevating on its south side into contact with the escarpment of the chalk those strata that would otherwise have dipped beneath it—particularly the Portland stone, nearly along the whole line which this fault traverses."

And again, referring to the part of Ridgway Hill now under consideration, it is stated that "at Upway, on the northern extremity of the general section and near the summit of the hill, the Portland stone covered with Purbeck beds occupies the south side of the fault and nearly *horizontal* chalk on its north side, the Purbeck and Portland beds rising at a high angle northwards towards the fault. From Upway for four miles westward to the final termination of the Portland stone at Portisham, the Portland stone is continued to the south side, and the chalk to the north side of the fault. It is exposed by no section, but the junction can be traced on the surface of the fields."

From these extracts we learn—

1st. That the Portland stone was considered to abut *directly* against the chalk; and

2ndly. That although the existence of the Purbeck beds was distinctly marked, yet their deposition was understood to be upon the shoulders of the chalk, and not in any way intervening between the Portland stone and the chalk.

In the same paper it is stated that "the Wealden or Hastings sands, after becoming gradually thinner in their progress westward through the Isle of Purbeck, *terminate* a little west of Lulworth." This place must be about twelve or fourteen miles *east* of Ridgway, and therefore the existence of the Wealden or Hastings sands so far west as Ridgway must be considered a new feature in the geology of this part of Dorset.

If we refer to our authors' surface-map we shall find the tertiary marked as existing near Came Down, and then not to be met with west of that locality until after a long-denuded interval it reappears on the high land of Blackdown. On ascending however the chalk hill of Ridgway, a little to the east of the intended railway, I found evident proofs of the presence of the supercretaceous deposit. I therefore endeavoured to trace its continuity westward, and was led to conclude that it actually reposed upon the chalk immediately above the tunnel now in progress. The inquiries subsequently made at the engineer's office, respecting the nature of the strata passed through in sinking the great vertical shaft, quite confirmed my views: I found that about sixty feet of tertiary had been pierced *before* reaching the chalk.

The remaining subject (I mean the existence of the Oxford clay in this locality) will be better understood after an examination of the section (p. 249) and a perusal of the subjoined explanatory facts.

The *cutting* represented in the section lies in a direction nearly due north and south, and is bounded on the north by the chalk of Ridgway, and on the south by the public road, under which a short tunnel has been made.

Now commencing from the south (*i. e.* from the short tunnel) we find the following strata:—

A.
- *a.* Thin layers of calcareous stone, sometimes ferruginous, with intermediate layers of clay, bluish from vegetable matter.
- *b.* Fibrous carbonate of lime.
- *c.* Hard marl.

B.
- *d.* Clay and lignite.
- *e.* Little sand with vegetable soot.
- *f.* Hard and soft marl.
- *g.* Lead-coloured loam.
- *h.* Sands, ferruginous and yellow.
- *i.* Loam, red, bluish and purplish, with *large bands* of vegetable matter and *lignite*.
- *k.* Sands, ferruginous and coloured, with intermediate bands of red and purplish loam.
- *l.* White sand.

C. Stiff blue clay.

The section will not only show the order of the strata, but the circumstance of the gradual increase of their dip (as we proceed northward) until they become *nearly vertical*. On the south side of the tunnel (*m*), and before reaching the cutting, the dip was to the north at about the angle of 30°. At the south end of the cutting the dip was about 45°; towards the middle of the cutting about 60°, and at the northern extremity between about 70° and 80°.

Group A. is clearly the *upper part* of the Purbeck formation.

We have on the south side of the tunnel (*m*) unquestionable Purbeck beds, and we can distinctly trace their continuity from the south to the north of (*m*). We find also the repetition of the same lithological details and the same fibrous carbonate of lime so prevalent throughout the Purbeck range, and which appears so much to mark its character in Purbeck Isle*.

In B. group, and not very far from the tunnel (*m*), were found remains of bones, stated by those who saw them to have belonged to the Iguanodon. Its characteristic nasal horn was also secured. The position of this fossil reptile was about the upper limits of the Purbeck and the lower parts of the Hastings sands. The coloured marls contained carbonized grasses and large bands of carbonaceous matter, with pieces of trees converted, in some cases, into pulverulent carbonized wood, and in others to complete lignite. I found also what appeared to be a broad compressed Calamite, but did not meet with any other fossils.

This B. group I believe to be the Hastings sand; and this inference will I think appear correct when we consider the features of the strata in connection with what I shall now subjoin.

Dr. Buckland, in his Bridgewater Treatise, states that "the Iguanodon has hitherto been found only, with one exception, in the Wealden formation of the south of England, intermediate between the

* Geol. Trans. vol. iv. p. 11.

marine oolitic deposits of Portland and those of the greensand formation in the cretaceous series." And in this excepted case it was found higher up and *not below* the Purbeck beds.

The authors of the paper already referred to consider the existence of the Iguanodon as one satisfactory proof of the identity of the Wealden formation (p. 11).

Dr. Fitton (in Annals of Philosophy for 1824) describes the Hastings sand formation "as consisting of an alternating series of beds of sand, more or less abundant in ferruginous matter . . . . . . with beds of clay much mixed with sand of a greenish or reddish hue or of a mottled or variegated appearance. Subordinate beds containing . . . . . wood, more or less changed, wood, coal, &c."

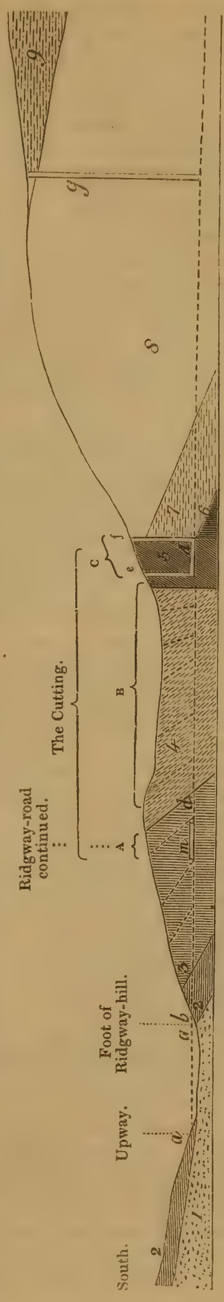
In the same paper we find that Dr. Fitton traced the Wealden formation to a little west of Lulworth, which, though somewhat distant, is yet geologically closely connected with the district now under examination. At that spot also Dr. Fitton found the strata placed under precisely the same circumstances as at Ridgway—nearly vertical.

I am aware, from the apparent thinning-out of the Wealden formation as it proceeds westward, that inferences have been drawn as to its termination east of Ridgway, but I do not think the facts stated *necessarily* lead to such a conclusion. The

Fig. 1. *General Section of Ridgway Hill and the adjoining Strata.*

The Ridgway Cutting runs nearly due N. and S. The range of the strata is W. by N. and E. by S.

North.



1. Portland sand. 2. Portland oolite. 3. Purbeck. 4. Hastings sands. 5. Oxford clay. 6. Greensand. 7. Chalk-marl. 8. Chalk. 9. Tertiary.

a a Raised embankment over the Upway Valley.
b b Continuation of railroad through acknowledged Portland and Purbeck beds.
m m Short tunnel under the road half-way up the hill.
d d The cutting referred to in pages 247 and 248.
e Shaft vertical and horizontal, from which only Oxford clay was obtained. Depth about 50 feet.
f Shaft vertical, from which only chalk and chalk-marl were obtained. Depth 56 feet.
g Vertical shaft on top of Ridgway Hill, sunk through tertiary to chalk.

substance of Dr. Fitton's Note on Vertical Strata, when connected with an examination of the sections referred to in the text, leaves the mind quite open for the discovery of a further extension to the west of the same strata. On the whole therefore I must conclude that the formation in group B. is that of the Hastings sand.

The Weald clay does not appear to be represented in this locality, but its absence may have resulted either from the pressure and confusion naturally connected with such verticality of strata, or from other causes easily to be conjectured. The Mewp Bay section has no Weald clay, and presents in its ferruginous sands details singularly analogous to those of Ridgway Hill*.

The next stratum (C.) consists of stiff blue clay. In this I found that a shaft was sunk to some depth from the surface-line of the country, and then carried many feet at right angles northward to reach another vertical shaft previously sunk in the chalk. I waited with some anxiety to hear the results which the horizontal shaft might disclose on reaching the chalk, and I have since learned from the engineer of the works that "the clay met the chalk (or rather chalk-marl) in *absolute contact* without the interposition of any sand and in a direction nearly *perpendicular*."

The relative position of the vertical and horizontal shaft, from which blue clay only was extracted, and the vertical shaft sunk in the chalk, from which chalk and chalk-marl only were obtained, will be clearly seen on reference to the section, in which the former is marked (*e*), the latter (*f*).

From this argillaceous deposit I collected several fossils, some of which were much broken by the workmen's tools. These I forwarded to Mr. J. Sowerby, who has bestowed much attention on them, and very kindly sent me the following communication:—

"Most of the fossils are in too imperfect a state to be named with certainty, but I have done what I could with them.

"The following is a list:—

1–6. *Gryphæa dilatata.*
7. Very near to *Ammonites catena.*
8. *Am. Arduensis*, D'Orbigny, Ter. Jurass. t. 185.
9. *Am. Mariæ*, D'Orbigny, Ter. Jur. t. 179.
10. *Am. Lamberti*?
11. *Pholadomya*; well-known, but I believe unnamed, with a small compressed *Astarte*, also unnamed, attached to the clay.
12. *Thracia depressa.*
13. Part of *Ammonites*, with an *Anomia* adhering.
14. *Nucula* and *Turritella*?
15. *Trigonia clavellata.*
16. *Modiola bipartita.*
17. *Modiola*, I think unnamed.
18. *Myacites musculoides* (Goldfuss, v. 153. f. 10).
19. *Thracia depressa.*
20. *Nucula*, same as No. 14; both too bad to be made out.

* Mewp Bay is about two miles east of Lulworth. The section in my possession was copied some years ago from one kindly lent me by Prof. Sedgwick.

21–23. Plaited oysters; two species, but I cannot pretend to name from such morsels without good geological and local evidence."

Am. Arduensis and *Am. Mariæ* are quite new in the fossil conchology of England, but they have been found in the Jurassic formations of France: No. 8 in the equivalent of the Oxford Oolite, and No. 9 in that of the Oxford clay.

On carefully reviewing the above list of fossils we shall, I think, feel satisfied that the deposit which contained such remains must be the Oxford clay.

I will merely add, that accompanying these Ridgway fossils are two Modiolas,—one procured from the Oxford clay of Wiltshire (between Laycock and Melksham), and the other I myself found in the upper part of the cornbrash and just below the Oxford clay at Weymouth. Mr. Sowerby has compared these with Nos. 16 and 17 of the preceding list, and considers the Wiltshire fossil as undoubtedly the same species as No. 16, and the other (from Weymouth) as probably the same with No. 17*.

Proceeding upwards in the geological series, I shall now refer to the greensand. This formation, although not exposed in the cutting, ought I think to be considered as existing and as making another addition to the already comprehensive stratification. It is visible at Bincombe within a mile on the east of Ridgway, and the chalk-marl met with by the two shafts shows us how near the level of the cutting is to the base of the chalk of the Ridgway range.

At Bincombe the greensand is seen to dip at about 20° to the north, with the superincumbent chalk reposing conformably upon it. I think therefore we may infer that the chalk of Ridgway is also *elevated* in a similar manner; indeed, reasoning *à priori*, we might be led to conclude that this chalk would be influenced by the general upheaving of the district.

Connecting the section, from the base of Ridgway Hill to its summit, with the strata to be found between Upway and Weymouth, we shall have within the distance of four miles the following remarkable extent of geological sequence—a sequence perhaps not to be paralleled in any other locality of equal limits.

1. Forest marble.
2. Cornbrash.
3. Oxford clay.
4. Oxford oolite.
5. Kimmeridge clay.
6. Portland sand.
7. Portland stone.
8. Purbeck beds.
9. Hastings sands.
10. Chalk.
11. Tertiary.

Having spoken of the beds which the railway cutting has just brought to light, I shall now add some remarks on the Portland and

* Since the transmission of the last two specimens of Modiolas, I have examined some parts of the Oxford clay of Wilts, in the vicinity of the cornbrash, and I have found that the Oxford clay *towards its junction* with *that formation* rather *abounds* in the *Modiola*. The idea therefore which I originally entertained, when in Dorsetshire, that there was at least an intermixture of the *lower* part of the Oxford clay in the Ridgway cutting, seems to be confirmed, and I cannot but add that the peculiar position of this argillaceous deposit, and the hypothetical causes which have been assumed as producing its protrusion, appear to me to derive increased probability from this fact.

Purbeck beds, which, though long known, have by the excavations of the railway carried on south of (*m*) in the section Fig. 1 been for the first time so completely laid bare for geological examination.

The Portland sand I traced on the other side of the Upway valley, and I learned that it had been previously denuded on the north side of the high road at *a b* Fig. 1. by the excavations made for building the north foundation of the viaduct. Considering the inclination of the Portland stone strata and the breadth of the valley, the Portland sand may be considered as well-developed in this spot.

The superjacent Portland stone is clearly defined in its limits by the arenaceous deposit below and the lowest of the Purbeck dirt-beds above. I found an ammonite in the lower part of this marine formation, and one of the superintendents of the works pointed out to me the place where a fossil fish, and what he described as "like a dog's jaw," were found. This place was in the upper part of the Portland stone, and not very far from its junction with the Purbeck beds.

The Portland stone is much less developed in this locality than in the Isle of Portland. The Purbeck beds at Ridgway possess, however, much greater thickness than the same formation in Portland, where even on the northern part of the island they do not attain a thickness of more than twenty feet. I do not say "developed," because we have in Portland no Hastings sand formation to mark the upper limits of the Purbeck beds, and therefore the absent superior strata may have formerly existed in the island and been subsequently removed by diluvial action.

The Purbeck beds now laid bare exhibit many dirt-beds; these however, do not possess the thickness of the dirt-bed in Portland which contains the silicified coniferous trees, but more resemble the thinner dirt-bed interposed between the "Skull-cap" and "Top-cap," and which contains only the *compressed* Cycadeoideæ.

The upper parts of this formation (which are wanting in Portland) contain the remarkable layer of fibrous carbonate of lime as well as what is denominated "Purbeck marble." Almost all the quarries on the south side of Ridgway Hill are in the Purbeck formation.

The Purbeck beds are characterized generally by their schistose structure and by the alternate occurrence of argillaceous and calcareous deposits. This alternation, carried on still further in detail, affects the composition of the Purbeck stone and imparts to it its peculiar streaky or ribbon appearance. I might add also that there is a remarkable persistency in these characters throughout the formation, at least from Upton, near Osmington, to Portisham*.

* Connected with Osmington I would call attention to the sections Figs. 9 and 3 of Plate 2 in the paper on the geology of Weymouth. Fig. 9 very correctly shows the *arched* strata of Osmington Mills running *east* and *west*, and Fig. 3 *one-half* of the arch running *north* and *south*. I found, however, on examining the shore at low-water, that the Oxford oolite washed by the waves decidedly dipped to the *south*, completing consequently the south side of the arch. Osmington Mills thus stand on the intersection of two arcs, cutting each other at nearly right angles, and seem therefore to be on the very focus of the upheaving powers formerly operating on this part of the coast. I ought to add, that both on the east and west of this spot the strata seen on the sea-shore resume their dip to the *north*.

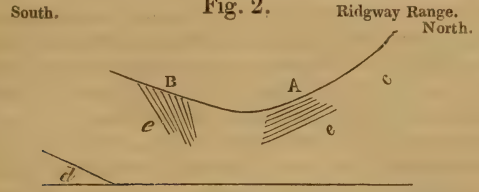
The dip of the Purbeck and its underlying Portland oolite is clearly exhibited by the railway cuttings, and we can see distinctly that the Purbeck beds do not lie in a basin or trough of Portland stone, as was supposed, but that they rest conformably upon it, and that both formations dip regularly to the north in their natural order under the Hastings sand. The dip increases from the base of the Portland stone to the top of the Purbeck; south of (*m*) in section Fig. 1, ranging about 30°, and on the north side about 45°.

The Purbeck and Portland beds have been subjected to great elevations and depressions in the locality under consideration, and as these disturbances are evidently connected with the singular position of the strata overlying them, it may be desirable now to consider these phænomena more particularly.

Near the cutting in which we find the Hastings sands and Oxford clay a gradual depression of the surface-line is perceptible, sinking more rapidly on the east near the farm-house. This depression I do not consider as merely external, but as essentially connected with the stratification below. We therefore find the different quarries on the hill presenting different inclinations, some dipping to the north and others to the south. This variation is even seen in contiguous quarries.

There is one quarry on the west of the cutting, and not very far from it, which dips to the *east*,—that is, *towards* the vertical strata, leading us to infer that the cause affecting both was a common one. On the same range, further west, there is another quarry (A.),

Fig. 2.



c. Chalk. *d*. Portland. *e*. Purbeck.

Fig. 2, in which the Purbeck formation presents the following strata, all dipping to the *south*:—

Gravel and large rubble.
Fibrous carbonate of lime.
Ribbon-like deposit of Purbeck stone.
Fibrous carbonate of lime.
Blue clay, containing what appeared to be small Ostreæ.
Blue, hard Purbeck marble.
Blue fibrous carbonate of lime.
Blue clay.
Stone.
Schistose stone.
Blue band.
Stone.
Schistose stone with ripple water-mark.

Sandy schistose stone.
Yellow sands.
Yellow clayey sand.

To the north-west of this quarry and at a little distance we find the strata dipping south and east, while on the south of this and of A. quarry, and rather near them, with a little depression of the surface-line intervening, we find a small quarry (B.), Fig. 2, in the same Purbeck formation, dipping in an *opposite* direction,—to the north, with some of its strata nearly *vertical*.

I cannot therefore but suspect that the gradual dip to the north of B. quarry increasing towards verticality points to the complete *bouleversement* of the Purbeck formation in A. quarry, and that the yellow sands and yellow clay are really a part of the Hastings sands*. If this be a correct view of the subject, we may have found the same cause acting here also which produced the conditions of the strata in the Ridgway cutting.

The local geological features of this district having been considered, it will now be desirable to take a more comprehensive view of the great chalk range in its comparatively undisturbed state; and it gives me pleasure to acknowledge that the importance of directing attention to the range generally was suggested to me by Mr. Lonsdale, our late and much-valued Curator.

If we consult Conybeare and Phillips, we find from about south of Wincanton, the high escarpment which continues its course to the south part of Dorset is generally composed of—1. chalk; 2. greensand; and 3. Oxford clay. It is stated† that "from Melksham (Wilts) the Oxford clay continues its course through Somerset and Dorset, passing by Wincanton and Sturminster, on the south of which it is overlaid by the great western extension of the chalk and greensand;" and although the coral rag is visible south of Melksham, yet "near Wincanton the greensand (overlying the basset edges of the coral rag) advances upon the Oxford clay."

Mr. Greenough in his Geological Map seems to be of the same opinion to a still greater extent, as the whole range (with one exception) from Frome to Ridgway is made to consist of these three several formations.

If we consult the surface-map of the authors of the paper above referred to, we find several localities exhibiting the same order within a short distance of the spot under consideration.

We may therefore on the whole consider the geological superposition of this great range as consisting generally of chalk, greensand and Oxford clay; and thus the Oxford clay will in effect be brought high up in the geological series.

The Oxford clay at Weymouth and the Oxford clay at Ridgway

* This idea, in connection with the positive existence of this formation in the Ridgway Hill cutting, leads me to conjecture that the *Hastings sands* really range much further west. They may be co-extensive with the Portland oolite, and thus reach nearly to Portisham. Perhaps too the Purbeck deposit may ultimately be found equally extensive.

† Conybeare and Phillips, 198.

clearly belong to the same stratum, although the latter is placed from circumstances in a very peculiar position. Before speaking, however, of this position, we must deal with the formations intervening between it and the greensand, taking them in their descending order.

We may infer a greater extension of the Hastings sands and clays in former times than what has hitherto been observed in the Weymouth district; and the Purbeck beds at Ridgway and Portland doubtless existed continuously anterior to the protrusion of the great boss of forest marble. But from our present knowledge of all the freshwater beds deposited between the oolitic and cretaceous systems, there is no *necessity* for supposing that the Hastings sands and Purbeck beds ever dipped northward under the Ridgway chalk. The Wealden formation in the aggregate is essentially a local deposit.

In considering, too, the whole upper system of the oolitic group, we cannot but be struck with "the sudden and total disappearance of the Portland formation at Portisham," which, according to the views of the authors of the paper referred to, "seems not to result from its accidental intersection at that place by the great Ridgway fault, but rather from a tendency, which is common to this with most other great formations, to terminate abruptly where they are accumulated to their fullest thickness." The reappearance and equally abrupt termination "of the Portland formation" are also to be seen "in the Vale of Tisbury and near Brill and Thame in Oxfordshire, and near Aylesbury and Whitchurch, Bucks, and near Swindon, Wilts."

These valuable observations, and many others on the same point, lead us to feel that the Portland formation, and indeed the whole upper oolitic system, may terminate abruptly on the north as well as on the west of our locality, and therefore that this system, conjointly with the Wealden, need not dip under the chalk of Ridgway. If this reasoning be deemed satisfactory, we shall have relieved our subject from great difficulty.

The existence or non-existence of the Oxford oolite between the greensand and the Oxford clay beneath the chalk escarpment is of no great consequence. I think, however, as it is developed north and south of the geological saddle of forest marble, that most probably it does pass northward under Ridgway Hill, immediately beneath the greensand.

Having considered all the strata interposed between the Oxford clay and the Ridgway chalk, we are now prepared to examine the actual circumstances of the Oxford clay in the Ridgway cutting. This clay is clearly not the Oxford clay stratum in its natural position, but a part of it forced out and raised above its own level by local pressure*. It thus stands like a trap-dyke intruded between the almost perpendicular walls of chalk and Hastings sand.

* The finished line of the railway in this cutting is about 247 feet above the level of high flood-tides at Weymouth, and the shaft sunk from the surface-line to the level is about 50 feet. The Oxford clay at Ridgway must therefore be about 300 feet higher than that near Weymouth.

We have here indeed an "upcast fault," as stated in the above paper, but the present cutting shows us that the strata have not only been elevated towards the chalk escarpment, but have been subjected also to a considerable subsidence and a partial *bouleversement*. These perhaps are just the effects which might be supposed to result from the geological conformation of the Weymouth district.

On examining the surface-map of Sir H. De la Beche and the Dean of Westminster, we find that the axis of the forest marble is very considerably nearer Ridgway than Portland, and therefore that the elevating power acted more directly on the northern part of the arc than on the southern. But the chalk escarpment would at first offer considerable resistance to an upward movement, until the hard bed of the Oxford oolite was at length fractured and snapped off. Then it was progressively elevated, with all its superincumbent strata grinding and producing the vertical wall of chalk.

The same elevating power having less resistance further south, protruded the forest marble between Chickerel and Langton Herring, and this effect led to a corresponding removal of a large mass of matter on both sides of the anticlinal axis, but particularly on the *shorter* side of the arc, *i. e.* on the Ridgway side.

This removal of matter from the sides to the centre of the arc would be necessarily connected with a proportionate depression of its extreme points, and their maximum depression would be simultaneous with the maximum elevation of the central boss.

This joint action of elevation and depression would, I apprehend, involve the upper Purbeck and Hastings sands in all the circumstances in which we find them placed,—I mean, both tilted up and overthrown.

The *subterranean* results of this supposed state of things would be the fracture of the Oxford oolitic stratum and great pressure on the subjacent Oxford clay,—a pressure however exceedingly concentrated at the base of the chalk range, as is evidenced by the verticality of the strata. Now this local pressure would, it seems to me, force up the Oxford clay from beneath through the opening thus made, that is, through the very place in which we find it—between the *chalk wall* and the *overturned upper surface* of the Hastings sands.

I cannot but feel that the geology of this part of the Weymouth district is connected with some difficulties, and my attempt has merely been to suggest a mode of reconciling with the acknowledged truths of geological science what, *primâ facie*, appeared somewhat anomalous. The impressions therefore which I received from personal examination, modified or confirmed by much subsequent consideration, I beg to offer with entire deference to those better qualified to form a correct judgement on the subject*.

* Since my examination of the locality and my announcement of its results to Professor Sedgwick, I find that Captain Ibbetson has been on the spot; I hope therefore that more light will be thrown on the question.

MARCH 8, 1848.

The following communications were read:—

1. *On the position in the Cretaceous series of Beds containing Phosphate of Lime.* By R. A. C. AUSTEN, Esq., B.A., F.G.S.

IN a letter published in the 'Gardener's Chronicle' of the 19th of February last, Mr. Paine of Farnham gives an account of some strata in which phosphate of lime is in sufficient abundance to render them of considerable importance to agriculture: and the editor of that journal, in noticing the value of Mr. Paine's communication, expresses a hope that it may lead to a successful search for like underground wealth in other parts of the country. It is in fulfilment of this hope that I propose to describe the true geological age and position of the beds in which this mineral exists. Much interest undoubtedly attaches to other parts of the subject—such as the chemical inquiry as to the source of so large a quantity of phosphoric acid, and the substances with which it is combined and associated; but these inquiries, as well as the circumstances which will eventually determine the economical value of these beds, are understood to be in the hands of Prof. Way and Mr. Paine, to whom they rightly belong.

The communication to the 'Gardener's Chronicle' is headed, "Discovery of Strata containing Phosphate of Lime in the Chalk formation:" the term "discovery" however can hardly be employed in this instance with strict propriety. The fact of the existence of phosphate of lime is stated in almost all the works or memoirs which have treated on the mineral character of the middle cretaceous beds; such as those of M. Brongniart, Dr. Buckland, Sir H. De la Beche, Dr. Mantell*, and Dr. Fitton†. The latter most fully describes the appearance and mode of occurrence of the phosphate nodules, when speaking of the gault of Folkstone: the chemical composition of these nodules is given in a note appended to this part of Dr. Fitton's memoir, on the authorities of Dr. Prout and Dr. Turner, page 111; and at page 145 he says, "In approaching Farnham, the gault near its contact with the sands abounds in nodules containing a large proportion of phosphate of lime, resembling those of the vicinity of Folkstone." It will be found that I have noticed them as constituting a marked character in the same part of the cretaceous series as developed in the neighbourhood of Guildford. Mr. Paine's communication is not geological, but rather agricultural and practical;—its great merit is that it calls attention to the fact, that this earth, which geologists had merely indicated, has actually been employed by him advantageously as a substitute for bone-dust, and that it exists in sufficient abundance to have an economical value.

* In a paper read before the Geological Society in February 1843, Dr. Mantell pointed out the preservation of the soft parts of mollusca in these beds, forming dark carbonaceous substances resembling coprolites, which he named molluskite. Proc. Geol. Soc. vol. iv. p. 35. See also Silliman's Amer. Journ. vol. xlv. p. 243; or Mantell's Medals of Creation, vol. i. p. 431.

† On the Strata below the Chalk, Geol. Trans., 2nd Series, vol. iv. p. 103.

After reading Mr. Paine's paper, I visited the various spots in my own neighbourhood where the middle cretaceous beds are exposed, and found the order and relative thickness in all the same. *The phosphate nodules are abundant in the upper greensand,* but they are generally small in the top beds; below come the fire-stone or malm-rock bands, twenty to twenty-five feet thick, and beneath these again other beds of bright green earth, of which one portion is argillaceous: this lower green band is the gault. *The concretions of phosphate of lime* are not so uniformly spread through the thickness of this mass as in the upper greensand, *but occur in two seams,* one in the argillaceous portion, the other lower, and only a little within the limits of this division of the series. These two beds of phosphate nodules, as well as a seam of pyrites, which in open sections produces a brown band in the gault deposit, are remarkably persistent.

Although this order of the beds is constant for twenty miles along the course of the North Downs, it by no means follows that the discovery of phosphate beds will invariably reward those who may explore for them along the foot of that escarpment. In this respect all published geological maps will mislead, as they give a most incorrect representation of the course of the subordinate members of the middle cretaceous group. Research is already very strongly recommended in various quarters, but this will often be attended with a fruitless expenditure, unless it is accompanied with a clear understanding of the accidents which affect the relative positions of the various strata along this range. All published sections too are equally delusive.

When seen from some distance within the Wealden area, the upper line of the North Down range seems to rise to a nearly uniform level; but when the beds which compose these hills are more closely inspected, it will be found that whilst the dip of the whole mass is to the north, the amount of dip varies continually from the horizontal nearly to the vertical—that beds of very different parts of the series are brought up to the crest of the escarpment—and that the range in reality presents a series of long undulations. With such a structure, the extent of the series exhibited in any one section will depend on the amount of inclination, being most where the dip is most rapid. But in addition to this, a fault, and one which in some places is of very considerable amount, runs along the base of the chalk escarpment; the lower greensand beds which occupy the south side of the gault also undulate, but the two sets of undulations do not correspond; that is to say, they have not their greatest curves opposite one another. The reverse indeed is very frequently the case, the greatest amount of disturbance on one side facing a small amount on the other, and thus it happens that in some places the beds of upper greensand and gault are exposed, and in others carried down below the surface; so that if laid down on a map they would be represented only at intervals along the base of the escarpment, as north of Gomshall, beneath Newlands Corner, near Guildford, at Puttenham and Seale: but it would require a map on a very much larger scale than that of the Ordnance to enable one to lay down these minute and complicated details.

All these several places present old pits from which the marly green earth has been taken in former times, doubtless for the purpose of amending the land; yet the period in some instances must be remote, as these pits are often occupied by large timber trees.

After having ascertained the positions of the several seams of phosphate nodules at the above-named localities, I visited those from which Mr. Paine is now raising this material in the neighbourhood of Farnham. The sections here are not so instructive, owing to the horizontality of the strata and the great accumulation of clayey gravel which covers the surface; the cretaceous beds have not in this part of the Wealden denudation that regular northern inclination which is given them in Dr. Fitton's section, and over the whole expansion of the middle group of beds from Farnham to Petersfield there is a series of undulations of which the axes shift round from N. and S. to E. and W., producing ridges having gentle opposite dips.

The component beds of the cretaceous series in the vicinity of Farnham differ only in one instance from the series exhibited near Guildford, and which I described in 'Geol. Proc.' vol. iv.; the exception is presented in the strata exposed in the great quarry on the road from Farnham to Crondall. Dr. Fitton notices it as a "cream-coloured subcalcareous sandstone," which well describes its appearance, but the calcareous portion hardly amounts to two per cent.; the great mass of it is friable, passing occasionally into cherty sandstones; these sandstones rest on the gault, which along the lower part of the valley forms the subsoil of the rich hop-ground west of Farnham; and they are clearly seen in the road section to be succeeded by a band of bright green sand. This mass of sandstone is the equivalent of the fire-stone to the eastward and the malm-rock to the west, but differs from them in the absence of lime, and represents merely the course of a current, which at that particular period, between the gault and upper greensand, drifted arenaceous and rather coarse materials along this particular line in the cretaceous ocean; the course of this current seems to have been somewhat north and south. From this point on the Crondall road, I had the advantage of being conducted by Mr. Paine to every one of the pits from which he has procured the phosphate of lime. In the road-side quarry the uppermost bed is denuded, but it is seen in a quarry in a cultivated field close by, and is remarkable from containing large nodules of pure white carbonate of lime. This bed is surmounted by a stratum of green earth from two to three feet thick, which has one subordinate line of nodules of phosphate. Crossing the valley, the same stratum of upper greensand is seen capping the whole of the ridge, over which Mr. Paine has opened numerous small pits, in the spoil from which the small, hard, dark-coloured nodules of phosphate are very abundant. Mixed with these are numerous fossils,—amorphozoa, bivalve shells; the Monomyariæ are perfect; the Dimyariæ occur only as internal casts; these all consist of phosphate of lime. *These beds are the uppermost* of the upper greensand series, and may be followed till they pass beneath the lower white chalk. Across a small valley Mr. Paine is removing the capping of greensand and marl, to get at the building-stone beneath, and which capping contains the large irregular concretions of phosphate described in his letter; here also fossil remains are abundant, but the whole mass is sufficiently rich to be worth removal. The gault is seen coming out from beneath the beds of sandstone on the south side of this ridge, resting on a mass of the upper ferruginous beds of the lower greensand, the latter forming a slight prominence along the road to Winchester. No beds are worked for phosphate along this line of gault: the various spots at which Mr. Paine has obtained this material belong to the upper greensand, to which part of the series he correctly refers it. He says, "The exact geological position of this stratum is the lower part of the lower chalk," and although he has not worked any of the beds of the gault, he states that the analysis of the fossils which were thrown out in draining this retentive stratum, according to the report of Prof. Way, afforded from eighty to ninety per cent. of phosphate of lime.

The portion of Mr. Paine's communication to the 'Gardener's Chronicle' which most surprised me, was that wherein he states that he had discovered a bed rich in phosphate of lime in the *lower* greensand; and we accordingly next proceeded to view the spots at which it was obtained; the first of these is in the crown of a hill or ridge above the village of Brackleshan, the second at rather a lower level across the valley of the Bourne stream.

The first of these is worked in the mass of gault which Dr. Fitton represents in his section, pl. 10, on the south of the valley of the Wey: the phosphate nodules occur in two bands, one, and by far the richest, near the bottom of the mass, the other higher up, but both within the dark green sands which constitute the lower portion of the gault: the gault clays occur at the summit of the ridge. The valley of the Bourne stream cuts deep into the beds of lower greensand; other inequalities of surface follow this in the line of section; but the gault, decreasing in thickness, is found on the intervening summits beneath the thick capping of tertiary clays and gravels. The cherty sandstone which occurs so abundantly on parts of Farnham Common, is the remains, *in situ*, of destroyed strata of firestone which once rested on this gault. Fossils are abundant in the beds worked above Brackleshan, and these refer them to the gault.

The *true* position of the gault on the south of the river Wey is not given in Dr. Fitton's section, owing to the scale of the sections, which horizontally are one inch, and vertically upwards of four inches to the mile. The thickness of the several groups is in consequence greatly exaggerated; and in this manner there is not space for these undulations of the beds from beneath the tertiary strata of Beacon-hill to the river Wey. The river Wey along this part of its course runs along an anticlinal valley, a disturbance which has been overlooked by those who have described the accidents of the Wealden district. The beds of lower greensand, which on the north side of the stream dip northwards, are found on the other side to dip south; proceeding in this direction they gradually become more horizontal, so that where the gault beds set on above Brackleshan, the southerly inclination is only slight, and it is from this cause that they are carried on much further than is represented in Dr. Fitton's section.

The beds productive of phosphate of lime in the neighbourhood of Farnham are, as everywhere else, confined to the upper greensand and gault; two seams in each of these divisions are richer than the rest, and present nodules almost exclusively composed of it; but the whole of these two masses afford phosphoric acid, and only in less degree than the nodules. It everywhere co-exists with green earth, though this mineral, when worked out from the rest of the mass, as is easily done, does not appear to afford a trace of it.

Phosphoric acid occurs in the waters of many mineral springs, but only in the minutest quantities; in combination it is equally scarce, the metalliferous and earthy phosphates belonging certainly to the rarer minerals, so that we cannot suppose the beds in question to have resulted from the destruction of strata containing them. Animal structures alone seem to contain it in any abundance, and this circumstance has obviously prompted the suggestion which has already appeared in several quarters, that these nodules are coprolitic. Dr. Buckland has shown that these fossil bodies consist largely of this earthy phosphate. It has been urged against this, that these nodules have not the convoluted forms so marked in the coprolites of the lias and in the Iuli of the chalk; this however is of no importance. When these upper greensand and gault nodules are rubbed down so as to show a section, they constantly present a concentric arrangement, as do agates and like bodies where cavities have been filled by infiltration. In the instances of the bivalve shells and ammonites which are now solid casts consisting of phosphate of lime, we know that these forms must have first been enclosed in the sand, that next the proper shelly matter was removed, and in process of time its place occupied by the earthy phosphate.

Though the nodules now under consideration have an internal structure which forbids our supposing them to be coprolites, yet they have the oblong forms of such bodies, and I am disposed to think that the phosphoric acid which these beds contain was originally of animal origin (coprolitic matter), at times with the external form preserved, as in the nodules, but for the most part broken up and mingled with the sand and ooze.

The beds which contain this calcareous phosphate have since their deposition been placed under conditions which must have promoted great internal chemical changes. The vast deposits of the chalk and whole tertiary series have been accumulated above them; they must have gone down to great depths, and have been subjected for a long lapse of time to an elevated temperature. Under one set of conditions the substance of the coprolitic bodies, or that of the shells, sponges, and wood, may have been removed, and the phosphoric acid may have become generally diffused throughout the mass; whilst under other conditions the vacant moulds left by these extraneous bodies may have been filled by the infiltration of the phosphate of lime. The coprolitic bodies are now casts, as are all the other remains; and when we consider the very peculiar character of the substance in question, the presence of these mere external forms seems almost sufficient to warrant the conclusion that the phosphoric acid in these beds was originally of animal origin.

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2. *On the presence of Phosphoric Acid in the subordinate members of the Chalk Formation.* By J. C. Nesbit, Esq., F.G.S.

It is well known, that upon certain strata of the upper and lower greensand, the use of bones and other substances containing phosphoric acid has not proved of the slightest benefit for agricultural purposes. I have for some time been engaged in collecting soils and rocks from these formations, for the purpose of chemical investigation into the origin of their fertility. Among others, I obtained from Farnham specimens of a fertile marl which is found on the estate of J. M. Paine, Esq. A cursory examination gave evidence of the existence of an unusual amount of phosphoric acid in the marl, and in November 1847 I communicated to Mr. Paine the discovery I had made.

From the marl was subsequently obtained by washing, substances, evidently coprolitic, containing twenty-eight per cent. of phosphoric acid; the general mass of the marl contained from two to three per cent. of phosphoric acid.

An examination of some nodules from the gault near Maidstone, sent to me by G. Whiting, Esq., showed the presence likewise of twenty-eight per cent. of phosphoric acid.

Every one who has visited the Isle of Wight must be aware of the existence in the Shanklin sand, at Shanklin and near Black Gang Chine, of nodular masses of shells of a dark iron colour. An examination of these substances showed that they contained phosphoric acid to at least the extent of fifteen per cent., and probably more. The whole of the substances examined contained likewise organic matter and fluorine, some of them in very large quantities.

I have qualitatively analysed at least a dozen other soils and rocks of these formations, and have found none destitute of phosphoric acid. The dark iron red sandstone rock, which occurs in masses in the upper portion of the lower greensand, as at Hind Head and other places, contains, for instance, 0·69 per cent. of phosphoric acid.

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3. *Outline of the principal Geological features of the Salt-Field of* Cheshire *and the adjoining districts.* By G. Wareing Ormerod, M.A., F.G.S.

In the following pages it is proposed to give only a general geological description of the district connected with the Cheshire salt-field. In so doing, such dislocations only as affect the general geological features will be noticed, and it is purposed to avoid as much as possible touching upon any theoretical points, confining this paper to mere description.

The word "fault" will be used as meaning a dislocation causing a general change in the direction of dip: the word "throw" when the direction is not altered.

Of the extent once occupied by the deposit of which the Cheshire salt-field forms a portion, it is perhaps impossible to form now an estimate. The salt-beds of Staffordshire only will here be considered as connected with Cheshire, forming the most south-easterly portion of the same deposit. These beds are found near Ingestrie, about five miles from Stafford. The brine is only worked; the spring is copious, yielding 2 lbs. 2 oz. of salt to the gallon. The following is a section of the measures: red marl and gypsum 324 feet, the same with particles of salt 15 feet, red marl and gypsum 69 feet; in all 408 feet. Of this depth 378 feet were sunk, and 30 bored. This salt deposit is now separated from the Cheshire salt beds by the North Staffordshire coal-field and the red sandstone hills (the Bunter sandstein), extending from the termination thereof near Whitmore to near Shrewsbury. The coal-measures crop out at the northern side of a ridge capped by the new red sandstone, extending from the south-west of Cheadle in Staffordshire (to the east of which place the observations contained in this paper do not extend) near Littley to Dilhorn. This is well shown at Delph-house and other places, and by the road leading from Draycott by Draycott Cross. Near this last place the coal was sunk to through the red sandstone. The dip of both measures is S.W. At Delph-house colliery I found the Holoptychius and Palæoniscus, a species of Unio, and specimens of Neuropteris, Sphenopteris and Pecopteris. At Caverswall the dip of the red sandstone is S.E. To the north of Lane-end the red sandstone overlies the coal, as at Abberley. It is found near Stoke, and appears to basset out along the rising ground as far as Woolstanton. It thence extends in an irregular line or curve to Madley, having a dip varying from W.N.W. to W.S.W. To this point we shall again return.

It is not here purposed to enter into an examination of the North Staffordshire coal-field, but merely to trace its connexion with the coal-field of Lancashire and Cheshire, and to notice the points of contact with the new red sandstone. The south-eastern side of this district has been just noticed. The western runs along the boundary of Cheshire and Staffordshire in a north-easterly direction till it meets the hill ground of Macclesfield Forest. This district is noticed slightly in Farey's 'Derbyshire,' and his observations, where correct, I have incorporated and extended. For much assistance in the examination of the Macclesfield Forest district I am indebted to Samuel Grimshaw, Esq., of Errwood near Buxton, Mr. Mercer of Newton, and Mr. Boothman of Whaley.

From Macclesfield Forest the carboniferous measures extend by Lyme, Disley and Mellor to Hyde and Mottram. The eastern boundary of the district to be examined is formed by a synclinal line, called by Farey (vol. i. p. 172) the Goyt Trough. This can be traced from Ludworth Moor, near New Mills, along the valley of the Goyt, between Goyts Moss and Thatch Moss collieries, between Flash and Quarnford, along Goldsitch Moor, east of Hencloud Roaches, and to the west of Thorncliff. Towards this line the rocks to the east thereof dip, as is shown north of Hayfield by the coal of Abbot's Chair dipping westerly; the flags at Car Meadow dipping W.S.W., a black goniatite shale on the south side of a throw at the same place dipping 15° N.W., carboniferous rocks (probably millstone) at Little Hayfield dipping about 15° W., and at the bridge in Hayfield about 30° W.; the measures from Spinner Bottom to near Highwalls dipping apparently west; the first quarry on the road from Hayfield to New Mills (apparently upper millstone) dipping 23° W.S.W.; the yard-coal at Ollerset dipping westerly, the carboniferous measures from thence to Whaley dipping in a westerly direction; the millstone flags at Fernilee and thence by the High Peak Railway and Goyts-bridge having a general westerly dip; the flags (probably millstone) east of Goyts Moss dipping 46° W. (the coal at Goyts Moss, on the west side of the anticlinal line, dips gently to the east), the rocks at Grin quarries dipping westerly, the coal at Thatch Moss (the lowest bed of the coal series) dipping 11° W. by N., the coals of Goldsitch Moor dipping gently S.W. by W., the coal (the thick 6-foot) at Hazlebarrow dipping 37° westerly, the coal-measure rocks at Thorncliff (probably the lower coal) dipping 17° W. by N. This synclinal line I have not traced further to the south, but the westerly dip is seen in Staffordshire near Oncote, Grindon and Ford, on the metalliferous limestone shales and the quarry at Waterhouses, where the dip is south-westerly. At Cauldon lime quarry, to the west of this point, the dip is 10° N.N.W. The same coal is worked at Ollerset, Whaley and Goyts Moss.

This fault does not proceed forward in a direct northerly direction from the point south of Ludworth Moor, where the description of it commences. It there appears to cease at or merge in a fault which ranges from W. by N. to E. by S., passing between Ludworth Moor and Mellor. The extent of this fault I have not had an opportunity of proving. To the north of the same the beds from the Water-meetings near Compstall to Chunal have a westerly dip, as seen by the black shale at Water-meetings dipping W. by N., the coal-rock at Cote Green dipping gently N.W., the coal and gannister near Boar Fold dipping W.N.W., the flags and shales to the east thereof dipping in the same direction up to the summit of Coombs Edge, where the dip is 8° N.W. by W. The yard-coal has been worked from Boar Clough to Ludworth Intakes having the westerly dip. This varies a little near the fault last mentioned. The yard-mine is worked near the brook north of Chadderton dipping gently W.S.W., and the coal-rock, to the east of a throw ranging north and south at that point, dips from 20° to 40° from S. by E. to S.W.

The western side of the synclinal line, or Goyts Trough, is proved at its northern extremity, on the south of the last-mentioned fault, by the yard-coal, which is worked along Thornsett Brows and by Cheetham Hill to near Mellor, dipping E.S.E. and E. by S. about 10°, and the flag cropping out from under the same, which is seen in the brook by Mill Clough near to the last-mentioned fault dipping gently N.E. An anticlinal line passes between Mellor and Marple, the coal-rock beds at the latter place dipping westerly. This anticlinal line can be traced to Forest Chapel, at which place it apparently divides. To this line the measures rise from the great Goyt fault or trough above-mentioned on the east, and from the eastern plain of Cheshire on the west. At Spout-house, a mile and a half north of Disley, the coal dips westerly. The anticlinal line is cut by a tunnel about three-quarters of a mile to the N. by E. of Disley; it passes near Disley Church; it is seen in the valley east of the Lantern plantation at Lyme Park, the millstone dipping W. by N. and the 13-inch coal E. It is traceable thence by the bottom of the valley below Jenkin Chapel, and passes under the chapel-yard at Forest Chapel. The strata along the latter portion of this line are limestone shale. These beds to the south of Forest Chapel on the easterly side of the fault are thrown up perpendicularly, and in one place are thrown slightly over. Along this district to Whaley the general range of the cross-throws is from N.E. to S.W., the same being mostly throws-down to the north; such also appears to be the general direction of the cross-throws to the north of Whaley. In the throw crossing at Whaley, and that also at Thatch Moss, lead is found in the coal-workings. At Forest Chapel several lines of dislocation apparently intersect. Though not proved, there is good reason to suppose that a line of throw passes from the north of Goyts Moss at this place, being a throw-up to the north.

The anticlinal line which has been above traced is here broken and appears to divide, one branch passing along the brook to the east of Shutlingslow to near the Dane. This is shown by the beds continuing to rise towards the west along the eastern side of the brook and the westerly dip of the insulated hill of Shutlingslow. This hill, one of the highest in this district, is capped with millstone dipping about 12° S.W.; the limestone shale bassets out from under the same at the north-eastern flank. The same direction of dip is seen at the south-west flank of the hill at Sparrow Greave. On the eastern side of the anticlinal line at Green Hills colliery near Quarnford Bridge the coal dips in an easterly direction. The continuity of the fault is broken at the Dane by a dislocation ranging about east and west, which has thrown in the range of the Back Forest dipping in a north-west direction, and ranging across the fault. To the south of this range the anticlinal line again commences and passes to the west of Gun End, and Gunstone quarries, in the limestone shale (these are on the crown of the saddle), by Upper Holker, having the limestone shale dipping 25° E.N.E. on the east, and the Bunter sandstein dipping 25° S.W. on the west, to near Leek. The Bunter sandstein of Leek there will be occasion again to notice. Returning to the fork of the anticlinal lines near Forest Chapel or Shutlingslow, a western branch traverses the lower carboniferous rocks, passing to the north-west of Coombs quarry on the north-east flank of Shutlingslow where the flags dip S.S.W., Green Barn where the shales dip gently to the S.E., and Haddon where stone-beds dip 14° S.S.E. to the south-east and south of the quarries at Teggs Nose dipping westerly, at Pyegreave dipping 11° N.E. by N., at Croker and Raecliff dipping about 10°

N.N.W., and Stonyfold dipping 8° S.W., and to the north-west and north of the ranges having a south-easterly dip extending from Haddon to Bosley. These ranges extend to Winkle, and thence to the north by the valley west of Shutlingslow, as shown by a dip of 17° E. by S. near Bosley Min, E. by S. at Long Gutter, 10° E.S.E. near Longdale, 19° E.S.E. at Winkle.

Between Bosley and Congleton Edge a line of dislocation occurs, which extends from Leek along the valley and here emerges into Cheshire. This will be more particularly noticed hereafter. After passing this fault at Congleton Edge, on the south-west side of Cloud End, the anticlinal line is again apparent. At Cloud End the millstone dips in a general south-west direction. In the Dane to the west of the aqueduct, Farey states, and I am informed correctly, that a line of fault is visible, the black shales and waterstone beds being in contact; this I was not able to verify in consequence of a heavy flood at the time of my visit. These last beds a little lower down the river are much broken, and the dip varies from 16° S.W. to 34° W.S.W. and 45° W. At Big Fenton the (apparently) limestone shales dip about 8° E.; at High Overton the Little roe-coal dips gently to the south-east. A synclinal line runs along coal-measures occupying the centre of the valley lying to the south-east of Mow, from near this point to New Chapel. The millstone crops out from under these coals, forming the summit of the Congleton Edge and Mow Cop Range; the dip at Congleton Edge is from 40° S.E. by E. to 50° E.S.E. This range is crossed near the lime-kilns on Mow Cop by a throw-down to the south-west of about ninety feet; this throw is about ten yards wide. (Information of Mr. Mellor of Ardwick.) The dip on Mow is from 40° to 50° E.S.E. On the northern or Cheshire side of Mow Cop at Newbold Astbury the limestone shale and carboniferous limestone crop out. This last is exposed at the saddle of the continuation of the anticlinal line above-mentioned. It is worked by a shaft to the depth of about ninety feet. This is erroneously considered by Farey (vol. i. p. 160) as the yellow magnesian limestone. It contains, *inter alia*, Producta, Spirifer, Terebratula, Corallines and Trilobites.

On a continuous line with this saddle, to the south-west thereof, the second roe-coal is worked; this dips both north-west and south-east, or towards Cheshire and Staffordshire. The millstone continues to cap the hill to the south-east of these beds. A throw-down to the west therefore passes between these coals and Mow on the dip, and between them and the limestone saddle on the strike, causing the beds to take a position as if cropping out from under the millstone grit.

The anticlinal line thence proceeds between the Bunter sandstein at Meerlake, dipping about 30° N., and the coal at Green-fields dipping about 11° S.

Thence the line is continued across Audley to Madley, where the Bunter sandstein wraps round the extremity of the Pottery coal-field, passing by Whitmore to Newcastle and the south-western side of that district as before mentioned.

Between the line above-mentioned extending from Overton to New

Chapel, and a line extending in a south-easterly direction from Cloud End by the western side of Rudyard Reservoir, the low coal and millstone beds dip in a westerly direction. This is shown at the collieries at Biddulph dipping 14° westerly, the millstone on Biddulph Moor dipping about 40° W., the strata at Broadmeadow dipping W.N.W., and the beds at Horrocks Bank and Grindlestone Edge by Rudyard dipping about 16° S.W. by W. From what has gone before it will be seen that Cloud End forms the northerly extremity of this triangular district, having a general south-west dip.

To the east of this line, from Rudyard to Cloud, the narrow patch of new red sandstone occurs which has been before adverted to. The limestone shales or carboniferous beds on the western side of the anticlinal line passing by Gunstone quarries before mentioned are on the western side also brought into contact with this patch of Bunter sandstein. To the south of Leek I have not extended a regular examination, but it does not appear from the information that I have received, nor am I aware, that the Bunter sandstein extends in that direction. The new red sandstone forms the bottom of the valley, and the rising ground on the eastern side thereof from Leek to near Bosley. At Ballhey near Leek it is shaken, dipping N.E.; at Abbey Green it dips about 25° S.W. as before mentioned; near the Fould it dips 25° S.W.; it there consists of a sandy red rock with large pebbles, some upwards of six inches in length. At Leek it lies very level, having a slight dip to the N.E. Near a brook running from Rudyard by the east of Will Gate it dips 37° N.E. and is in contact with the (probably millstone) beds of the carboniferous measures. These are seen, as before mentioned, at a quarry at Harper's Gate, on the west side of the valley, dipping 16° S.W. by W., and at quarries at Grindlestone Edge having the same dip. Axestone Springs on the easterly side of the valley rise out of the line of fault between the lower carboniferous measures on the east and the Bunter sandstein, which is here seen in an old quarry dipping gently N.N.W. Hence this sandstone can be traced by Fair Edge Hill, along the old road from Leek to Macclesfield, and by the side of the canal-feeder to the river Dane at Hug Bridge. On the western side of this bridge clayey beds, probably the magnesian marls, are seen in the crook of the river, dipping about 15° N.E. by E. The average width of this patch of new red sandstone is about a mile. Near Leek it is a mile and a half across; this appears to be the greatest width. The two faults bounding this patch appear to approach gradually together at Hug Bridge; near this place they probably coalesce and pass by Cloud End through the break in the hills through which the Dane runs, and then enter Cheshire.

In a paper by Mr. Binney, contained in the fifth number of the Quarterly Journal of the Geological Society, the particulars of the points of contact of the new red sandstone and the coal-measures at various points between Manchester and Macclesfield are stated, showing a general south-westerly dip. At Fool's Nook by the canal, about two miles south of Macclesfield, the waterstone beds occur in close proximity to the low coal-measures. The Bunter sandstein appears on the western side of Macclesfield at Alderley Edge. The dip varies from north-west to south-west, and from 10° to 16°. The beds vary much in character; copper, lead and cobalt have here been worked. The Bunter sandstein is exposed in the Bollin above the works at Quarry Bank, and extends thence in a northerly direction to the Lancashire coal-field.

From Quarry Bank to near Bowdon the waterstone beds occur; these are much broken and contorted. Gypsum is found by the Bollin near Castle Hill; the general dip is south-westerly. At Timperley the upper beds of the Bunter sandstein occur for a short space dipping south from 8° to 10°.

The general dip of the whole of this triangular district, bounded on the north by the South Lancashire coal-field, on the east by the Peak and Macclesfield Forest ranges, and on the south-west by the fault next mentioned which separates it from Cheshire and connects it with Lancashire, is south-westerly.

This dislocation ranging from Leek to Bosley, where it enters Cheshire, thence apparently passes north of the great gypseous or saliferous district of Cheshire, ranging between it and Alderley Edge. Rosthern Mere is probably on the line. This piece of water is about 100 feet in depth, or the bottom is about 20 feet below sea-level. The Bunter sandstein beds dipping 4° S. are broken off abruptly at Lymm, and at Warburton the waterstone beds are found dipping from 20° to 46° S.S.W. and much broken; these beds are then thrown down upwards of 1500 feet to the N.E.

They are again broken off on the rise to the east of Millbank, where the highest beds of the Bunter sandstein crop out. At Woolden, on the south-west edge of Chat Moss, the same Bunter sandstein is seen and a brine-spring has been found. On Chat Moss, near this place, iron rods were driven to a depth of 180 feet (or about 90 feet below sea-level) without reaching the bottom. At Woolstone, near Warrington, brine was met with at a depth of 104 feet, or about 50 feet below sea-level. It therefore appears highly probable that the line of fault ranges by Rosthern Mere, and to the east of Millbank and of Woolden, breaking the beds abruptly and causing the depressions which are now occupied by Carrington and Chat Mosses. At Rosthern this dislocation is crossed by a throw reaching from Holt, west of the Peckforton hills and Northwich, and passing a little to the east of the Bunter sandstein at Timperley. To the north of the first-mentioned and the west of the latter faults, with the exception of the lower portion of the Weever, the salt-beds do not appear to extend.

Returning to Bosley, near Great Fenton the waterstones dip westerly, crop out from under the gypseous beds, and are in contact with the limestone or millstone shales.

The upper red marls extend along the western base of Congleton Edge and Mow Cop, coming into contact with the carboniferous limestone and coal-measures which are broken off on that side on the dip, causing at Astbury a down-throw to the north-west. The amount of this equals a portion of the thickness of the carboniferous limestone, the whole of the thickness of the millstone and coal-measures, and the greater part of the thickness of the new red sandstone. The red sandstone at Meer Lake has been already noticed. From this point to Madley and Whitmore the district is so covered with drift that the eastern basset of the new red sandstone is not exposed.

The broad valley extending from near Malpas to Congleton, sweeping in a crescent between the red sandstone hills of Shropshire and the Staffordshire coal-field on the one side, and the high ground of the Peckforton hills and Delamere range on the other, appears to be occupied by the saliferous and gypseous beds, lying as it were in a trough, to which the adjoining portions of both the above ranges dip.

At but few places in this valley, or trough of the salt-measures, do natural or artificial sections extending down to the rock occur. The country is mostly level and covered with deep drift. In the absence of sections we are compelled to have recourse to other clues. In the northern part of the county, as at Winsford and Northwich, the melting of the beds of rock-salt by the overlying brine causes subsidences of the ground. Similar subsidences have taken place in the southern districts, few indeed in number, but sufficient to connect the points where the presence of brine is proved.

The most southerly point at which brine has been worked is at Dirtwich, or Foulwich, situate on the boundary of Cheshire, about two miles to the south of Malpas.

The last pit was sunk through clay to the depth of 450 feet (or by estimation 300 feet below sea-level). The brine comes into the shaft at the depth of 60 feet in a small stream about the thickness of a finger.

Proceeding in a north-easterly direction, at Bickley, situate about three miles to the east of Malpas, a subsidence of the ground took place on the 8th of July 1659. (Ormerod's 'Cheshire,' vol. ii. p. 361.) The place is called the Barrel-fall, and is now dry and overgrown with brush-wood.

At Combermere Abbey, about four miles to the south-east of Bickley and the same distance to the north-east of Whitchurch, a subsidence took place and the pool was filled with brine, which was worked about 1533.

At Audlem, further to the east, the brine-springs rise to the surface.

At Moss-hall Farm near Audlem, and other places in that vicinity, the red marls crop out from under the lias shale and dip S.W. and S. 5° to 7°. To the south-east of the country just noticed, which occupies the valley lying to the south-east of the Peckforton range, lias and lias shale occur. They form a slightly elevated pear-shaped district, the northern side reaching from Wem by Whixall, Tilstock, Burley Dam and Brooks Mill to near Audlem, and overlying the saliferous or gypseous marls. This district is described in Murchison's 'Silurian System,' vol. i. p. 25. This continuous bed of lias is an additional proof of the continuance of the subjacent beds of salt-measures. Through the eastern edge of the lias shales (as described in Murchison's 'Silurian System') a boring was made at Kents Rough, near Adderly in Shropshire, about two miles to the south of Audlem, for coals, but brine was found at a depth of 300 feet. This is, I believe, the most south-eastern point at which salt has been proved in this district. To the south of this patch of lias, as has been before stated, the red sandstone again crops out, dipping in a north-westerly direction and forming the elevated ranges of the Clive and Hawkstone hills, and thence extending near Market Drayton and Ashley Heath to Whitmore.

This outlier of lias occupies the centre of the trough of the red sandstone, having the basset edges of the red marls lower on the north or Cheshire than on the south or Shropshire side. In this south-eastern salt district no rock-salt has yet been actually proved, but the brine at and between Audlem and Nantwich is found close under the soil and running into the river Weever. This peculiarity is possibly explained by the circumstance just mentioned, the southern side of the trough being more elevated than the northern. Thus the water sinking down along the above-mentioned ridges would be thrown out along the line of country lying to the south-east of the Peckforton range; it would then spread along the surface of the measures and, as at Audlem, impregnate the sand.

From Audlem to Nantwich, a distance of seven miles, brine is found on both sides of the river. To the north of Nantwich the brine for a short distance has not been proved. The brine (as I am informed by Mr. Peter Hodgkinson) is tapped at 91 feet 6 inches below the surface (or about 86 feet above the level of the sea). The measures passed through are marl 20 feet, quicksand 1 foot 6 inches, clayey marl with gravel at the bottom 28 feet 6 inches, flag overlying the brine 1 foot 6 inches.

At Acton, a mile from Nantwich on the Chester road, a weak brine rises to the surface. The analysis of the Nantwich brine as made by Dr. Daubeny (Phil. Trans. for 1830) differs very slightly from that at Middlewich.

At Broad Lane in sinking a well brine was found; this is the most northerly place at which brine has, I believe, been found in the vicinity of Nantwich.

The most easterly, I believe, is at Hatherton: this place is situated three miles to the north-east of Audlem. On the western side the brine has been found at Austerton and Baddington, at which places it has been worked.

The most northerly place to the west of Nantwich containing brine-springs is Baddeley, five miles to the north-west of Audlem, and about three miles to the west of Nantwich. At Spurstow, a village situate on the south-east side of the Peckforton hills, a mineral spring is found in a field forming part of the rising ground at their foot: it rises out of a stratum of red and white clay which has been penetrated into nine feet. This water, when it rises, has a slight opake or opaline appearance; on standing some time it deposits this cloudiness and appears remarkably clear: it exhales sulphuretted hydrogen.

A partial analysis by Mr. Whittel gave as the ingredients of a gallon of water 109 grains of solid dried matter, besides carbonic acid and perhaps other gases. Of this solid matter about 50 grains appeared to be purgative salts, containing a few grains of muriate of lime; the remaining 140 grains are composed of about 120 grains of sulphur, and 20 of carbonate of lime. (Ormerod's 'Cheshire,' vol. ii. p. 159). From Audlem to Nantwich the superficial covering is deep sand: this is cut by the brooks into small dingles, and forms a gently undulating surface.

For a short space to the north of a line drawn by Spurstow, Baddeley, Nantwich and Broad Lane, the salt has not been proved. Between these places and the Wheelock and Lower Dane the country is flat, and continues to be covered with drift in the varieties of gravel, sand and marl. At Church Copenhall, in a gravel-pit, several teeth and bones were found about seventy feet below the surface. One tooth was three inches long (Thomas Hodgkinson). To the north of this district the salt is again met with. The most easterly place at which salt is found is Lawton. The gypseous beds, as before mentioned, here abut against the coal, millstone and limestone of Mow Cop and the Cloud. Rock-salt was worked here in the year 1779. This rock-salt is described as being equal in quality to that at Northwich. The mine has not now been worked for many years. The sinkings were through—

Soil and gypseous marls . .	126 feet.
Salt	4
Indurated clay	30
Salt	12
Indurated clay	45
Salt sunk into	72
Total . .	289 feet;

the highest bed being about 290 feet above the level of the sea.

Brine is worked in the neighbourhood of Church Lawton, on the north-east and south-west sides of the Wheelock. The depth to the brine-spring is 225 feet; the level at which the brine stands is 210 feet from the surface, or about 200 feet above sea-level. It rises from one spring, which is copious and strongly saturated, and has been worked for a considerable period.

Near Hassall Green a shaft was sunk to the depth of about 190 feet, or about 84 feet above sea-level, without finding brine. The measures passed through were gypseous, with little specks of salt. The works were abandoned, being unproductive. At Malkins Bank, to the north-east of the Wheelock river, three pits within a short distance of each other are in constant work, at the same depths, with copious supplies of strong brine. The engines when at work can only lower the level of the brine in the pits 9 feet. The depth to the spring is 185 feet, and the depth to the level at which the brine stands 84 feet below the surface, or about 70 and 171 feet respectively above sea-level.

The following are the beds passed through in descending order :—

	ft.	in.
Marl	100	0
Gypseous beds with slight portions of rock-salt	37	0
Marl	3	0
Hard gypseous beds	1	6
Marl	3	0
Hard gypseous beds	1	6
Marl	3	0
Hard gypseous beds	1	6
Marl	3	0
Hard gypseous beds	1	6
Marl	3	0
Gypseous beds very hard at the bottom	22	0
Rock and gypseous beds saturated with brine	2	0
Brine	1	6
Hard matter not penetrated, believed rock-salt.		
	183	6

At this pit a shaft 6 feet in diameter was sunk to the depth of 173 feet; a boring of 5 inches in diameter was then made. When the boring-instrument had penetrated the saturated plaster or gypseous beds to the brine-spring, it suddenly dropped 18 inches, and seemed to rest upon a solid substance. Immediately on the spring being tapped, it rushed in with such rapidity as to carry one of the men to the height of 90 feet before he could be rescued. Brine-pits continue to Wheelock, where a considerable salt trade is carried on.

At the Limekiln pit, or Wheelock Salt-works, is a copious and strong brine in constant work. The depth to the spring is 180 feet, or 3 feet below sea-level; the depth to the level at which the spring stands 84 feet, or 93 feet above sea-level.

The most westerly pit at Wheelock belongs to the Trent and Mersey Canal Company. It is situated on the south-west side of the river Wheelock; it is a brine-pit, and is not now worked.

These pits have been mentioned separately, as they form a line of works, situated at short intervals, carrying on the line of section.

Following the course of the Wheelock, to the west of the shaft or pit of the Trent and Mersey Canal, in sinking the foundations of the viaduct of the Manchester and Birmingham Railway over the Wheelock, brine was reached. About a quarter of a mile lower down the Wheelock, and nearer to Warmingham, a boring was made through marl 102 feet and then into gypseous marls 57 feet, in all 159 feet, or about 22 feet below sea-level, without finding brine, when the work was abandoned. At Pettywood Farm, half-way between Warmingham and Middlewich, on the course of the Wheelock, in boring for the foundations of a bridge, gypseous beds were met with at a depth of 30 feet, when the boring was discontinued.

Salt-springs have not, I believe, been actually detected between the Wheelock and Weever. South of this point the intervening country is covered with deep sand. In some localities, as at Minshul Vernon, brackish water is met with.

The next point at which salt is known or worked is Middlewich. Between the line of salt-works reaching from Lawton to Middlewich and the river Dane, the drift covers the greater part of the country; but from various borings and sinkings, and the sections exhibited in the banks of the Dane, the extension of the gypseous beds to that river is proved. Their further extension to the north is, as before stated, certainly not extensive; they are probably cut off by the prolonged Rudyard fault.

The red marl (as I am informed by Mr. J. H. Williamson, to whom I am indebted for much information both as to the coal and red sandstone of the district near Mow,) can be traced from Lawton to Congleton, lying at the western foot of Mow Cop.

As above mentioned, the waterstone crops out in the Dane a little distance to the west of Bosley aqueduct. It is here much broken, but the general dip is west by south. Near the fault the dip is 45°, which gradually diminishes to 16°, and then continues to near Holmes Chapel at a variable dip, probably not exceeding, and generally less than, that last mentioned. The waterstone beds are of similar character and have the same peculiar crystal as those at Lymm, Preston-on-the-hill, and elsewhere*. At Colley Mill the gypseous beds crop out, overlying the waterstones, and extending thence downwards along the Dane. These are irregular and contorted, but have a general westerly dip. I have not been able to procure any evidence of salt being found near Congleton; the evidence rather tends to show that the contrary is the case.

At Bug Lawton, about half a mile from Congleton, two borings were made by the side of the Dane, one of them to the depth of 360 feet, or about to sea-level, and brine was not met with. Gypseous beds are seen at intervals along the banks of the Dane and the brooks falling into it down to Cranage, near Holmes Chapel, and having the same general westerly dip. Between the Dane and Wheelock the existence of salt may be presumed at Arclid, two miles west of Sandbach, from the sinking ground. At Sandbach, near Mr. Percival's factory, at 90 feet or 143 feet above sea-level, the gypseous beds were reached, but no brine was found. At Elton, gypseous beds were reached at 90 feet, which were bored into 99 feet, in all about 140 feet below sea-level, and salt was not found. At Red Lane, at Elton, half-way between Booth Lane Head and the river Wheelock, a brine-spring rises to the surface, about 130 feet above sea-level. At Sproston Green, half-way between Middlewich and Holmes Chapel, and a quarter of a mile to the south of the Dane, gypseous beds were reached at 90 feet, or a little above sea-level.

For many particulars as to this district I am indebted to the Rev.

* At this place the crystals are of silicate of protoxide of iron. This seeming crystal is probably caused by the component matter taking the places of scattered crystals of chloride of sodium, the form of which both in Cheshire and at Slime Road in Gloucestershire they have taken; exhibiting, if so, the lowest traces of the salt.

Vernon Tipping of Lawton, Mr. John Latham of Congleton, Mr. Thomas Williamson of Stonetrough Colliery, and Mr. Hodgkinson of Booth Lane Head.

For particulars of the brine at Middlewich I am indebted to Mr. R. Llewellyn Vawdrey, Mr. Brereton, and Mr. Peter Hoole of that place.

Rock-salt has not been found at Middlewich. The strata through which all the pits are sunk are composed of alternate beds of red and blue indurated clay with gypsum.

In the pits at Northwich and Winsford, and also it is presumed at Malkins Bank, the brine lies on the rock-salt or "rock-head;" such also is doubtless the case at Lawton. At Middlewich it is found in two different positions, which are worthy of attention as probably explaining the reasons of the appearance of brine-springs in other parts of the country apparently remote from salt-rock.

In seven brine-pits at Middlewich, the brine, to use the local term, is a "seek;" that is, it wells out from a layer of black gravel, about nine inches in thickness, between two horizontal beds of indurated clay or rock. In most of these pits there is but one seek, at about 78 feet from the surface. To this depth the majority of the pits were originally sunk. Two other seeks, however, are met with at the depths of 126 and 144 feet. It does not appear that any advantage has been gained by deepening the pits to these depths. These pits, including the borings, vary in depth from 78 to 309 feet. The level of the brine is 18 feet from the surface. The amount of salt yielded is from 2 lbs. 6 oz. to 2 lbs. 10 oz. to the gallon.

The remaining pit differs from those just described. It is situated to the east of the town and of the pits just mentioned: it is 177 feet deep. This pit was originally only 135 feet deep, but was extended below this depth by "auger-holes" kept open by iron rods. About eight years since, there being a deficiency of brine, a by-shaft or level of about 10 feet was cut, and then a perpendicular one of 42 feet. Since this time the supply has been constant and never failed. It is a very old pit; the date of sinking is not known. The brine here rises so near the surface as to be within reach of the hand. The brine never fails: it yields 2 lbs. 12 oz. to the gallon.

This last pit may probably afford a key to the peculiar position in which the Middlewich brine is found. This pit, very probably, judging from the quantity of water and the level to which it rises, is sunk on or near to a fault, up which, as a conduit, the brine, though apparently here coming also from a seek, rises from the strata where it has become impregnated, forming originally a natural, but now an enlarged Artesian spring. From this fault the brine would percolate through the "black gravel" between the horizontal gypseous beds, forming the seeks found in the other pits.

The level of the rivers Dane and Wheelock at Middlewich is about 85 feet above the sea. The level of the Weever at Winsford Lock is 59 feet 6 inches. The level to which the last-mentioned brine-spring rises is higher than the brook, which runs about 300 feet to the north of the same and falls into the Dane, and is about 120 or 130 feet above the sea.

That a dislocation must exist between this place and Winsford is shown by the fact that here pits are sunk to the depths of 177 feet and 309 feet, or about 57 and 214 feet respectively below sea-level, without meeting with rock-salt, which at Winsford is found at a depth of from 150 to 180 feet, or about from 90 to 120 feet below sea-level. That there is no connexion between this brine-fountain and the Winsford brine is also evident; had such existed, the brine-springs there would also have risen to the same level. Such however is not the case; the level to which the brine at Winsford rises is on the average about that of sea-level; those at Middlewich, as was before remarked, being about 120 and 100 feet above the sea-level.

About one mile to the north-west of Middlewich, at the Flint Mill, brine was found, but has not been worked. Between this point and Leftwich, brine has not, I believe, been searched for, and no such springs rise to the surface. An old brine-pit was formerly worked about a mile to the south of this town, near Manor Hall; this pit was situate on the Wheelock, near the aqueduct, and was copious and shallow. The pit is now closed up.

Between the old pit by Manor Hall and Weever Hall, lying about a mile and three-quarters to the south-west of the former place, salt has not been sunk for, but its existence is shown by various sinkings of the soil which have taken place at Clive and Weever Hall. At the former place, about fifteen years since, a portion of a field sunk down during the course of a night from two to three feet. At Weever Hall a similar sinking has taken place. In this vicinity the land still continues sinking, and the water now covers land which a few years since formed a field.

The land continues to sink along the course of the river to near Winsford, forming large pools. Near Stock's Stairs, about half a mile above Winsford, the sinking parts branch to the west and to the east of the river, leaving the banks firm. The bridge has not sunk. At Winsford the salt-works commence and continue by the side of the river to Newbridge, about a mile and three-quarters north-west of the town. The works along this part of the river appear firm, though the cracks are apparent on the hill-side on the west side of the river a little to the west of the town.

The works at Winsford are mostly brine; the level to the brine-head is from 150 to 180 feet below the meadow-level, or about from 90 to 120 feet below sea-level. The level at which the brine stands when the pits are not at work is about sea-level. When the pits are at work the level of the brine is lowered 45 feet.

The rock-salt has been proved from Winsford to below Newbridge. In most cases the brine has penetrated the shafts, and the same are worked as brine-pits. The measures overlying the salt consist of red and blue marl with gypsum. The brine-head lies on the surface of the upper rock-salt.

The upper stratum is 120 feet in thickness; it is impure and not worked. Two flags of one yard in thickness respectively occur at the distances of four and a half and sixteen yards from the surface of this bed. In this point it differs from the upper bed at Northwich, which otherwise it resembles. In both places this salt-bed is impure; here it is 120 feet, and at Northwich from 84 to 90 feet thick. The upper surface of the top bed is not level; this is caused probably by the action of the water or brine-head which overlies it. At Winsford this surface consists of parallel undulating lines which range from east to west: at Northwich the surface is irregular.

Below this stratum lies a bed of indurated clay called "stone," from 33 to 36 feet in thickness. Like the similar bed at Northwich (which is there 30 feet in thickness) this bed is traversed by veins of salt called "leaders" reaching from the upper to the second stratum of salt.

Below this bed lies the second bed of salt. Like the second bed at Northwich the upper portion is impure. There the impure portion is from 60 to 75 feet in thickness, below which the next 15 feet is the portion which is worked; below this the salt is again impure.

At Winsford, in a like manner, the upper portion for a thickness of about 75 feet is impure, below which 15 feet of marketable salt occur; the salt below this is impure. This second bed has been penetrated to a depth of 120 feet, but has not been sunk through. Below Newbridge or Moulton the rock-salt has not been found till at Northwich.

For many particulars as to Winsford I am indebted to Mr. Jump, a mining-engineer of that place.

A throw probably passes near Moulton, as a difference of almost 20 yards in depth to the rock-salt was found between two sinkings made in the same level 100 yards from each other.

Between this point and Leftwich no rock-salt has been found. On the west side of Hartford Bridge, below the same, and also opposite Vale Royal, near Eaton, small salt-springs rise to the surface. Sinkings were made near the spring at Hartford to the depth of 240 feet, or about 138 feet below sea-level, and brine was not found. These sinkings are valuable as showing the line of fault between the Winsford and Northwich salt, the depth to the salt at Winsford on the south being from 90 to 120 feet, and at Northwich on the north about 39 feet below sea-level.

At Hartford Clough, about one mile above Northwich, and in Leftwich, borings were attempted; in both places they were abandoned on account of the sand.

In King's 'Vale Royal' it is stated that at Northwich there was a salt-spring or brine-pit on the bank of the river Dane from which the brine runneth on the ground in troughs of wood covered over with boards until it came to the Wich-houses where they make salt. It will be observed that the spring is spoken of as on the Dane, and therefore in Leftwich or Witton. This spring is not now in existence.

The brine at Northwich does not rise to the surface. The rock-salt at Mr. Marshall's pit in the centre of the town is 55 feet below sea-level. The depth at which the brine stands varies according to the number of pits at work. When in full work the level will be lowered from 34 to 46 feet below sea-level.

The rock-salt was accidentally discovered in 1670 at Marbury, near Northwich.

The district generally known by the name of Northwich is locally divided into Hartford, Castle Northwich, and Winnington on the western side of the Weever; Leftwich, between the Weever and Dane, which there join; Witton and Northwich, having the Dane on the south, the Weever on the west, and Witton Brook on the north; and Marbury and Anderton on the north side of the Weever. In Leftwich, on account of the great depth of quicksand or drift, few attempts have been made to find brine. A few years since a pipe was forced down more than 96 feet through the sand. In the remaining townships the brine and salt are generally found in the same conditions and preserve the same levels; they will therefore be treated of together.

In the following particulars of Northwich, as well as occasionally elsewhere, I have incorporated portions of the information given to this Society by Dr. Holland in his paper on the 'Cheshire Salt,' vol. i. Trans. of Geol. Soc. (Old series), in which a particular description of the Northwich salt is given.

For much information and assistance in the local examination of this and the adjoining district I am indebted to the Rev. George Eaton, of the Pole near Northwich. My thanks are also due to Mr. Cheshire, one of the most extensive salt-proprietors here and at Winsford, for his ready help and the examination of the parts of this paper relating to Northwich.

The depth to the upper bed of rock-salt at Northwich varies of course with the undulations of the surface of the land, and in a small degree on account of the irregularity of the upper surface of the bed. This depth varies from 96 to 159 feet. The depth to the upper stratum is stated by Holland as being 87 feet below the level of Witton or Wincham Brook, being at least 36 or 39 feet below sea-level at Liverpool. (Vol. i. p. 47 of First series of Geological Transactions.) The exact depth of, I believe, the nearest pit to the Weever as furnished to me by Mr. Thompson of Northwich is given before.

The thickness of the upper bed is stated to vary from 84 to 90 feet in the pits sunk to the north-west, decreasing near the east border to 81 feet. It thins off towards the south-west, losing 15 feet in thickness in the course of a mile. The upper surface of this bed is irregular, forming cones and irregular figures. Below lies a bed of indurated clay 30 feet in thickness, with veins of salt traversing it. This overlies the great bed of salt.

The highest portion of the second or great salt-bed for a depth of from 60 to 75 feet consists of salt with a considerable portion of earth, and is not worked; for 12 to 15 feet below this the salt is more pure, and from this part of the deposit the rock-salt is got; below the proportion of earth is as large as in the upper part, and this is not worked. These beds, it will be remembered, were compared with those just described in the Winsford district.

Till within a few years the second bed had not been penetrated. At a pit at Marston, to the north of Northwich, belonging to Mr.

Nieuman, a shaft has now been sunk through the second salt, proving it 96 feet thick at that locality. At other places it has been penetrated to a depth of 117 feet without being sunk through.

The following is a section of this sinking:—

	ft.	in.
a. Compact light blue and brown laminated stone	5	8
b. Red salt with veins of clay	6	7
c. Pale red salt	3	4
d. Compact laminated brown stone with thin laminæ of salt	13	9
e. Pale red salt	6	0
f. Compact laminated brown and blue stone traversed with thin veins of salt	7	6
g. Lowest bed of salt variable in colour from white to red, with a slight admixture of blue clay	11	6
h. Compact laminated brown and blue stone	77	0
i. Hard light blue stone with splintery fracture, with small detached crystals of salt	9	0
k. Compact heavy laminated stone, brown and blue, with small portions of salt between the laminæ (bored into)	11	0
	151	4

The depth from the surface to the lowest point of these borings is therefore, taking the average,—

	ft.	in.
From the surface to highest bed	127	0
Highest bed	85	0
Stone..............................	30	0
Second bed	106	0
Borings at Marston	151	4
In all	499	4

The constant working of the brine and salt at Northwich has caused alterations, and occasionally extensive subsidences of the surface. To the melting of the upper surface of the rock-salt is to be attributed the irregularity of its surface and the contortions of the beds overlying it, evidently originally deposited on a level surface.

Along the river Dane no sinking has taken place, and the bridge over the Dane at Northwich is firm.

The highest point up the Weever at Castle Northwich at which the land sinks is at the Navigation-yard on the western side of the river, a little to the south of the bridge. The sinking here is upwards of eighteen inches towards the river.

Near this place the road to Chester has sunk six feet at least; to the west of this point by the road towards Winnington Bridge the subsidence of the ground is shown by the cracks in various houses.

On the west side of the river the bank has also sunk. Above the Dane-bridge no signs of sinking are apparent, but between the bridge and the point where the Dane and Weever meet a rapid subsidence is taking place.

Between the bridge and a new lock situate about 100 yards lower down the Weever, a subsidence has taken place. This is shown very clearly in the course of a stone-breast wall supporting the towing-path built along the west side of the river. On the spot where the new lock is now placed there was formerly a rock-salt mine; this gave way about seventy years ago, and the place silted up. The new lock was erected about 1838; in 1843 it had sunk very little, and the weir not at all; in 1846 it had sunk so much that the Weever trustees were constructing a new lock and weir to the south of the last-mentioned bridge, where no subsidence has taken place. The buildings at the east extremity of the weir, firm in 1843, have given way. In a yard at the eastern end of the weir at Northwich a factory formerly stood; a pit-shaft however gave way, and since then the ground has continued to fall rapidly towards the centre, more particularly towards the corner of Leicester-street and Witton-street. Here there was formerly a rock-salt pit. This ground is now covered by the water, and is connected with the Weever, forming a wharf or basin.

Below the new lock the sinking continues by the Weever, to the west of the junction of the Weever at Witton Brook. It has been necessary to raise the salt-pans of all the salt-works along the banks of this part of the river. In some cases they have been raised six feet. Five of the works in June 1846 had been abandoned within a very short period.

The towing-path below the old lock, situated near the junction of the Weever and Witton Brook, was a few years since raised five feet. For some weeks the subsidence was at the rate of three inches per week. This towing-path has the Weever to the south, and the lake formed by the sinking of the land along the Witton Brook to the north. This lake or pool has rapidly increased within the last few years. The depth is upwards of 20 feet. Along the margin of this pool the land continues to sink, as may be seen at the tram-road quay at the eastern side. The sinking keeps extending, apparently taking a north-easterly direction. The sinking of the land ceases a little to the east of Winnington Hall. Winnington Lock and Bridge are firm.

The following account of the sinking along Witton Brook is inserted from information furnished to me in the year 1843 by the late Mr. Fowls, for many years the able engineer to the Trustees of the Weever Navigation:—

"In the year 1802 he was at the building of some salt-works near the eastern end of Witton Brook, which is a part of the Weever navigation reaching from Witton Mill to a lock called Witton Brook Lock, extending nearly a mile in length; at the time there were two lines of water, one for the passage of vessels, and the other for the current of the brook, the land being considerably above the water on both sides; the land had then begun to sink considerably about the middle of the length of what is called Witton Brook. In the year 1811 (he being resident engineer to the Trustees of the Weever Navigation) great complaints were made to the Trustees that the raising of the water at Witton Brook Lock was injurious to the land, and also to Witton Mill, which were then considerably sunk. He was ordered to lower the surface of the water four feet, and to connect that part of the navigation to the pond below Witton Brook Lock; for which purpose he had occasion to deepen or take out the bottom, so that there might be six feet deep of water for vessels to sail in or navigate: this was done in the year 1811.

"This lowering of the surface of water (four feet) by the removal of the lock and weir again brought the water off the meadows into its proper channels, which before had overflowed the lands. The land has continued to sink since that time.

"He in 1842 or 1843 had a survey and admeasurement taken of the land that was covered with water, and found the area, exclusive of the course of the navigation and of the course of the stream, to be about twenty statute acres. He had the depths of the water taken along the line of the navigation where he had in 1811 to take out the bottom to make the depth of water six feet, and found the depths in 1843 to vary in the different places from ten feet at the parts near to where the lock stood, to all the numbers up to thirty feet and more; so that some of the land has between 1811 and 1843 sunk twenty-four feet. A timber-lock was made new in the year 1827 for the purposes of the trade higher up the river at Winsford, &c., but not to raise the water in Witton Brook or near to Witton Mill, and in nine years (or in 1836) he had to raise the lock to its former level, in some places five feet. It was in 1843 become useless, likewise the weir to which it was connected.

"There are some wharfs and loading quays at the top of Witton Brook, near to Witton Mill, which were formerly used, but in 1843 sunk so much as to become useless. He had their heights taken in May 1839, since which time they had in 1843 sunk more than three feet."

Another subsidence is hereinafter mentioned as taking place in a field by the side of the brook connecting Pickmere and Budworth Meer, pieces of water themselves, probably owing their origin to former subsidences.

The subsidences caused by pits falling in it is not needful to register; they have been mostly caused by the miners not leaving sufficient pillars, or by the irruption of the brine. The following example will suffice to show the distant effect arising from a pit falling in.

In 1842 the brine got into three of the rock-pits at Dunkirk. The brine ran from the surrounding land into these pits, and the rapid drainage had a visible effect on the surface. Thus at the fork of the roads to Warrington and Marbury a row of cottages leant towards the west. During the time that the brine was running into the pits these cottages gradually settled towards the east, and the cracks closed. In March 1843 the cracks were almost closed, and the houses were not so distorted as to attract attention. Since that time they have been pulled down. The distance from these cottages to the pits that filled is about one-third of a mile.

With respect to the boundaries of the salt at Northwich, the following particulars may be mentioned. At the brook between Pickmere and Budworth Meer are the most northerly traces of the presence of salt. That this exists there may be inferred from the gradual sinking of the ground which is taking place. Near Budworth Meer the water from the brook is gradually increasing on a field, and a farm-house situated near the same place is shaken by the same cause. The exact northern extent has not been discovered. It is probably the line of fault before-mentioned which passes from the South Lancashire coal-field by Warburton and Rosthern, in a south-easterly direction to the Rudyard fault.

The north-west and south-east sides thereof are by Dr. Holland stated to be apparently parallel, and to be distant from each other about 1300 yards. These sides are found to be abrupt. At a mine approaching very nearly to the eastern limit of the area contained between the above boundaries the upper bed of rock-salt was actually worked through in a horizontal direction on that side, and was discovered to fall off with a very rapid declivity. A similar case is said to have been observed in another pit on the same side. (Holland's Cheshire Salt, Geol. Trans. vol. i. p. 46.)

That these salt-beds do not now extend to the east continuously is shown by the Middlewich beds above-mentioned, and by the borings for salt made by Mr. Smith at Wincham. These borings to the depth of 300 feet, or about 200 feet below sea-level, were as follows:—

27 feet soil and marl.
150 feet plaster and marl.
2 or 3 inches of rock-salt.
123 feet marl and plaster ending in common red marl.
(Information of Mr. Dodgson, Holford Mill.)

These borings were made by the side of the canal, and therefore on the same level with some of the pits at Marston in which the depth to the first salt is about 135 feet, or about 35 feet below sea-level. These workings therefore show the existence of a line of fault. This is supposed to run almost along the course of the Weever in a north-easterly direction from the crook in the river near Vale Royal.

On the south the sinking of the land has been shown as ceasing a little to the south of the Weever Bridge, and that south of and near this point borings have been taken deeper than to the level of the salt at Northwich without reaching the same. To this point the salt may be considered as extending, and to be there cut off by the north-westerly extension of the dislocation before-mentioned as passing between Winsford and Middlewich. This dislocation will thence pass to the north of Barnton.

At Barnton, Dr. Holland states, by the side of the Weever, a weak brine was discovered at the depth of 115 feet. In 1842 a search for salt was made at the same place. A bastard brine was met with at a depth of between 165 and 190 feet. At 18 feet lower a second brine was found; to this point a shaft was sunk, and then tunnels were driven north and south. In the north tunnel a bastard brine was met with, in the south tunnel a strong brine, but both were in small quantities. Borings were taken below this point to a depth of about 180 feet, or 130 feet below sea-level, when the rods were lost. The borings have been since continued, and without success.

A brine-spring breaks out in the garden near the top of this boring. On making the Barnton cutting for the Weever navigation about the year 1837, brine was discovered running into the river as far as Saltersford Lock, about 50 feet above sea-level, and a large mass of gypsum was found from which several tons were blasted in forming the canal.

Pursuing for the present the course of the Weever; at Weaverham, below Northwich, on the west side of the Weever, brine has been worked. Salt was made in this township in the seventeenth century, as appears by some leases extant in the Harleian MSS., Nos. 2090 and 2091. (Ormerod's History of Cheshire, vol. ii. p. 57.) The depth to the brine I have not been able to discover.

At Acton and Kingsley borings were taken to the depth of 300 feet, or about 250 feet below sea-level, about thirty years since. At both places they were unsuccessful. Salt-pits are noticed in the township of Kingsley in "Inquisitions of Edward the Third." Some weak brine-springs are now existing in the townships, but no salt is made there. (Ormerod's History of Cheshire, vol. ii. p. 45.) I am not acquainted with the exact spots at which these springs are found, but I believe that they are situated near Crewood Green.

At the western end of Kingsley village, on the road to Newton, a thin shaly red rock is seen in a small stream at the side of the road. Sufficient of the rock is not exposed to show to which division of the new red sandstone it belongs.

At the bend of the Weever, about a quarter of a mile below Saltersford Lock, are contorted beds of red and white marls. The white marl is very friable, and contains small portions of gypsum.

At Whitley in the year 1803 or 1804, in boring for coal, it is stated that a bed of rock-salt was discovered about forty yards from the surface. This is the most westerly point at which salt has been found on the north bank.

At Dutton Bottom shaly beds, consisting mostly of soft red stone, are seen; these are accompanied by hard thin white layers.

At Dutton viaduct the gypseous marls were exposed in digging the foundations for the piers.

About one mile below Pickering's Lock, broken red and white soft marly stone is seen forming a saddle, having a north and south strike and dipping 15° on either side.

About half a mile lower down, on the north side of the river opposite Crewood Wood, is a cliff of red marl containing two bands of gypsum, about five feet in thickness; these bands are subdivided into laminæ two or three inches thick. The red marl is much broken, and is penetrated in every direction by thin strings of gypsum connecting the two beds, and chiefly near them.

The most westerly salt-works along the Weever are below Frodsham Bridge. The salt made here is not from rock or brine found on the spot, but from the salt water of the Mersey strengthened by rock-salt from Northwich. At these works borings were made to the depth of 475 feet, or about 450 feet below sea-level. The measures bored through were chiefly of a hard gritty nature, forming eighty-eight beds, of which the thickest was 30 feet, and the thinnest two inches in depth; forty-seven of these beds were under three feet in thickness. Rock-salt was not detected. A weak brine was found at the depth of 288 feet 10 inches. It is impossible to say whether this brine derives its impregnation from rock-salt on the spot, or finds its way from some distant point by means of the many dislocations which traverse this district. As however the brine was found to be stronger when the boring had been stopped for a few days, it is possible that a thin vein of rock-salt exists here which has not been detected, but been classed as a sandy grit.

A second boring was taken near the one just mentioned to the south-west thereof, the particulars of which coincided with it.

A shaft was sunk at the above works near the Mersey to the depth of 90 feet, and then abandoned. The upper beds contained a little spar, but were generally gritty with hard ferruginous bands. These it was necessary, on account of their hardness, to blast.

The beds here met with are similar in character to the upper portion of the waterstone beds seen on the northern side of this valley at Preston Hill; they probably exhibit the change from the gypseous or saliferous to the last-mentioned strata.

The district just described (being that in which the salt is mostly worked), it will have been doubtless perceived, extends nearly in a right line from east to west across Cheshire. From the following approximate estimate of the heights compared with sea-level at which the brine is tapped and stands, and the salt found, it will be seen that it is traversed by great dislocations. The extent and direction of these are as yet unknown, the adjoining districts both to the north and south being unproved. At the east of Lawton, as before-mentioned, an anticlinal line runs from north to south, passing through the coal-measures, which are there broken off on the westerly dip, bringing them into contact with the saliferous beds.

	feet.	
At Lawton the rock-salt found	290	above sea-level.
Near the same place, brine found	185	,,
Near the same place, depth at which brine stands	200	,,
Hassall Green, brine not found at	84	,,
Malkins Brook, brine found	70	,,
Malkins Brook, brine stands	171	,,
Wheelock Salt-works, brine found	3	below sea-level.
Wheelock Salt-works, brine stands	93	above sea-level.
At Sandbach brine was not found at	143	,,
Near Elton a brine-spring rises to the surface	130	,,
Near Warmingham brine was not found at	22	below sea-level.
At Sproston, near Middlewich, brine was not found at a little above sea-level.		
At Middlewich brine rises to the surface	120	above sea-level.
At Middlewich brine is found	7	,,

	feet.	
At Middlewich rock-salt is not found	214	below sea-level.
At Wincham no workable salt or brine was found at ...	200	"
At Winsford rock-salt and brine are found at	90	"
At Winsford brine stands at about sea-level.		
At Hartford neither rock-salt nor brine was found at ...	138	"
At Northwich rock-salt and brine are found at ...	55 to 39	"
At Northwich the level at which the brine stands..	34 to 46	"
At Marston (Mr. Nieuman's pit), rock-salt found	27	"
At Marston, level of brine when at full work	5	above sea-level.
At Marston, level of brine when pits standing	32	"
At Barnton brine was found at	130	below sea-level.
At Barnton brine rises to the surface	50	above sea-level.
At Acton brine was not found at	250	below sea-level.
At Frodsham Bridge rock-salt was not found at	450	"
At Frodsham Bridge a weak brine was found at	250	"

The Peckforton hills have been described by Sir R. I. Murchison.

To the west of these hills and a line prolonged from thence across the eastern side of Delamere Forest rock-salt has not been found, neither has brine, save at the springs at Aldersey and, as before mentioned, in the valley of the Weever below Northwich, and the springs at Dunham and Millbank in Cheshire, and Woolden and Woolstone in the adjoining part of Lancashire. Aldersey, the most southerly of these, is situated in a valley lying between the westerly side of the Peckforton range and the low hills of Bunter sandstein lying on the easterly side of the Dee. The brine was here formerly worked to a small extent. The springs are met with near Aldersey Hall; they rise from drift-clay and sand which occupy the centre of the valley. The dislocation is here a considerable throw-down to the west, the Bunter sandstein beds at the hills on the western side being high in the series. The dip on both sides of the valley is in a general easterly direction.

The waterstone beds occur at Overton near the southern extremity of the range, dipping 15° E. by S.

Along the valley of Beeston Brook and the Gowy, between the northern extremity of the Peckforton range and the south of Delamere Forest, a dislocation having a north-west and south-east direction runs. From the great extent of drift and the occurrence of but few and distinct exposures of rock along the flat, on the level lands lying along the banks of Beeston Brook and the Gowy, I have not been able satisfactorily to prove the same, but to the west of the Peckforton fault the throw-down to the south-west probably is marked by the course of the Gowy. The chief lines of dislocation affecting Delamere Forest are the Peckforton fault above-mentioned passing to the west of Handley, Tattenhall and Tarporley, near Utkinton, and Oak Mere; a line of fault ranging almost magnetic N. and S. passing between the waterstone at Willington and Kelsall dipping E. by S., and the Bunter sandstein at Eddisbury Hill dipping 4° N.N.W.; between the Bunter sandstein capped with waterstone at Simmond's Hill and Heycliffe dipping E. by S., and the waterstone at Finney Hill dipping W.N.W.; between the Bunter sandstein of Alvanley, Helsby and Beacon Hill, near Overton, dipping easterly, and the Bunter sandstein of Five Crosses and Frodsham dipping S.W. Thence the fault probably crosses the Weever, passing between Weston and Rocksavage, and to the east of Higher Runcorn, between that range and Lower Runcorn. Here it appears to join a line of dislocation passing along the northern side of Delamere. It is evident from the contour of the country that a dislocation does exist there, but the drift here also shuts out all certainty. Near Lower Runcorn-ferry there is an anticlinal fault, the rocks dipping W. by N. and E. by S. The beds of waterstone at Rocksavage above-mentioned dip gently W. by N. To the east of Frodsham Bridge they dip easterly 80°. To the north of Frodsham the anticlinal is seen in the Bunter sandstein crossing the road. The westerly dips at Five Crosses and Finney Hill have been already mentioned, and along the escarpment of high ground to the south-east of those places ranging near Norley it is probable that this anticlinal fault extends, being the line to which the waterstones of the Lower Weever will rise. To the north of the Weever, on the west side of the Peckforton fault, about two miles to the north of the point near Budworth where the land is sinking, the waterstone beds (or stone marl) are seen near the mill at Arley on the east of the park, and are also met with near the south-westerly angle of the park: they are there horizontal. These beds are again met with cropping out along the ridge from Hoo-green by High Legh to Grappenhall, and overlying the Bunter sandstein from Agden to the west of Lymm. Between these places the traces of the Cheirotherium are found in great abundance. The dip is there about 4° southerly.

The fault ranging to the north-east of Lymm, between that place and Warburton, has been already mentioned. These beds appear to be cut off on the south-west by a fault extending from Northwich east of Stretton, then passing down a valley to the east of Hill Cliff, and thence proceeding by the east of Warrington, where it passes into the South Lancashire coal-field.

On the west of this line are the Bellefield beds. These last are Bunter sandstein capped with an outlier of waterstone, and dip a little south of east. To the south-west of Bellefield the beds have been thrown down to the west upwards of 160 feet, as the waterstone is again met with dipping south-easterly in the valley at the foot of Hill Cliff. This throw is apparently the continuation of that before mentioned as running between Winsford and Middlewich, and to the south of Northwich. The Bunter sandstein is seen crossing the Mersey near Wilderspool Brewery. The waterstones again appear for a short distance to the south-west, dipping in an easterly and south-easterly direction, and overlying the Bunter sandstein of Darsbury. They are then again thrown down to the west, appearing on the Preston Brook range dipping south-easterly. The Bunter sandstein crops out from under them near Norton-town, dipping in the same direction; thence it extends to Halton Castle, where conglomerate beds occur. Here the Bunter sandstein beds again are thrown down to the west and continue to Lower Runcorn, where, as before mentioned, they are crossed by a fault near the Ferry.

These last-mentioned beds of Bunter sandstein do not extend to

SECTIONS TO ILLUSTRATE THE GEOLOGY OF CHESHIRE.

Fig. 1. *From Burley Dam in Shropshire, across Cheshire, to the South Lancashire Coal-field.*

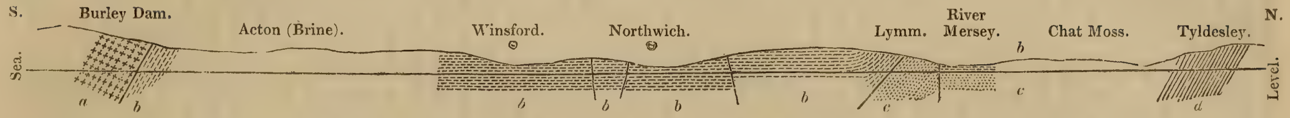


Fig. 2. *From the River Mersey near Warrington to Chinley in Derbyshire.*

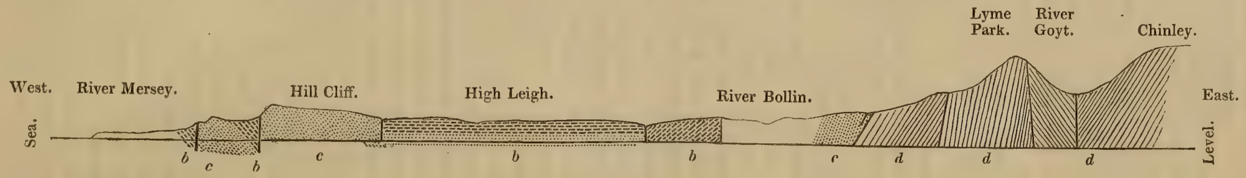
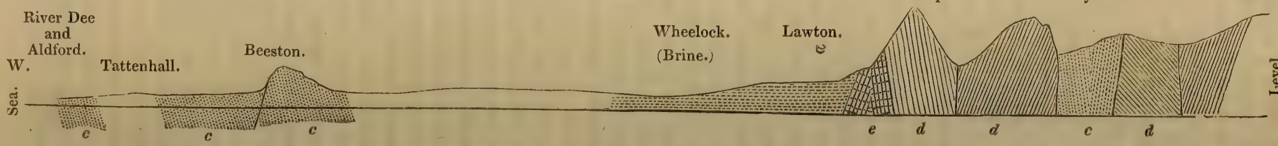


Fig. 3. *From the River Dee (South of Chester) to near Mixon in Staffordshire.*



a. Lias. *b.* Keuper. *c.* Bunter sandstein. *d.* Coal, millstone and limestone shale. *e.* Carboniferous limestone. Θ. Rock salt.

the Weever on the south, as has been before shown when describing the course of that river. To the north they cross the Mersey into Lancashire, as is seen near Warrington and Runcorn. The further extension to the west of the new red sandstone in South Lancashire and in Wirral will not now be noticed. The district of Wirral is separated from the rest of Cheshire by the anticlinal fault throwing up the coals at Neston, and can be more properly noticed in connexion with Flintshire than with the district which has been here described.

Thus in the foregoing pages it has been attempted to trace an outline of the chief geological features of Cheshire. We see it bounded on the eastern side by the high range of hills forming a portion of the Lancashire, Cheshire, and the Pottery or North Staffordshire coal-fields. From Forest Chapel, or Shutlingslow, as the central point, dislocations extend in almost every direction, the chief of these being an anticlinal line extending thence in a northerly direction to Ludworth, a broken anticlinal line (being a continuation of the same) extending thence southerly towards Leek, and an anticlinal line passing by Mow Cop and the borders of Cheshire to Madley. Connected with these, a synclinal line has been shown to extend from Ludworth to near Leek, parallel to and to the east of the first- and second-mentioned anticlinal lines. A synclinal line has also been shown to range parallel to and to the south-east of the anticlinal line passing by Mow. In this same district it is seen that a narrow band of the Bunter sandstein of an average width of one mile occupies the valley from Leek to Cloud End, bounded on both sides by millstone or limestone shale. From Bosley, where this last red sandstone fault emerges into the plain of Cheshire, it has been stated that the same is most probably continued across Chester to Rosthern, between Lymm and Warburton, forming the north-eastern boundary of the Cheshire salt-field. Thus it has been shown that dislocations affecting both the North Staffordshire coal-field, the chief Cheshire coal-field, and a considerable part of Cheshire, centre in or near Shutlingslow. The salt of Cheshire, with a few exceptions, has been shown to be situated in a broad valley or trough between the western side of the anticlinal line ranging by Mow Cop and the ranges of the Peckforton and Delamere Hills. Along these last ranges a dislocation passes from south-west to north-east, bounding the Northwich salt on the west, and thence continuing by Rosthern. The origin of the insulated brine-springs at Aldersey, Millbank, Woolstone and Woolden has been here ascribed to dislocations bringing the brine into those districts from other parts, as dislocations pass from the salt-districts by or near to those respective places at which no traces of salt-rock had been found. With respect to the brine and the gypseous beds on the Weever, below Northwich, these appear to be the remains of the saliferous beds now confined to a narrow valley, the underlying Bunter sandstein and waterstone beds being thrown up on the north and south sides thereof.

The existence of rock-salt in the south of Cheshire has not been proved, but may be inferred from the sinkings of the ground in those brine districts, similar to the sinkings which take place from the melting of the rock-salt in the districts of Northwich and Winsford.

It was shown that the salt-measures are exhibited in the best manner in a line taken from Mow to Middlewich and Northwich, and along the lower valley of the Weever to Frodsham. On the Dane, above Congleton, the gypsum bassets out conformably above the waterstone beds. At Frodsham, and again on the Bollin near Castle Hill, gypseous beds in a similar manner overlie the waterstone beds, showing that the gypsum underlies as well as overlies the salt beds.

The thickness of the red marls overlying the gypseous beds I have not been able to estimate.

At Bug Lawton, near Congleton, the gypseous beds were bored into 360 feet. At Church Lawton, also in the same vicinity, as shown by the section before given, the salt-measures were sunk into 289 feet without penetrating through the lowest bed. These sinkings give a thickness of 649 feet to the saliferous and gypseous beds in that district, without taking into calculation the portion intervening between the lowest point reached at Church Lawton and the top of the beds at Bug Lawton.

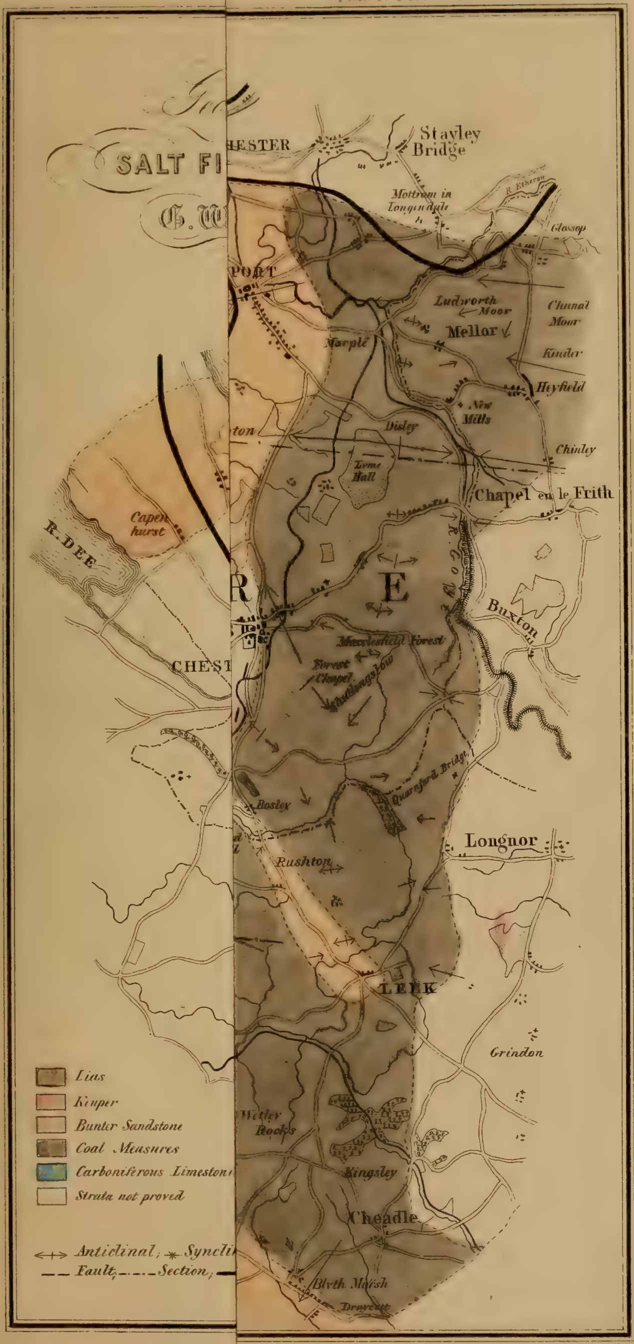
At Northwich the saliferous and gypseous beds have been sunk into 499 feet, and at Middlewich the beds (which I consider as underlying the Northwich beds) have been sunk into 309 feet, making a total thickness of 808 feet. The thickness therefore of the gypseous and saliferous beds, taking the average from these, the only places where any estimate can be made of their thickness, is upwards of 700 feet. The waterstone beds underlying the gypseous beds I estimate as upwards of 400 feet in thickness. The Bunter sandstein I estimate as upwards of 600 feet in thickness. Marls, which appear to be the magnesian marls, I have found at Hug Bridge, and Mr. Binney has found these marls at Poynton. At both places the beds are so thin as to be not worth notice in estimating thickness. The total thickness therefore of the new red sandstone in Cheshire may be estimated as above 1700 feet. This I consider to be far below the thickness. Each subdivision is probably much thicker.

As stated at the commencement, it has been only attempted in these pages to give a general outline of the chief geological features of Cheshire. To enter into a full account of the greater portion of the district would be little more than to detail the varying dips of the beds of the new red sandstone, and furnish particulars of borings in the sands and clay. The first, a map will show more clearly than any description. The last, as also numerous separate portions of this district, can only be satisfactorily considered by themselves.

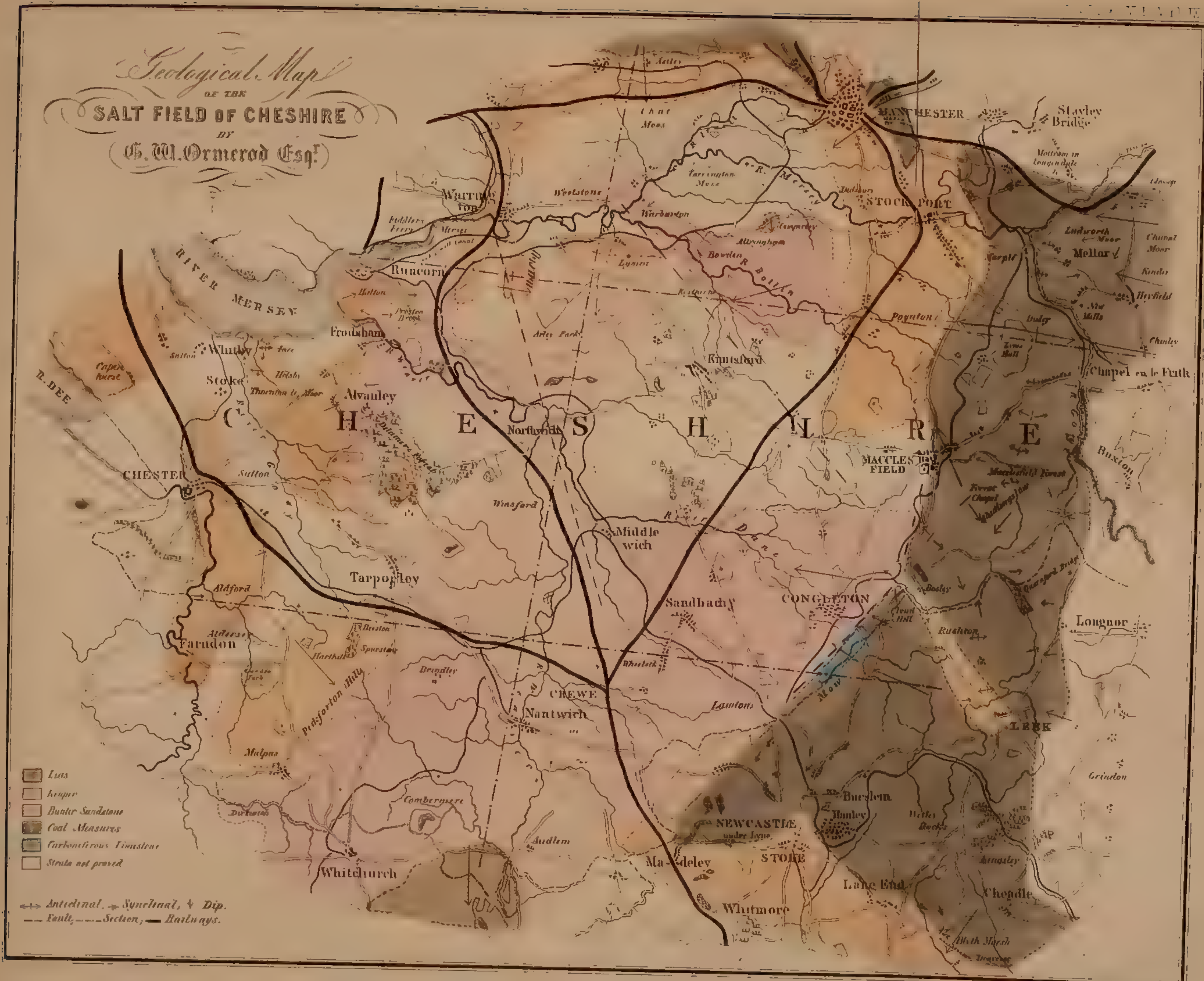
March 22, 1848.

N. Beardmore, Esq., Wm. Freeland, Esq., John R. Maclean, Esq., William Wills, Esq., Robert H. Semple, Esq., and Capt. R. T. W. L. Brickenden, were elected Fellows.

The following communications were read:—



Reeve, Benham & Reeve Lithogr.

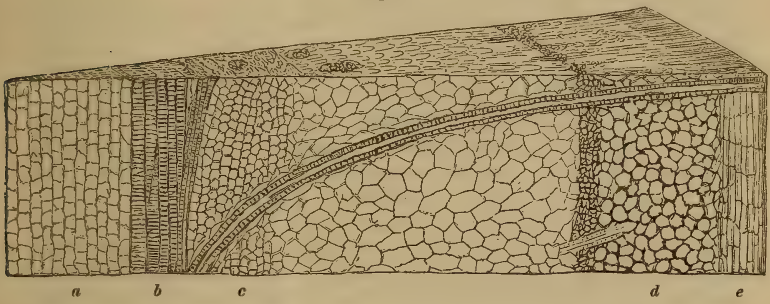

Geological Map
of the
SALT FIELD OF CHESHIRE
by
G. W. Ormerod Esq.r
MANCHESTER
Stayley Bridge
STOCKPORT
Warrington
Runcorn
RIVER MERSEY
R. DEE
Frodsham
Alvanley
Northwich
Knutsford
MACCLESFIELD
CHESTER
Middle wich
Tarporley
Sandbach
CONGLETON
Farndon
Aldford
CREWE
Nantwich
Malpas
Whitchurch
Combermere
Audlem
NEWCASTLE under Lyne
Burslem
Hanley
STOKE
Madeley
Lane End
Whitmore
Cheadle
LEEK
Longnor
Buxton
Chapel en le Frith
Mellor
C H E S H I R E
Lias
Keuper
Bunter Sandstone
Coal Measures
Carboniferous Limestone
Strata not proved
Anticlinal, Synclinal, Dip.
Fault, Section, Railways.

1. *Remarks upon the Internal Structure of* Halonia.

By John S. Dawes, Esq., F.G.S.

It was proposed by the authors of the 'Fossil Flora' that the genus *Halonia* should comprehend all those plants combining the surface of the Lepidodendra with the mode of branching of the Coniferæ, to which latter order they considered these fossils to be analogous. The discovery, however, of better-preserved specimens has clearly shown that the supposed remains of alternate branches, noticed more particularly upon one species, the *H. gracilis*, must have been merely impressions of the protuberances which characterize these fossils, and that they are in fact, like the Lepidodendra, dichotomous. A still further proof of cryptogamic affinity is now afforded by sections of a specimen from the neighbourhood of Birmingham, in which traces of the vegetable structure have been preserved. By reference to the drawing fig. 1, it

Fig. 1.



will be seen that this stem is composed of a central medullary column (*a*), surrounded by a series of scalariform vessels (*b*), these being succeeded by a compact cellular tissue (*c*), which becomes more lax between this central part and the cortical zone, the latter (*d*) being composed of a thick-membraned, very regular tissue, and bearing a large proportion to the rest of the stem, equal in some specimens to one-third of the diameter. There are no concentric rings, or, strictly speaking, medullary rays, neither any ligneous fibre, or indeed any indication whatever of affinity with the Coniferæ, or even with that division of Dicotyledons, except that some similarity exists in the character of the striated tubes which surround the medullary column, and the pseudo-vascular bundles of certain Zamiæ. Neither are these plants to be referred to that class which includes the Sigillaria, Anabathra, &c.; for although the structure in some important respects may correspond, the arrangement of the tubes of the vascular system is altogether reversed; consequently the curved scalariform bundles which traverse the stem from its axis to the periphery do not emerge from the tissues immediately in connection with the medullary column, but are thrown off from the outer portion of the sheath. These leaf-cords, which appear somewhat to resemble the stem in miniature, take a direction for some distance nearly horizontal, so that different portions of the tissues of several neighbouring bundles are usually cut through, giving to the transverse section some appearance of a radiated structure. I should observe that these fasciculi differ in size, the smaller ones having a direction towards the spirally-arranged scars which cover the surface of the stem, the larger ones being connected with the processes that occur upon it at certain intervals, each of these projections exhibiting a roundish cicatrix at its apex, as though some leaf-like appendage had been supported upon it, and having some resemblance to the well-known tubercles of Stigmaria. These few observations will be sufficient to show that the fossil in question belonged to the vascular Cryptogamiæ, and that when compared with the other plants of the coal-measures, the nearest affinity is with the Lepidodendron. We might in fact, considering their tortuous root-like appearance and on other accounts, be tempted to speculate as to the relationship they bear to this fossil; but possibly some other specimens in my possession, not yet sufficiently examined, may throw further light upon the subject.

Since the above remarks were forwarded to the Society I have been fortunate enough to obtain some very good sections of another specimen of this fossil, and am now enabled to mention a peculiarity in the structure which had previously escaped notice, viz. that a narrow ring of very regular, compact, elongated tissue exists on the outer portion of the cortical zone (*e*), similar to the prosenchymatous arrangement mentioned as occurring in the corresponding part of the Lepidodendron. Having however had an opportunity to look through many specimens of this latter fossil, I may venture to say that the descriptions hitherto given of it do not in this and in some other respects correctly represent its structure. Such discrepancies have probably arisen from the inferior state of the specimen first met with by the Rev. C. G. Vernon Harcourt, and also in consequence of Mr. Witham having originally figured from portions of two distinct fossils, apparently mistaking in one instance an imperfect fragment of Halonia for a piece of Lepidodendron (see Transactions of the Natural History Society of Newcastle, 1832, and 'Internal Structure of Fossil Vegetables,' Edinburgh, 1833, pl. 12. fig. 3, pl. 13. fig. 1). Brongniart indeed admits being unable to detect this exterior tissue, but nevertheless describes it, both in his 'Histoire des Végétaux Fossiles' and in the 'Archives du Muséum d'Histoire Naturelle,' upon English authority: he has however discovered a very similar tissue, although differently placed, in the cortical zone of the *Sigillaria elegans*.

There are some other points connected with, and in the constitution of these fossils, that I hope to refer to on a future occasion, and may perhaps now observe that the medullary column does not, either in the Lepidodendron or Halonia, consist of the usual parenchymatous tissue, but seems to be composed of large quadrangular cells arranged in perpendicular series, and presenting an appearance as though each minute column was confined within a slight membrane or tube. I believe that no such structure has been found to exist in recent vegetation, the nearest approach to it being probably in the *Psilotum*, one of the Lycopod family, and is of course incompatible with the idea of this central portion being a true medulla; these plants must therefore be still further removed from any supposed phanerogamic alliances.

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2. *Observations on the* Cystidea *of* M. von Buch, *and the* Crinoidea *generally.* By Thomas Austin, Esq., F.G.S.

The following observations are offered with the view to explain, and it is hoped make clear, some hitherto doubtful points as regards the Crinoidea and Cystidea, particularly the geological distribution of the last-mentioned family.

In Baron von Buch's Notice of a new family of Crinoidal Animals, which he has termed *Cystidea*, published in No. 5 of the Journal of the Geological Society, and also in the more lengthened paper on this subject, a translation of which is given in the same number, some observations are made, which I humbly conceive will not bear the test of close examination. At page 11 it is said, the Cystidea are distinguished "by having the mouth constantly at the apex, and in the centre, which is rarely the case in the Crinoidea."

This observation appears to be correct, as far as our knowledge of the Cystidea extends. But the assertion respecting the situation of the mouth in the Crinoidea is unsupported by the evidence of the most perfect specimens hitherto obtained, for a great majority of species have the mouth placed centrically; and the three or four species of *Platycrinus* alluded to as having excentrical mouths, are rather exceptions to the rule than the rule itself. An enumeration of the following species, all of which have centrical mouths, will sufficiently prove this fact:—*Platycrinus lævis, P. granulatus, P. elongatus, P. spinosus, P. trigintidactylus, P. antheliontes; Actinocrinus lævis, A. triacontadactylus, A. polydactylus, A. elephantinus, A. cataphractus, A. Colei, A. aculeatus, A. lævissimus, A. longispinosus; Poteriocrinus crassus, P. tenuis, P. granulosus, P. radiatus, P. rostratus, P. quinquangularis, P. plicatus, P. longidactylus, P. pentagonus,* &c. &c. This list could be greatly augmented, but the species enumerated seem fully sufficient.

With respect to almost all the Crinoidea having a bilateral arrangement, a right and left side, nothing can be more certain than that this is the case, and that without reference to any inequality of the basal plates. In different genera we have all the gradations of dorso-central plates composed of one, and up to five pieces, but this latter number is never exceeded. The genus *Platycrinus*, in which the basal or dorso-central plate is undivided, contains some species with excentrical mouths, but in the majority it is centrical. Whether it is proper to retain species, which differ in this respect so materially from each other, in the same genus, is a question for consideration.

In the second Part of the Journal, No. 5, page 22, M. von Buch observes, that the influence of the mouth upon the form and distribution of the plates is universal in all the Crinoidea; and that where the basal plates are not exactly similar in form or arrangement, the mouth is invariably upon the side. To illustrate this, the genus *Actinocrinus* is cited, and the figure of *A. amphora* (Portlock's Geol. of Londonderry, pl. 15. fig. 4 *a*) is selected as an example.

From this view I must venture to dissent, and to assert, on the contrary, that in all known species of *Actinocrinus* the mouth is invariably central,—and further, that the specimens referred to are not true *Actinocrini,* from which they differ materially in the number of lateral plates and other particulars;—and that although the basal plates are similar in the two genera, the position and form of the mouth being widely different negatives the idea that the number and arrangement of the basal plates, as a necessary consequence, regulate the position of the mouth.

So striking is the difference between the so-called *Actinocrinus amphora* and the true *Actinocrini,* both as regards the position of the mouth and the number of plates composing the calcareous skeleton, that I have been induced to place the *A. amphora* and three other species with excentrical mouths in a new genus, for which the name of *Amphoracrinus* is proposed. The genus consists of *A. Gilbertsoni, A. crassus, A. granulatus,* and a fourth species which has not been named.

Extended observations do not support the opinion that the mouth is only central in those cases in which the cup is based upon perfectly regular five-sided plates. On a close examination and comparison it will be found that the form of the dorso-central plate has little or no relation to the position of the mouth. In support of this statement, it can be demonstrated that all the Platycrines before enumerated have the mouths placed centrically, as may be seen on reference to our Monograph on the Crinoidea, or to numerous specimens in the author's cabinet, while the *Platycrinus rugosus, P. mucronatus,* and *P. tuberculatus,* with precisely the same formed dorso-central plates, have the mouths placed excentrically.—Again, in the genus *Cyathocrinus,* where the dorso-central plate is composed of five equal pieces, forming a pentagon, the mouth in some species is excentrical. The *C. planus* is a case in point, so that no reliance can be placed on the form of the basal plate as indicating the position of the mouth.

Respecting the geological distribution of the fossils which M. von Buch has placed in the family Cystidea (but which had been previously arranged in the family Sphæronidæ of Gray, *vide* 'Annals of Natural History,' vol. x. p. 111), M. von Buch at page 40, 2nd Part of the 'Geological Journal,' No. 5, states that the Cystidea belong unquestionably to the most ancient formation of the earth's surface, to the Silurian strata of the Palæozoic period,—that *nothing analogous to them has hitherto been met with in more recent formations,*—and that they form the extreme verge of an entire group of Radiaria, the Cariocrinus indicating the way in which the passage from Cystidea to Crinoidea may have taken place.

M. E. de Verneuil appears to entertain similar views respecting the Cystidea. In the General View of the Palæozoic Fauna of Russia, which forms the Introduction to the second volume of the work on

Russia by Sir R. Murchison, M. E. de Verneuil and M. von Keyserling, it is observed, that "this family is the more interesting to the palæontologist, since it seems to have preceded the other Crinoidea in order of time, and presents, as it were, the primitive form of animals of this class, since most of the genera of which it is composed are peculiar to the *Lower Silurian system, and disappear entirely where that terminates.*"

The opinion that this family preceded the Crinoidea is not supported by conclusive evidence, as the remains of true Crinoids, furnished with rays, are found in the Lower Silurian system, and they were thus co-existent with the Cystidea of M. von Buch. The fact that several species of this family are found in the carboniferous limestone of Yorkshire is also opposed to M. E. de Verneuil's assertion, that animals of this family disappear entirely where the Lower Silurian rocks terminate.

In order to show that no doubt can exist as to the generic identity of the fossils alluded to, it may be stated that M. von Buch, in No. 5, page 39, of the Geol. Journal, claims two species of our proposed genus *Sycocrinus* as *Cryptocrinites* (Cystidea), and laments that the locality of these specimens was not given, or that the Crinoids with which they were found associated were not enumerated. This omission I now rectify by stating that they occur in the carboniferous limestone of Yorkshire, and are associated with the following species of Crinoidea:—*Amphoracrinus Gilbertsoni* (Austin), *Actinocrinus Gilbertsoni* (Miller), *Platycrinus mucronatus* (Austin), *P. rugosus*—with a new species of Pentremite, which M. von Buch alludes to at page 29, No. 5, Journal, and which in 1842 we named *Pentremites astraformis* (*vide* Annals of Nat. Hist. vol. x. page 111). The singular fossil for which we have proposed the name of *Astrocrinus tetragonus* also occurs in the same locality. Two out of our three species of *Sycocrinus* are considered by M. von Buch as *Cryptocrinites,* and therefore come within his family of Cystidea, while the *Sycocrinus clausus* he admits to belong to a new genus, but which must also be ranged with the same group, either as Cystidea, or in the family Sphæronidæ of Gray, in which we had previously placed them.

I perfectly agree with many of the observations advanced by Dr. Alex. von Volborth in the introductory chapter of his Memoir on the Russian Sphæronites, but want of space obliges me to confine my remarks to one or two points relating to the Cystidea. That many species of this group, as defined by M. von Buch, had arms, no one can doubt; and although the rays in some are not similarly placed as in true Crinoids, yet their presence renders it necessary to separate the rayless species from those which are furnished with arms and tentacula.

The foregoing observations are made with great deference to the distinguished palæontologists from whose opinions I have ventured to dissent, but with perfect confidence as regards the correctness of the facts adduced in support of my own.

It is worthy of observation that a large species of *Echinocrinus* occurs in the Wenlock limestone of Gliddon Hill. This species in some respects resembles the *E. pomum* of Agassiz, a carboniferous limestone fossil. The difference consists in the Silurian specimens being larger, having wider ambulacra, and a greater number of plates in the interambulacral spaces. The small spines had the same form, and the manner of attachment and shape of the plates agree in every particular with the carboniferous limestone species.

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3. *On Fossil Bones found in the* CRAG *of* SUFFOLK. By JOHN WIGGINS, Esq., F.G.S.

THE author states, that near Ramsholt Creek, Sutton, and in other parts of Suffolk belonging to the Crag formation, large quantities of fossil teeth, bones, and coprolitic substances are found. These remains are rich in phosphate of lime, and are now collected for agricultural purposes. They are found mixed with sand and gravel from two to four feet below the surface, and about 300 tons had been procured from about a rood of ground which had been turned up.

APRIL 5, 1848.

James McAdam, Esq. and Robert W. Mylne, Esq. were elected Fellows of the Society.

The following communications were read:—

1. *Sketch of the Structure of parts of* NORTH *and* SOUTH WALES. By Professor RAMSAY, F.G.S., and W. T. AVELINE, F.G.S.

[Abstract by the Authors.]

THE country to the south and south-east of the Dolgelly and Bala district may be briefly described as follows.

Towards the higher part of the rocks that rest on the Bala limestone are certain bands of sandstone, of comparatively trifling thickness, but important as regards the part they play in explaining the structure of Wales. They are not continuous, but local and intermittent, skirting in parts the base of the overlying formations through Montgomeryshire and Radnorshire, far down into South Wales in Caermarthenshire. Above these sandstones, wherever they occur, from the neighbourhood of Dinas Mowddy to Llanddewi-ystrad-enny in Radnorshire, are certain slaty shales from 1000 to 1500 feet thick, and above these thick masses of sandstone (mingled with occasional shales), sometimes attaining an aggregate thickness of about 2000 feet. These sandstones we believe to be the true Caradoc sandstone of Sir Roderick Murchison, bearing the same general relation to the underlying slates and the overlying Wenlock shale that the typical Caradoc sandstone exhibits in Shropshire. The contortions in these beds towards the east in Montgomeryshire occasionally bring up the underlying slates. In one instance also the Wenlock shale overlies them in a long trough, which is crossed by the Mallwyd and Welshpool road at Llangadfan and Llanerfyl.

Above these shales the Ludlow rocks of Montgomeryshire appear in their usual position, capped by certain outliers of old red sandstone long since mapped by Sir Roderick Murchison. From beneath the Wenlock shales of Montgomeryshire rise the slates and associated contemporaneous igneous rocks of the country north of Bishop's Castle. On a smaller scale these rocks present the same characteristics as the igneous rocks and slates of Merionethshire, and from beneath rise the old purple, green and grey sandstones of the Longmynds, bearing great resemblance in lithological character to the sandstone series of Barmouth, and occupying the same position with regard to the Bishop's Castle traps that the Barmouth sandstones do to the igneous series of Merioneth and Caernarvonshire.

A mere trace of Caradoc sandstone is occasionally to be seen between the Wenlock shales and the older members of the Bishop's Castle district. The Wenlock shale on the south runs across *the strike* of this boss, resting alike unconformably on both. On the east of the Longmynds is a great fault, throwing down the country to the west, and running from the new red sandstone of Shropshire in a south-west direction into Radnorshire, on the east of Builth.

On the north-east of Welshpool from beneath the Wenlock shale, the black slates and their associated contemporaneous traps again rise to the surface. On the north of Builth the same black slates, with beds of greenstone and volcanic ashes, again appear. The Wenlock shale, without the intervention of the Caradoc sandstone, laps nearly completely round this district, resting in the east on the lowest beds, and in the west on the highest beds of the igneous series. At Llanwrtyd and Baxter's Bank in Radnorshire ashy traps again appear in small bosses from beneath black slates, and at St. David's in Pembrokeshire the same kind of contemporaneous traps, also associated with black slates, come to the surface. At the last locality purple slates and sandstones rise from beneath, having exactly the same relation to the igneous rocks there that the Barmouth sandstones bear to the igneous series of Merionethshire, and the Longmynds to the parallel rocks north of Bishop's Castle.

The fossils of the slates associated with this igneous series are so well known, that it is unnecessary to particularize them. We would however invite attention to the fact, that wherever the disturbances of the country bring up the deeper parts of the series, beneath the fossiliferous slates associated with contemporaneous traps and volcanic ashes, there are certain sandstones and slates, generally of a purple and greenish hue, and these, in spite of all the search that has been made in them, seem to be perfectly unfossiliferous.

The igneous rocks that occasionally appear in the line of the great Shropshire and Radnorshire fault are of different date and structure from those heretofore alluded to. They are always massive (greenstones, syenites, &c.); they invariably appear in the line of great dislocation, and alter by baking or semi-fusion, whatever strata they chance to come in contact with, of whatever age these strata may be.

We shall now endeavour to show what have been the successive disturbances that affected the country, as this throws much light on its absolute structure. The strike of the Longmynds (part of the Cambrian rocks of Professor Sedgwick) and of the Bishop's Castle slates and traps (Llandeilo flags of Sir Roderick Murchison) is N.N.E. and S.S.W. To the south-west of Church Stretton the Wenlock shale and part of the Caradoc sandstone is thrown down on the west by the great fault already noticed. The Caradoc sandstone, in a thin band, rises from beneath this strip of Wenlock shale, and rests unconformably on the Longmynd Cambrians in such a manner that it is plain the latter formed an original boundary to the sea of the period.

The Caradoc, which is here a conglomerate, is composed of water-worn pebbles derived from the Longmynds. It folds round the southern extremity of the Longmynds across the strike, and is immediately afterwards overlapped by a band of limestone, which lies beneath the Wenlock shale. This limestone skirts along the Longmynds and Llandeilo flags to Church Stoke, across the strike of the older beds. Round other parts of the igneous series to the north the Caradoc sandstone appears at intervals, and always quite unconformably, on the Llandeilo flags. Twelve miles south, near Brampton Bryan, Caradoc sandstone is again seen in a small boss, resting unconformably, on slaty shales. The well-known boss of the same sandstone at Presteign with its overlying limestone is highly indurated, occurring in the line of fault through which traps occasionally protrude. At Old Radnor another boss appears in the same line of disturbance, with similar overlying limestones. Here the rock has suffered a still greater amount of alteration, being in some instances almost fused.

The occasional patches of Caradoc that dip beneath the *overlapping* Wenlocks around the Bishop's Castle traps and slates rise from beneath the Wenlock shales on their western outcrop, near the banks of the Vyrnwy, two miles west of Llanfair. The slates beneath this Caradoc rise in an anticlinal, and in the roll to the west a trough of Wenlocks is again thrown in: on the west of this near Garthbibio, the Caradocs spread out for six or eight miles to within two miles of Mallwyd.

If we now trace the western boundary of the Caradoc sandstone to the north, we find it turning round with the great Merioneth anticlinal of Professor Sedgwick. On the north-east of Dinas Mowddy it is several thousand feet above the Bala limestone, but in its progress north and west it gradually creeps over these higher beds, till at last at Yspytty Evan it fairly reaches the level of that limestone. This evinces unconformity. If we trace it south from Dinas Mowddy we find an irregular outline proceeding into Radnorshire, and everywhere at certain distances beneath are the intermittent beds of sandstone, which in some localities characterize the higher part of the slaty series on which the Caradoc rests. As the Caradoc rocks approach the region of the Builth beds they turn off to the east, as if the Builth series had formed a barrier to their further original deposition in that direction. They never again appear in the south, the Wenlock shales overlapping them and resting directly and unconformably on the Builth beds, and also on the rocks further to the south-west.

The rocks which may be called the igneous series, with the underlying rocks of Barmouth and the Longmynd, were evidently disturbed before the deposition of the Caradoc sandstone. In some places we have direct evidence of the margin of the Caradoc sea, as at the Longmynds. Throughout most of the range described, if its lithological character be examined, it will be found to be composed in great part of trappy felspathic debris, and it seems not unlikely that (as we certainly know part of the Bishop's Castle country was above water before the deposition of the Caradoc) the igneous countries of Merioneth, Bishop's Castle and Builth also rose above the water, and by the waste of these old lands the Caradoc sandstone was in part formed.

That the Wenlock shale rests more or less unconformably on the Caradoc can be proved by the fact that it overlaps the Caradoc near Bishop's Castle, gradually creeps over it towards Builth, and in that country rests directly on the *lower* part of the igneous series on the one side and on the higher part on the other (see list of fossils).

The sandstones to which we have so often alluded as underlying the Caradoc can be followed in their strike towards the small boss of ashy traps at Baxter's Bank, where they are about 1800 feet above the traps. From thence they can be traced to Garth, six miles west of Builth, where in their turn they are overlapped by the Wenlock shale, again to appear at Castell-craig-gwyddon near Llandovery. South of Rhayader they roll over to the west, rise again on the left bank of the Teifi greatly increased in thickness, and roll over again on the right bank, from whence in a series of contortions they reach the sea at Aberystwyth.

When we consider this unconformity in connection with the old coast line of the Longmynds and Bishop's Castle igneous series, there seems little doubt that both at Builth and Bishop's Castle these lands were above water before the deposition of the higher rocks, and gradually became depressed during the accumulation of the Wenlock and Ludlow rocks, and thus we can show that rocks once at the surface as land, during a period of lengthened depression had many thousands of feet of marine strata deposited above them, and now are again by denudation exposed at the surface.

Memorandum respecting some Fossiliferous Localities alluded to in Professor RAMSAY *and* Mr. AVELINE'S *Paper, as noted on the spot, by* Professor EDWARD FORBES.

1. Between Church Stretton and Bishop's Castle the Caradoc sandstone rests directly and unconformably on the Longmynd rock, which was consolidated at the time of the deposition of the Caradoc, since pebbles of it occur in the latter: hollows in it are filled with Caradoc. The fossils in the Caradoc here are *Terebratula furcata* and *decemplicata, Pentamerus lævis,* and a *Cybele.* On the sandstone rests a limestone full of the *Pentamerus,* associated with shales full of *Orthis elegantula.* The characters of these beds, mineralogically and palæontologically, indicate their identity with the band of "Woolhope" limestone, seen in sequence with the Caradoc and Wen-

lock shales near Caer Caradoc. I infer, consequently, that the Caradocs skirting this part of the Longmynds are the uppermost beds, and that the lower beds are deficient.

2. Conglomerate near the Longmynds at Little Stretton, resting at a low angle on highly inclined flags. The fossils in this conglomerate are *Pentamerus lævis,* abundant, *Spirifer radiatus,* and some badly-preserved brachiopods and corals (*Favosites, Turbinolopsis bina*). These are probably upper beds of the Caradoc resting on Llandeilo flags.

3. Caradoc limestone quarries, at Esquire Hall, near Bishop's Castle. Brown sandstones and sandy bluish limestone bands.

The fossils most abundant in this locality are the *Pentamerus lævis* in the limestone bands, and *Atrypa reticularis,* var. *orbicularis,* in the sandstone. Other species are—

Atrypa hemisphærica.	Orthis calligramma.
Leptæna sericea.	—— Actoniæ.
Orthis expansa.	Spirifer radiatus.
—— elegantula.	Terebratula imbricata.

Of univalves three species, including *Littorina striatella* : of Trilobites, *Cybele punctata* : of Corals, &c., *Favosites alveolaris* ?, *Tentaculites annulatus.*

This locality shows the connection between the sandstone beds and limestone, and therefore indicates the sequence in time of the former with the Wenlock beds above the latter.

4. The compact quartzy sandstone of the Bogmines: a small outlier resting unconformably on the Llandeilo flags, and resembling in mineral aspect the Stiper rock, which is a member of the latter. Very fossiliferous and nearly horizontal.

[Brachiopoda.] The most abundant species are *Leptæna depressa* and *Atrypa reticularis* var. *aspera* ; *Terebratula imbricata, furcata, decemplicata,* and 5 other species; *Orthis elegantula* and 3 other species; *Chonetes sarcinulata* ?, *Pentamerus lævis* ? ?

[Lamellibranchiata], 2 species.

[Univalves], 12 species, including *Turritella cancellata* and *Bellerophon Wenlockiensis.*

[Annelida], 3 species; *Tentaculites annulatus* and *scalaris,* and *Cornulites serpularius.*

[Trilobites], *Trinucleus Caractaci, Calymene Blumenbachii,* plentiful; 2 species of *Cybele* and 2 other Trilobites; 2 Corals.

This rich list of 45 species was noted in a single small quarry in less than an hour. It indicates a relation to both Caradoc and Wenlock, with local peculiarities besides. The beds are doubtless the upper beds of the Caradoc, accumulated near to land or to a great elevated reef, of which the Stiper stones are the remains, and furnished the materials of the surrounding beds.

5. This view is borne out by an examination of the Hope Quarry, where a peak of Llandeilo flags is seen rising in the middle of the Caradoc, and around the peak is accumulated a similar assemblage of peculiar species, especially univalves.

In the Hope Quarry, *Orthis vespertilio, O. Actoniæ, O. calli-*

gramma and *O. expansa* also occur, and *Turbinolopsis bina* and *Favosites multipora.* The presence of abundance of *Pentameri* in the upper parts here reminds us of the *Esquire Hall Quarry.*

Summary.

The fossil evidences here cited indicate—

1. That the sandstones skirting the Longmynds are the upper beds of the Caradoc.
2. That they were deposited under peculiar local conditions.
3. That they were deposited around the margin of land.
4. That in all probability they were deep-sea deposits around high and steep land.
5. That the land was of Llandeilo flags or older rocks.
6. That they are in sequence with the limestone bands at the base of the Wenlocks.
7. That part of the Meifod fossiliferous beds are in a lower parallel, and probably Middle Caradoc.

Note by J. W. SALTER, Esq., *on the Fossils of the lowest Wenlock Shales east of* LLANDEGLE, BUILTH.

In the following list there is a mixture of Upper and Lower Silurian species, *i. e.* of Caradoc and Wenlock shells; it consists of Trilobites and Brachiopod shells, and a single coral.

The Brachiopods are partly the same as those of the Llandeilo flags, but only because such are widely distributed species, partly the same as those of the Caradoc districts, such as Church Stretton, May Hill, &c., and partly Wenlock species.

The absence of ordinary bivalve and univalve shells, and of Cephalopoda and Bellerophons is very curious, and but one coral is present —the universal *Turbinolopsis.*

Although apparently a mixture of Upper and Lower Silurian, the group is not at all like the Woolhope limestone, being deficient in Terebratulæ, large flat Orthides, corals, and characteristic Trilobites. Nearly all the species are found in Upper Caradoc.

The most abundant Trilobite, *Cybele punctata,* ranges to the tilestones near Builth.

Cybele punctata (abundant); *Cheirurus speciosus*?; *Illænus,* fragments; *Calymene Blumenbachii*; *Tentaculites annulatus*; *Lingula, sp.*; *Orthis calligramma, O. testudinaria* and *O. elegantula,* small; *Strophomena applanata*; *S. expansa,* a Lower Silurian species; *Leptæna sericea,* variety with faint striæ*; *L. transversalis**, common; *L. depressa,* small; *Atrypa reticularis**, most plentiful; *Atrypa,* a smooth convex species; *A. undata**, plentiful, a Llandeilo flag shell; *Terebratula didyma*; *Spirifer radiatus,* Sowerby?; *Terebratula marginalis**, common; *Turbinolopsis bina**.

[Those marked with an asterisk are characteristic species of the uppermost beds of the Lower Silurian in the Vale of Meifod—considered as passage beds by Prof. Sedgwick.]

2. *Sketch of the Structure of the country extending from* Cader Idris *to* Moel Siabod, North Wales. By J. Beete Jukes, F.G.S., and Alfred R. Selwyn, of the Geological Survey of Great Britain.

[Abstract by the Authors.]

The rocks are arranged into the following groups, of which the names are only provisional, and the thicknesses assigned from rough estimation. In the ascending order:—

A. The Barmouth and Harlech sandstones, 3000 feet. A mass of quartzose sandstone and conglomerate, with some beds of blue and purple slates, and occasionally trap rocks.

No organic remains discovered in this group.

B. The Trappæan group, 15,000 feet: subdivided into—

B 1. Blue and grey schistose slates and flagstones, interstratified with many beds of a grey calcareo-feldspathic "ash" often crystalline, together with feldspathic trap and greenstone; the slaty rocks predominating.

B 2. Great masses of feldspar-porphyry and some greenstone, with feldspathic trappæan "ash" arranged in beds a few inches or many feet in thickness. Interstratified with these, and passing into them (especially into the ash) by almost imperceptible gradations, are many beds of black slate, forming often irregular and apparently lenticular-shaped masses. In some parts of B 1, Lingulæ are found in great abundance, and a few other fossils. In B 2 Lingulæ and Graptolites also occur, but not very abundantly.

C. The Bala group, 9000 feet: subdivided into—

C 1. Black slates of variable thickness, very fine-grained, brittle, and frequently having their true lamination or stratification entirely obscured by cleavage and numerous joints.

C 2. Grey, fine-grained, arenaceous *slate-rock*, often passing into a hard, compact, splintery gritstone; in its lower portion are one or two beds of trappæan ash, sometimes crystalline, sometimes flaky and sometimes brecciated, often highly calcareous. About its centre is one thin bed of impure limestone (Bala limestone), and sometimes, but very rarely, another little band in its upper portion (Hirnant limestone). Organic remains are very rare in C 1; but in C 2, as is well known, are very abundant and in great variety.

The top of the Bala group sometimes passes into black slates and shales with beds of sandstone, which are covered by sandstones belonging to the Caradoc sandstone group. The latter however generally overlaps or rests otherwise unconformably on the beds of the Bala group.

The Barmouth and Harlech sandstones (A) occupy the coast between those two places, and extend inland as far as the Dolgelly and Trawsfynnydd road, including the ranges of Rhinog Fawr and Y Craig ddrwg. Neglecting minor undulations, the beds of this tract dip on every side from its central portion except towards the sea. Between Barmouth and Dolgelly the dip is S.E. at about 60°. Along the Trawsfynnydd road the dip is E. at about 25°. About Trawsfynnydd the dip is N. at 25° or 30°; and between Trawsfynnydd and Harlech the dip is N.W. at angles varying from 10° to 50°. Round this rudely bastion-shaped mass sweep the rocks of group B, dipping S.E. about Cader Idris, E.S.E. in the neighbourhood of Aran, E. in Arenig Fawr, and then suddenly curving to N.E. and N. about Arenig Bach and Festiniog, to the west of which latter place the dip is N.W. for several miles. Outside of this curved tract again, and taking a wider sweep, lies the Bala group (C), with the same general inclinations; dipping E.S.E. from Dinas Mowddwy to the Dee near Bala, and thence to the Clwyd three miles north of Bettws Gwerful Goch, and N. along its northern boundary about Cerrig y Druidion and Yspytty Ifan. The change however from one dip to the other is much more sudden, or at least more sensible in these beds than in the lower groups, and can be well seen on the part of the Clwyd abovementioned. This sudden change is produced by a broad, low, but strongly pronounced anticlinal flexure of the rocks, called by Professor Sedgwick "The great Merioneth Anticlinal," which more or less apparent in the lower groups, causes the trap rocks about the Arenigs to project three miles north-east of their mean boundary up to the hills of Carnedd Filiast, and spreads the rocks of the Bala group in a broken and distorted arch over all the country included by a line running from Bala to the head of the Clwyd, and thence by Cerrig y Druidion to Yspytty Ifan. To the north-west of this tract are several smaller but sharper anticlinal and synclinal curves (likewise described by Professor Sedgwick), the axes of which run nearly north-east and south-west. A synclinal line traverses the valley of Yspytty Ifan, an anticlinal that of Penmachno, and another synclinal that of Dolwyddelan. As these flexures sink or become less towards the north-east (their axes not being horizontal, but inclined in that direction), the outcrop of any bed forms curved lines, Vandyke-fashion, across the country, by following which lines the Bala beds have been traced into the valley of Dolwyddelan.

Besides these flexures, the country is traversed by many large dislocations, which have been traced whenever the character of the rocks is sufficiently distinct to allow of it. Near Bala, by means of the ash beds underlying the limestone, many large faults have been laid down, and others of still greater magnitude indicated; and it has been found that the supposed three or four bands of limestone are all broken parts of one bed, each piece ending suddenly both ways, and having at the proper distance below it a piece of ash of the same shape and dimensions, likewise ending suddenly in each direction. The lines joining the ends of these pieces likewise are nearly parallel, running about N. by W. and S. by E. In this way the limestones of Y Gelli-grin, Rhiwlas, Llwyn-y-ci, Penmaen, and Eglwys Anne, were found to be fragments of the same bed, drifting as it were across the country, half a mile apart, to the northward of their apparent strike; still farther north of this tract the dislocations are so enormous that they are no longer traceable in the Bala group, but the boundary of the Caradoc sandstone in this line is thrown suddenly forward by a fault, which is believed at present to have a perpendicular downthrow to the north of about 4000 feet.

In conclusion, the authors stated that almost the whole of the traps in group B were regularly bedded, and contemporaneous with the rocks in which they lie; that scarcely a single instance of a "dyke" had been anywhere observed; and that whatever may have been the exact mode of formation of the rock called "ash," its lithological characters show it to have been derived from igneous materials, its bedding and interstratification with slates show it to have been deposited by water, while its gradually dying out (the beds becoming fewer and thinner) above and below the traps show that its exhibition was intimately connected with the commencement and ending of the igneous action which produced them.

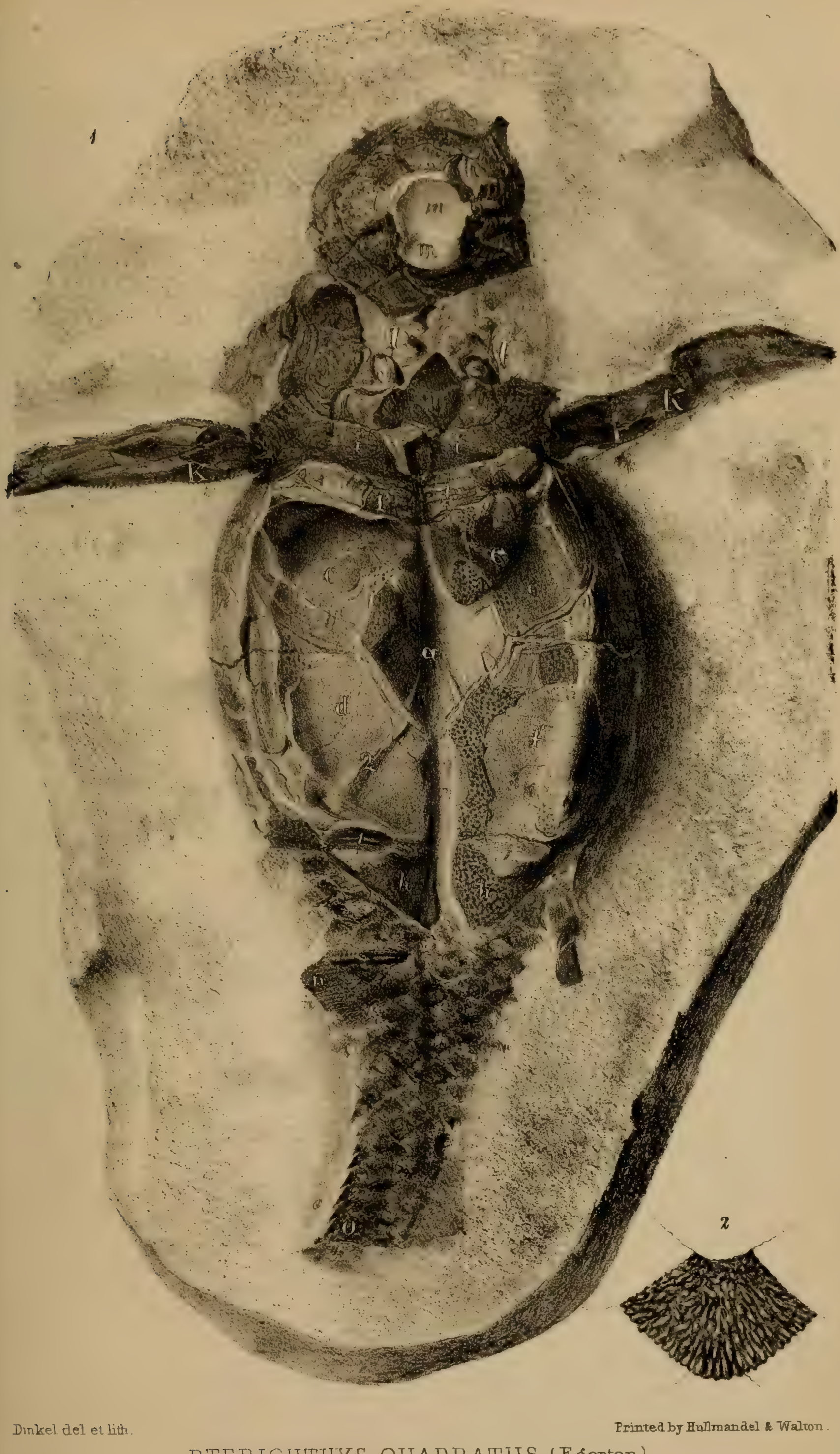
April 19, 1848.

Sir John Lubbock, Bart. was elected a Fellow of the Society.

The following communications were then read:—

1. *Palichthyologic Notes, supplemental to the Works of* Prof. Agassiz. By Sir Philip Grey Egerton, Bart., M.P., F.R.S. &c.

I have been frequently and painfully reminded (since the departure of Agassiz for America), by numerous applications from scientific friends for information on the subject of Fossil Ichthyology, that this branch of Palæontology has not kept pace with the progress that has been made in the collateral departments of the science. In fact, since the publication of the Monograph of the Fishes of the Old Red Sandstone, it has been all but stationary. It is much to be regretted that a study so interesting in itself and valuable to the geologist should be so much neglected. The eminent success which rewarded the labours of Professor Agassiz, and the fertility of the ground, ought to have enticed many labourers into the vineyard. Such however has not been the case, and the fruit has accumulated in useless profusion, which might have been made available for the general benefit of the geological community. The extent of these unproductive materials will be partly appreciated on reference to the general table of fossil fishes issued with the last livraison of Agassiz' great work. The species therein recorded with asterisks prefixed have been neither figured nor described. Deducting the fishes of the Old Red Sandstone, which have been subsequently described in the Monograph, there still remain 389 species under this category. To this list must be added a considerable number known to Agassiz but not yet named, many others which have not come under his cognizance, and all the discoveries since 1844. The period of the learned professor's return is stated to be distant; if therefore some effort be not speedily made to render these accumulated materials in some sort available, the stock on hand will soon be too gigantic even for Agassiz to undertake with any hopes of regaining the lost ground and making head with



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PTERICHTHYS QUADRATUS. (Egerton.)

the kindred branches of Palæontology. Unfortunately I have neither the talent, the means, nor the time to grapple with so vast a subject on a scale commensurate with the requirements of science; I am nevertheless anxious to render what services I can, subject to these limitations, to the general fund of knowledge. I propose therefore to communicate to the Society, from time to time, notices on fossil fishes, which may be considered supplemental and auxiliary to the works of Professor Agassiz. They will contain characters of new genera and species, corrections and amplifications of previous descriptions when warranted by conclusive evidence, and intimations of and reference to ichthyological discoveries recorded by other authors, British and foreign. Such communications can hardly be presented in a form interesting to the general reader; they may nevertheless prove worthy of a place in the Journal of the Society, as being useful for general and special reference; they will also greatly facilitate the labours of Agassiz, when he resumes his promised series of monographs, in continuation of his great work on Fossil Ichthyology.

The subject of the first notice is the family of Cephalaspides, commencing with the genus *Pterichthys*, in the preparation of which I have had the advantage of the valuable co-operation of Mr. Hugh Miller, the original discoverer and interpreter of the materials out of which this strange group of fishes has been elaborated.

Family Cephalaspides, *Genus* Pterichthys. By Sir Philip Grey Egerton and Mr. Hugh Miller.

On perusing the description of the genus *Pterichthys* given at page 9 of the Monograph on the Fishes of the Old Red Sandstone, I cannot divest my mind of the suspicion that Agassiz has inverted the order of nature and assigned a supine position to the ventral surface of the fish. The reasons which have engendered this doubt (for I am loath to advance a positive opinion in contravention of such high authority) will appear in the sequel. I may premise that I am not singular in the view I take of the relative position of parts in the dermal economy of this genus, for Mr. Hugh Miller, the original discoverer of these enigmatical organisms, with the intuitive talent so conspicuous in his very original little volume on the Old Red Sandstone, has described and figured this curious fish in two positions, showing the arrangement of the plates both on the back and belly. The sketch is so graphic, and at the same time so correct, that I cannot refrain from quoting the passage:—"The body," says Hugh Miller, "was of considerable depth; * * * the under part was flat, the upper rose towards the centre into a roof-like ridge, and both under and upper were covered with a strong armour of bony plates. * * * The plates on the under side are divided by two lines of suture, which run, the one longitudinally through the centre of the body, the other transversely, also through the centre of it; and they would cut one another at right angles, were there not a lozenge-shaped plate inserted at the point where they would otherwise meet. * * * The plates on the upper side are more numerous and more difficult to describe, just as it would be difficult to describe the forms of the various stones which compose the ribbed and pointed roof of a Gothic cathedral, the arched ridge or hump of the back requiring in a somewhat similar way a peculiar form and arrangement of plates. The apex of the ridge is covered by a strong hexagonal plate fitted upon it like a cap or helmet, and which nearly corresponds in place to the flat central plate of the under side." (The Old Red Sandstone, by Hugh Miller, page 49, plates 1 and 2.) It will be seen from the above that Mr. Miller distinctly describes the back of the fish as arched, the belly as flat, each region being characterized by bony plates peculiar both in form and adjustment. Agassiz describes the arrangement of the plates on the flat side*, but he considers this the dorsal surface, in contradiction to Mr. Miller, who views it as the abdomen. The other or dome-shaped surface he does not allude to directly as a determinate character; he nevertheless mentions it incidentally in the description of *Pterichthys testudinarius* as the "*face inférieure*" of the fish, with some hesitation adding, "It will be necessary to ascertain from more perfect specimens whether the longitudinal elevation traceable along the median line be really a specific character, or whether it results from the bad state of the specimen." This feature is more pointedly acknowledged in the description of *Pterichthys Milleri*, and is truly considered as the "*face supérieure*." He says, "The carapace rises in the middle into a longitudinal keel, *assez saillante*, which gives to the superior face the form of a roof." In the detailed account of the anatomy of this species, the central plate of the *inferior face* of *Pterichthys testudinarius* is stated to be enormously large, and the corresponding plate in the *superior face* of *Pterichthys Milleri* to have nearly the same proportional dimensions. Here then we see two prominent features, common to two species of the same genus, assigned to opposite positions in each. Whether Agassiz be correct or not in this particular will be considered in the sequel; in the meantime it is clear that the passages above-quoted afford presumptive evidence that in two species of the genus one surface of the fish was more elevated than the other, and that so far Mr. Miller's description is correct. These parts are generally greatly fractured and displaced; the plane surface, on the contrary, is frequently preserved as perfect as when the fish was endowed with life. This is not to be wondered at; for in the process of decomposition, the destruction of the internal soft parts, and the interstitial animal matter of the sutures would cause the dome to collapse, a result not so likely to befall the more even surface, especially if reposing on a muddy or sandy bottom. Even should the parts retain their natural position until potted in their now hardened matrix, the irregularity of their contour would baffle the efforts of the geologist's hammer to disengage them, a plane of far less resistance being offered by the more even surface. The hardness of the stone and brittle condition of the bones preclude the more delicate operations of the chisel. The plates however are not unfrequently found perfect when disjointed, and, from their characteristic forms,

* Monographie des Poissons Fossiles du vieux Grès rouge, p. 7, pl. 6. fig. 1.

the positions they occupied in the bony investment of the body are easily discerned. The central plate (fig. 1, *a*) described by Miller as helmet-shaped has rather more resemblance to a Lottia or Patella with

Fig. 1.

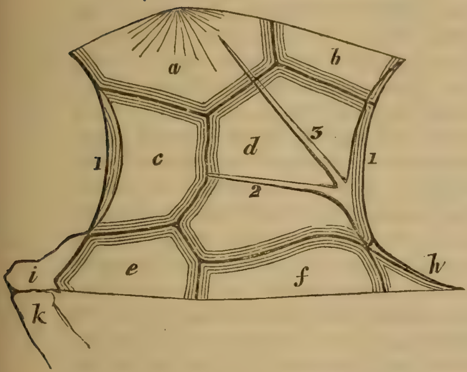
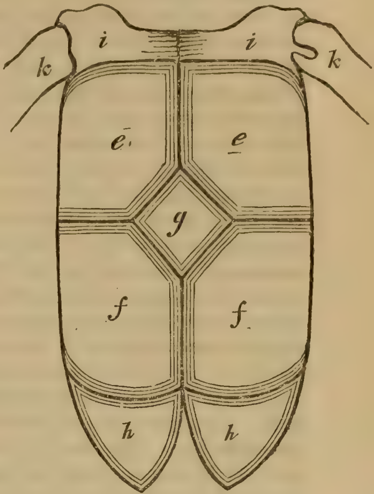


Fig. 2.



the anterior margin truncated, the posterior one abruptly rounded. As compared with the lozenge-shaped plate of the same individual (fig. 2, *g*) it is full double its size, and in relation to the body of the fish occupies (as described by Agassiz in *Pterichthys testudinarius* and *Milleri*) at least half the entire area of the side with which it is associated. The anterior truncated margin formed the boundary of the carapace, thus intercepting the union of the anterior lateral plates (fig. 1, *c*) on the median line. These plates are pentagonal and articulate with the central umbonated plate *a*, the posterior lateral plates *d*, and the anterior ventro-lateral plates *e, e*. The anterior edge was hollowed out to allow the lateral motions of the head, and was strengthened by a marginal rim or thickening of the bone on the inner surface (fig. 1, 1). The posterior lateral plates *d* are also somewhat pentangular, but the lower angles are produced to fit the anterior plates; they articulate with these, with the anterior dorsal plate *a*, the posterior dorsal plate *b*, and the anterior and posterior ventro-lateral plates *e, e, f, f*. They are hollowed out on the posterior margin to give freedom to the lateral inflections of the tail, and are finished with a thickened rim (fig. 1, 1), and further strengthened by a rib of bone (fig. 1, 3) running diagonally in the direction of the largest diameter of the plate. The posterior plate *b* is somewhat similar in form to *a*, but smaller. It articulated with the central plate *a* anteriorly, and with the posterior lateral plates *d, d*. In describing the under surface of *Pterichthys latus*, Agassiz says:—"There appears to have been no central plate on this side, but that the anterior and middle lateral plates were united by their corresponding margins." The specimen from which this description was taken is now before me, and shows, in fact, not the under surface of the fish, but the side view; and has enabled me, with the assistance of two other specimens from Gamrie, to decipher the relations of the plates protecting this part of *Pterichthys*. The lateral plates of the flat surface (fig. 2, *e*, *e*, *f*, *f*) to which I have alluded appear to have been reflected at right angles, and to have extended along the side of the fish until meeting the lateral plates of the opposite side (fig. 1, *c*, *d*). In consequence of this form they are frequently crushed and mutilated, and it is only after a careful examination of a great number of specimens that I have convinced myself that the appearances frequently seen of division along the line of the angle are not due to natural sutures, but to accidental fracture. All the component plates of the carapace, with the exception of the lozenge-shaped plate *g*, are united by simple sutures; this on the contrary is attached to its neighbours by broad squamous sutures, the lateral bones overlapping its margins on all sides. Consequently this bone when seen from the inside occupies nearly twice the area of its external visible surface, a fact which requires to be borne in mind when seeking for specific characters. It is difficult without restorations to convey a clear idea of this complicated arrangement of parts composing the bony envelope of the *Pterichthys*. The contour must have had considerable resemblance to a high-backed tortoise, with the carapace culminating near the anterior margin; thus a transverse section through the umbo would be not unlike the outline of a stirrup-iron, or the head of a Gothic arch of the decorated period; a longitudinal section would more resemble the section of a Parmophorus or any Patelliform shell with an excentric apex. The question now arises, whether the helmet-shaped plate and its associates, or the lozenge-formed plate and its collaterals, constituted the back of the *Pterichthys*? And first we will consider the adaptation of the form and anatomical structure of the being to its presumed habits and mode of life; for it is a law without exception, save where human presumption has dared, in its ignorance, to arraign the all-wise designs of the Omnipotent,—a law based immoveably on the study and contemplation of the Creator's works by the wisest and most gifted mortals who have so exercised their talents,—a law receiving day by day more emphasis as our limited knowledge extends into new regions of investigation,—that the organization of living structures is ordained with special reference to the conditions under which they are destined to exist*. If then the habits of *Pterichthys* required it to float and sail on the surface of the ocean, the ridge-formed surface would be well-adapted, like the keel of a boat or the sternum of a gull, to cleave the waves as well as adjust the equilibrium of the body. But the density of the tegumentary investment, and the entire organization of the animal, forbid such a supposition. Nor is it probable that a fish all but destitute of fins, and of great specific gravity, could have frequented

* See Ray, Paley, Buckland's 'Bridgewater Treatise,' *passim*.

the midwater. It is then fair to presume that Agassiz is correct in considering the members of this genus as ground feeders, living on the mud and sand at the bottom of the sea. If so, what an impediment to its motions, and what an obstacle to progression in any direction must this umbonated sternum have been! The most vigorous efforts of the tail, although aided by the cephalic oars, would have failed to effect the most limited amount of locomotion. But if we reverse the order of things, what form could be better adapted for such a mode of life? The level ventral surface would glide with the slightest impetus over the slimy bottom; at the same time the vaulted carapace would afford a most effectual buckler of defence against injury from external violence. This view is fully corroborated by comparison with other fishes of similar habits. In modern times we see the Sturgeons and allied forms, which seek their food by grovelling at the bottom of rivers and estuaries, protected by strong bony plates covering their arched heads and bodies, those along the dorsal line very much resembling the central dorsal plate of *Pterichthys*. Among the contemporaneous inhabitants of the primæval seas we find the nearest allied forms, *Cephalaspis* and *Coccosteus*, flattened below, arched above, and defended by a similar panoply of plate armour. This argument, founded on reason and analogy, for supposing Mr. Miller's description of the economy of *Pterichthys* to be the correct one, receives remarkable confirmation from the knowledge of the mode in which the plates of the carapace are jointed together. I have before stated that the plates covering the back and sides are united by simple apposition of their corresponding edges, like the masonry of an arch, the umbonated central plate representing in position and effect the key-stone, the plates on the flat surface being united to the central diamond-shaped plate by broad squamose sutures. As these plates *overlap* the edges of the central plate, a very slight vertical blow from a stone or other moving body would suffice to dislocate it were it supine, but situated on the belly it would be effectually removed from all danger from external violence. If this be its true position, we may assign the exceptional mechanism of its attachments to the discharge of a most important function in the economy of the animal, namely that of providing for the occasional distension of the internal area of the body when required for the lodgement either of food or ova. The position of the pectoral fins or oars must not be overlooked in arguing this question. The plates carrying the articulating surfaces for the attachment of these organs are situated on the anterior margin of the flat region of the body. Now if this be considered the back of the fish, these appendages would bear more resemblance in form and position to the jointed horns of Pliny's Æthiopian bull than to the natatory organs of which they are affirmed to be the homologues; whereas on the opposite supposition of the relative positions of the parts, they would be serviceable either for progression or defence, for stirring up the mud in search of food, for scooping out hollows for concealment or deposition of spawn, or for clouding the water on the approach of an enemy. In searching for further evidence in support of my views, by comparing *Pte-*

richthys with the description and figures given by Agassiz of the allied genera, I have been surprised by the great similarity between the restoration of the genus *Pamphractus** and the dorsal integuments of *Pterichthys*. Having never seen a specimen of *Pamphractus*, I should not be justified in expressing any positive opinion respecting this genus, but I cannot help thinking that it is founded on a specimen showing the true dorsal arrangement of the lorication of *Pterichthys*. The central plate *a*, the anterior and middle lateral plates *b, b* and *c, c*, and the posterior plate or plates *d, d*, are arranged precisely as I have endeavoured to show was the case in *Pterichthys*. There appears to be some difference in the form and position of the cephalic plates, but it is very possible, owing to the mutilated condition of these parts in the generality of specimens, that this may not prove an insuperable obstacle to the reunion of the two genera. The genus *Chelyophorus* is only known from two or three specimens; these are limpet-shaped plates somewhat similar to the dorsal plate of *Pterichthys*. The scale of *Actinolepis*, figured at plate 31. fig. 15, seems also referable to the same position on the fish, in which case this genus should be included in the family of the Cephalaspids. *Homothorax* and *Placothorax* are assigned to this family, but I have not the means of comparing them with *Pterichthys*. The genus *Coccosteus*, although widely differing in many respects from *Pterichthys*, has nevertheless some points of resemblance so striking, that I have no doubt future discoveries will tend to determine the homological relations of most of the dermal plates of the two genera. The most important point for my argument is fortunately that which is best known, namely the occurrence of a central lozenge-shaped plate similar in form, in position and structure to that found in *Pterichthys*. This plate characterizes the ventral region of the fish, and thus affords remarkable testimony to the accuracy of the view I have taken, in assigning the like position to the homologous plate in *Pterichthys*.

Since the above was written, I have been in correspondence with Mr. Miller on this subject, and with his full permission I append to this paper the information with which he has kindly favoured me. The accuracy of his observation and the idoneity of his descriptions are too well known to require any eulogium from me, or any apology for communicating them to the Geological Society. The following speaks for itself:—

"My collection of fishes of the Old Red, greatly more extensive now than it was in 1840, when I had the pleasure of being introduced to Agassiz, enables me to reply with very considerable certainty to your queries regarding the *Pterichthys*. It is a somewhat curious circumstance, that the naturalist of Neuchatel is better acquainted with the upper surface of this ichthyolite than he himself believes. I much question the existence of his genus *Pamphractus*; but I have specimens which I think demonstrate that the restoration to which he gives that name (see Monograph of the Fishes of the Old Red, tab. 6. fig. 2) represents in a manner tolerably adequate,

* Monographie des Poissons Fossiles du vieux Grès rouge, tab. 6. fig. 2.

in at least the part of the figure below the wings, the dorsal surface of the *Pterichthys*. In his restoration of the *Pterichthys* in the same tab. fig. 1, there is a marginal strip marked *l, l*, outside the four plates, which certainly overlap, as you remark, the lozenge-shaped plate in the centre. Now this marginal strip is merely part of the sides thrown out by pressure. These originally struck upwards at nearly right angles with the flat ventral surface, as the sides of a travelling-trunk strike upwards at right angles with its bottom. They were of considerable height,—fully equal, I should say, to half the breadth of the ventral superficies,—thus giving depth to the creature's chest, which was rendered still more capacious from the circumstance that the back was arched—to hold by my illustration—like that of the travelling-trunk. No travelling-trunk, however, has a back so *steeply* arched; and instead of terminating in the centre in a longitudinal rectilinear ridge, it terminated in a longitudinal pointed one—a single plate, formed somewhat like a limpet-shell, covering the apex. The arched central plate on the upper side was nearly opposite the flat central plate on the under one, but, as shown in the original restorations of the *Pterichthys* published seven years ago in my little work on the Old Red, it was surrounded by five, instead of four plates. The arched back must have been of very considerable strength; a thick band of bone, fig. 1, 2, ran along the top of the sides, *i. e.* the walls, from which the arch sprang, as the builder places on the top of *his* wall a strong wall-plate; and each of the plates that rose from them to form the arch had also a thickening of the bone at its edges, which seems to have served the purpose of rafters springing from these wall-plates, or rather that of the ribs of a stone roof. And now for my restoration. The carapace consists of eleven plates in all, five on the ventral and six on the dorsal superficies. The strongly arched plate *a*, —as I have found, at the expense of some labour and an indifferent pen-knife,—overlapped the plate *c* in a broad squamous suture, of an irregularly curved form; but it was in turn overlapped by plate *d*, in a suture of nearly similar form. Again, in a comparatively narrow band of suture, that narrowed still more towards the centre, it overlaid the anterior end of plate *b*, while yet again this plate on its side overlaid with a broad edge plate *d*, thus locking it fast. The diagonal rib, fig. 3, which you describe as traversing plate *d*, was, I find, prolonged to the apex of plate *a*. By far the strongest portions of the carapace were the bands which laced it, ring-like, at both its anterior and posterior openings (fig. 1, 1); and the thickest and stoutest parts of these were in what an architect would term the groinings. The anterior ring of the cuirass ran along the edge of the ventral plates *e, e* and the dorso-lateral plates *c, c*, but it did not continue along the anterior edge of the plate *a*. The head was at this central point dovetailed to the body by the occipital plate; and it was on the *male* dovetail attached to *it* that the ring was continued. This insertion of the head was both dovetail and keystone,—dovetail to the head, and keystone to the ring;—the dovetail in the *plan*, if I may so speak, being a keystone in the *section*. The wall-plate fig. 1, 2, was restricted to plate *d*. It occurs in the line in which pressure applied in a slanting direction, from the front to the anterior part of plate *a*, would tell with most effect, and which had to be strengthened accordingly. It was at once a wall-plate to the roof above, and a rib directed from a strong groin towards the frontal part of that rhomboid which the cuirass composed. He must have been no apprentice workman who constructed the *Pterichthys!* Regarding the ventral superficies of the animal, I have only to remark, that the abdominal portions of the plates *e, e,* extended farther forwards towards the termination of the creature's head or snout, than the dorsal plate *a*.

"Two of my specimens indicate, I am inclined to think, the place of the eyes. They were placed on the arched upper side, a little above the point at which the wings were inserted. The plates which covered this occipital part of the creature were small and numerous, not fewer than eight of them occurring in a space scarcely larger than that occupied by the central limpet-like plate. The creature's wings, as shown by an unique specimen in my possession, were articulated to the body by a finely-formed ball and socket joint (fig. 2, 1). I never met with any vestiges of teeth; and infer, as I have now laid open many hundred specimens, that it had none. It bore on its tail a fin, like one of the two fins on the tail of the thornback, save that it was placed higher up, and had a small spine on its anterior edge; and the minute scales with which this terminal part was covered were roughened with tubercles ranged more in lines than those of the plates.

"Having in no specimen detected more than a single fin, I have made that fin a dorsal (Plate X. *n*); but there may possibly have been two opposite fins, as was supposed by the late Lady Gordon Cumming of Altyre; and if so, I would conclude that they were the creature's ventrals. The fringe or *chevaux-de-frize* (Plate X. *o*), with the peculiarly-formed scale on its anterior edge, which runs to the point of the tail, occurs on the same side as the fin. See, for evidence on this head, Agassiz' figure, tab. 2. fig. 2,—evidence supported by all my specimens that bear on this point at all. This fringe seems to have been formed of peculiarly-shaped scales. At one time I regarded it as the result of a chance grouping of the common scales seen in profile, but its invariable occurrence in the same place precludes the supposition; and another supposition which I subsequently formed, that it was simply a protrusion of the processes of the vertebral column, proves equally untenable, as there existed on the spines tubercles indicative of external exposure. I possess two well-preserved specimens of the anterior scale: it was by far the strongest on the creature's posterior extremity, pear-shaped, and fretted with minute confluent tubercles arranged in longitudinal lines.

"I am afraid I can add nothing farther to my early description of the *Pterichthys* in my little work on the Old Red,—a description in which, though slight, I have not yet found much to amend. Agassiz figures, in his Monograph of the Fishes of the Old Red (tab. 30 *a*, figs. 17, 18), a large hexagonal arched plate as the ventral centre-plate of *Coccosteus maximus*: from its appearance in the print, I would be more inclined to regard it as the hexagonal dorsal plate of the *Pterichthys major*. Besides the general form, the squamous suture shown on the right-hand side,—of course taking into account the circumstance that it is a cast, or impression rather, not the plate itself, that is exhibited,—was evidently bevelled off from the under side of the plate, as is the case in the dorsal plate of the *Pterichthys*, not from its outer side, as would be the case were it the ventral plate of a *Coccosteus*. Agassiz' genus *Homothorax* (tab. 31. fig. 6) has, I suspect, like his genus *Pamphractus*, no existence in nature. It seems to be founded on but a drawing of some imperfect specimen of *Pterichthys* of the Upper Old Red of Fife. But regarding his genera *Chelyophorus* and *Actinolepis*, to which you refer, I cannot, in the absence of materials on which to form a judgment, venture to come to any conclusion. I have not much confidence, however, in the specific characters founded on peculiarities of tubercle, unless very striking indeed; as I have seen the forms of these vary in the plates of even the same individual, whether *Coccosteus*, *Pterichthys*, or *Asterolepis*. In conclusion, I must be permitted to say, that my repugnance to traverse in aught the findings of the distinguished naturalist of Neuchatel would be really insurmountable, were I not convinced that he himself would, of all men, be the first to assert the necessity of leaving open an appeal from Agassiz to Nature."

The foregoing description, so remarkable for anatomical detail, mechanical argument, and graphic illustration, requires no comment from me. It gives great weight to the observations I had previously recorded in every instance where its author coincides with them; and in the singular case in which he differs from, or rather, I should say, exceeds them, namely in the detailed description of the relations between the dorsal plate and the surrounding plates, the mechanical argument I founded on my limited evidence is immeasurably strengthened by his more extended investigation. The ball and socket joint to which he alludes, by which the pectoral fin was articulated, was, strictly speaking, only so anteriorly; the posterior limb of the ball was hollowed out for the reception of a bony process extending from the socket, somewhat similar to the odontoid process of the human axis (see fig. 2, 2), giving great strength to the joint, and providing against dislocation without materially constraining the power of motion in those directions in which the organ would require to be exercised.

In a subsequent communication Mr. Miller says, "I have succeeded in tracing to its origin the *Pamphractus* of Agassiz. The specimens which he figures (Old Red, tab. 4. figs. 4, 5, 6) could never have furnished the materials of his restoration. These materials he evidently derived from the print of a *Pterichthys* of the Upper Old Red (showing the dorsal superficies of the creature), given by the Rev. Dr. Anderson of Newburgh, in his Essay on the Geology of Fifeshire (Quarterly Journal of Agriculture, vol. xi. 1840), as that of a fossil beetle. You will see, on comparison, how true it is, in the position and general form of the plates, (with the exception of the division of the dorsal plate at what is simply a strongly-marked groove,) to the upper surface of *Pterichthys*. It is not equally true, however, as I have ascertained by the examination of the greater number of specimens of this species yet found, in the general outline of the carapace, which was longer in proportion to its breadth than in the print, and not defined by such regular curves. The real proportions are much more correctly given in the figure of the *Homothorax* (Old Red, tab. 31. fig. 6); for the *Homothorax* is, I find, the under side of the *Pamphractus,* drawn from a rather imperfect specimen of *Pterichthys hydrophilus,* which did not indicate the divisions of the plates. In the museum of our Highland Agricultural Society here [Edinburgh], there is a specimen of yellow sandstone from Dura-den, Fifeshire (Upper Old Red), which exhibits several individuals of this species. All of them present their ventral surface, and in all the central part is more or less mutilated, so that the small lozenge-shaped plate cannot be traced; but the transverse and longitudinal sutures which separated the four large plates are distinctly visible. One of the most striking specific distinctions of the creature consists in the length and bulk of the arms, and the comparatively great prominence of those angular projections by which they are studded on the edges,—projections which seem to be but exaggerations of those confluent lines of tubercles by which the arms of all the other species are fringed.

"It may seem idle work to be writing and thinking so much about one little fish that perished myriads of ages ago; but the heaven-implanted instincts of man's nature are greatly wiser than man himself, and it is in due accordance with these that we should be thus engaged. I have a little curious boy of five years, who intently takes note of all I do, and instinctively imitates me; and in him I recognize the instinct as eminently wholesome, because essential to his development as man. And are we not also children, in an early stage of mental growth, and engaged, like the boy, in intently examining the handiwork of our Father? The records of His wisdom, inscribed in the rocks, are often, as in this instance, obscurely written; but that very obscurity serves only to whet curiosity the more, and, by concentrating upon them the powers of the attention, brings into greater prominence the profound meanings which they convey."

Description of Species.

PTERICHTHYS LATUS. Mon. Old Red, Tab. 3. figs. 3 & 4.

The figures of this species show the abdominal plates; but, as they are both casts of the interior, the central plate appears larger and more rounded than it would be if seen from without. The tubercles of the plates in this species are coarse, and frequently confluent.

PTERICHTHYS TESTUDINARIUS. Tab. 4. figs. 1 & 2.

I have stated in the foregoing remarks that I am inclined to believe that fig. 1 is the ventral, fig. 2 the dorsal view of this species.

PTERICHTHYS PRODUCTUS. Tab. 3.

Fig. 1 shows the ventral surface. The left-hand portion of the drawing does not belong to the Pterichthys, but shows a crushed specimen of Cheiracanthus. Figs. 2, 3 & 4 all give the same view. In figs. 2 & 3 a dorsal plate is seen dislocated.

Pterichthys cornutus. Tab. 2.

Figs. 1 & 2 represent a beautiful little specimen, one part of which is at Florence Court, the other at Altyre. The artist however has reversed the fish. When looked at in its proper position it gives a very tolerable idea of the outline of Pterichthys seen in profile. Figs. 4 & 5 show the under surface. The horn-like protuberances in the former appear to indicate the position of the glenoid cavity for the reception of the articulating head of the pectoral fin. The dorsal plate in this species is very large ; in a specimen of which the carapace measures $2\frac{1}{4}$ inches it occupies more than $1\frac{1}{4}$ of the surface.

Pterichthys oblongus. Tab. 3. figs. 1 & 2.

Both figures show the inferior surface. In addition to the characters assigned by Agassiz to this species may be mentioned that the pectoral fins are covered anteriorly with strong tubercles (in section they almost resemble the teeth of Coccosteus), and the scales are ornamented in like manner.

New Species.

Pterichthys quadratus, Egerton. Plate X.

On looking over a large collection of Gamrie nodules I found that many of the specimens of Pterichthys indicated a larger and broader fish than the common species of that locality, *P. oblongus*. On comparing these specimens with the Lethen and Cromartie species it was evident they were not the remains of any species yet noticed. The best specimen shows the ventral plates *in situ*. This surface was shorter and broader than the corresponding part in *P. latus*, which it most resembles. The rounded form and large size of the central plate are characters common to the two species, and eliminating both from the other species of the genus. The most marked distinctions between them are found in the form of the posterior ventral plates and the ornament of the carapace. In *P. quadratus* these plates contract rapidly in diameter as they recede from the middle lateral plates, and terminate posteriorly in an angular form, in contradistinction to the corresponding plates in *P. latus*, which are broad and rounded. The ornament of the carapace is not coarse and confluent as in *P. latus*, but more like *P. oblongus*. The tubercles are granular or arenate, and arranged rather irregularly. They are not uniform in size, but all small and distinct from each other. The central dorsal plate is not proportionally so large as in *P. cornutus*, nor is the apex so acute. The pectoral fins were strong, and covered with rugged tubercles. This species appears to have been nearly as common as *P. oblongus*. In the collection of the Society I have recently found a most beautiful specimen of this species, indeed altogether the most instructive and interesting example of the genus *Pterichthys* I have ever seen. The fish reposes on its back, and by a fortunate accident the ventral plate and the ventro-lateral plates of the right side have been removed so as to display the interiors of the dorsal plate and the anterior and posterior lateral plates of that side. On the left side the ventro-lateral plates remain *in situ*. The posterior ventral plates and the thoracic plates with the pectoral fins attached are also shown. The head is partly dislocated, but the outlines of some of the plates are seen, as also two circular points which may possibly be the capsules of the eyes. The posterior portion of the fish is nearly entire, and shows the arrangement of the scales, and the position and characters of the dorsal and caudal fins. The specimen is from Gamrie. There is doubtful evidence of a third species at Gamrie; the specimens may possibly be young individuals of one of the other species, as they are all of small size.

Genus PAMPHRACTUS.

PAMPHRACTUS HYDROPHILUS. Old Red, Tab. 4. figs. 4, 5, 6.

This appears to be the figure of the dorsal superficies of a Pterichthys. It should therefore be restored to that genus, under the designation of *Pterichthys hydrophilus*, the name originally given by Agassiz to this specimen.

Genus HOMOTHORAX.

HOMOTHORAX ——? Old Red, Tab. 31. fig. 6.

A view of the ventral surface of the above.

Woodcut, fig. 1, p. 305.—*Interior profile.*

- *a.* Dorsal plate.
- *b.* Posterior dorsal plate.
- *c.* Anterior lateral plate.
- *d.* Posterior lateral plate.
- *e.* Anterior ventro-lateral plate.
- *f.* Posterior ventro-lateral plate.
- *h.* Posterior ventral plates.
- *i.* Thoracic plate.
- *k.* Pectoral fin.
  - 1, 1. Marginal rings.
  - 2. Horizontal rib.
  - 3. Diagonal rib.

Woodcut, fig. 2.—*Ventral view.*

- *e, e.* Anterior ventro-lateral plates.
- *f, f.* Posterior ventro-lateral plates.
- *g.* Ventral plate.
- *h, h.* Posterior ventral plates.
- *i, i.* Thoracic plates.
- *k, k.* Pectoral fins.
  - 1. Glenoid cavity.
  - 2. Ditto, in section.

PLATE X.—*Pterichthys quadratus.*

- *a.* Dorsal plate.
- *c.* Anterior lateral plate.
- *d.* Posterior lateral plate.
- *e.* Anterior ventro-lateral plate.
- *f.* Posterior ventro-lateral plate.
- *h.* Posterior ventral plates.
- *i.* Thoracic plates.
- *k* Pectoral fins.
- *l.* Eyes?
- *m.* Head.
- *n.* Dorsal fin.
- *o.* Caudal fin.
  - 1, 1. Marginal rings.
  - 2. Horizontal rib.
  - 3. Diagonal rib.

2. *On the Transportal of Erratic Boulders from a lower to a higher level.* By C. DARWIN, Esq., F.R.S., F.G.S.

IT will, I think, be generally admitted that the most valid objection which has been advanced against the theory of the transportal of erratic boulders by floating ice, lies in the fact of their having not unfrequently been carried from a lower to a higher level. Mr. Hopkins *, indeed, referring to certain boulders of a peculiar conglomerate described by Prof. Phillips, considers this fact as affording an absolute proof of the diluvial theory, since, he adds, "it is evident that no floating ice could possibly transport a boulder from the depths of the vale of Eden over the heights of Stainmoor." Prof. Hitchcock has several times alluded to similar cases in North America as offering a very great difficulty.

The first instance recorded, as far as I know, of the transportal of boulders from a lower to a higher level, is by Prof. Phillips †, who in 1829 described numerous large blocks of grauwacke not far from Kirby Lonsdale, scattered over the mountain limestone from a height of 50 to 100 feet above the parent rock, which lies immediately beneath. He adds, "Further on, to an elevation of 150 feet, the blocks are still numerous, and they may be seen, by ascending one ledge after another, almost to the top of the Fell, 500 feet above their original position. They appear," he continues, "to have been driven up at a particular place by a current towards the north, and afterwards carried along the surface of the limestone in a narrow track toward the summit of the Fell." The conglomerate alluded to by Mr. Hopkins has been transported from the bottom of the valley of the Eden, where the rock lies *in situ* at the height of 500 feet above the level of the sea, to and over the pass of Stainmoor at the height of 1400 feet ‡: therefore the boulders now lie 900 feet above their original position. In 1838 I observed many boulders of granite strewed on Ben Erin on the western side of Glen Roy §, up to the height of 2200 feet above the sea; the granite resembled in character that seen *in situ* at the head of the Spey, and which, in Macculloch's Geological Map, is likewise the nearest district of granite: if, as I believe, the boulders came from this place, they must have been carried up at least 900 feet. Mr. Maclaren || has described (1839) numerous blocks of sandstone on the higher parts of Arthur's Seat, "400 feet above any spot where sandstone now exists *in situ*." Quite recently Mr. D. Milne ¶ has noticed other boulders on the same hill, belonging to the coal series, and remarks "that there is no place in the neighbourhood from which these blocks could have come which is not at least 200 feet below their level." In the Isle of Man, the Rev. J. G. Cumming has observed with great care a

* Journal of the Geol. Soc. vol. iv. p. 98.
† Transactions of the Geol. Soc. vol. iii. (second series) p. 13.
‡ Treatise on Geology (Lardner's Encyclop.), by John Phillips, vol. i. p. 270.
§ Philosophical Transactions, 1839, p. 69.
|| Geology of Fife, &c. p. 47.
¶ Edinburgh New Philosophical Journal, vol. xlii. p. 167.

striking case, and has most kindly communicated to me the details, which will immediately appear in his work* : near South Barrule there is a hillock formed of granite, quite different in nature from any other rock in the island; this mass of granite is about three-fourths of a mile square, and is 757 feet above the level of the sea; from this point the boulders are thickly dispersed to the south-west, and they can be continuously followed up to a height of 788 feet above the summit of the present boss. Mr. R. Mallet informs me that facts of a similar nature have been observed in Ireland. More striking cases occur in the United States, in New England, in New York, and in northern Pennsylvania. Prof. Hitchcock observes†, that the Silurian rocks of New York and the quartz in the valleys of western Massachusetts have undoubtedly been carried over and left upon the Hoosac and Taconic mountains, at a height of "upwards of one thousand or two thousand feet." Lastly, I may mention the analogous case of the chalk-flints, associated with boulders of various kinds, observed by the Dean of Westminster and myself on Moel Tryfan, at the height of 1392 feet above the level of the sea, and which (as well as the chalk-flints at the intermediate point of the Isle of Man‡) there is good reason to believe must have come from Ireland, and therefore, at least in the case of North Wales, from a considerably lower level.

The first point to consider is whether, in these several instances, the boulders have really come from a lower level, or whether they may not (and I am indebted to Sir H. De la Beche for this caution) have been derived from strata now entirely denuded, but which formerly extended up to the same level with the boulders. Or secondly, whether the boulders, after having been deposited, may not have been raised by an unequal elevatory movement above their parent district, or the district itself have been depressed by subsidence below them. With respect to the former supposed greater extension and subsequent denudation of the parent rock,—in such cases as those near Edinburgh it is possible that this may be sufficient to account for the phænomenon. Where the boulders are of granite, as at Glen Roy and the Isle of Man, this view implies that a mass of that rock has been worn down, equalling in thickness the difference in level between the existing mass *in situ* and the boulders: in North America, where the boulders lie from 1500 to 2000 feet above their source, the denudation on this view must have been immense, and it must all have been effected within the glacial period, as the low country is covered with boulders; this likewise is the case with the boss of granite in the Isle of Man. Can it be supposed with any probability that the chalk-formation formerly extended in Ireland up to a height of nearly 1400 feet? In the case of the boulders described by Prof. Phillips, I am assured by him that the above view is quite inadmissible; and he has pointed out to me conclusive reasons, but which, considering

* The Isle of Man, its History, &c., by the Rev. J. G. Cumming.

† Geology of Massachusetts, vol. i. (Postscript, p. 5*a*), and Address to Association of American Geologists, 1841.

‡ The Rev. J. G. Cumming in Transactions of British Association, 1845, p. 61.

his high authority, I do not consider it necessary to give in detail; I will only mention that the grauwacke was planed down level, before the thick mass of mountain-limestone on the surface of which the boulders lie was deposited on it, and that at a short distance the grauwacke is quite cut off by the Craven fault: the conglomerate beds, whence the boulders at a height of 900 feet on Stainmoor were derived, are horizontal.

With respect to subsequent unequal elevation having caused the boulders now to lie above their parent rocks, the simple fact of the number of points, irregularly placed both in Great Britain (namely, in northern and central Scotland, in the Lake district, North Wales, Isle of Man and Ireland,) and likewise in the United States, appears to me to render this view extremely improbable; for on such a view it must be admitted that in Great Britain and America several great mountains and mountain-chains have been formed so lately as during the glacial period, and this is a proposition to which few geologists will be inclined to assent. Moreover, in the case of Stainmoor, it is known that its crest now holds, one part with another, the same relative level as it did during the glacial period, for the boulders have crossed it only in one notch or gap, which is now the lowest part; and certain chains of hills which would at present intercept boulders coming from one quarter likewise did so at the glacial epoch.

In the Isle of Man the parent granite and the boulders which lie 788 feet above it are scarcely more than two miles apart, and in the intermediate tract, thickly covered with the boulders, Mr. Cumming has in vain searched for evidence of a fault. In the Lake district there is, I think, conclusive evidence that unequal elevation is not the true explanation, for the boulders there lie so close to the rocks *in situ* that there would necessarily be, if the boulders had been subsequently upraised, a fault or abrupt flexure, in one case of 900 and in the other of 500 feet. Hence we must conclude, in accordance with the views of the several authors who have described the above cases, that the boulders have really been drifted nearly as many feet upwards (that is, making in almost every instance some allowance for the subsequent denudation of the parent rock) as they now lie above their original source.

Those who believe in the powerful agency of ice in moving boulders will probably at first conclude that icebergs have in some manner transported them from a lower to a higher level. But the most obvious method by which fragments of rock can get on icebergs is by their having first fallen from the surrounding precipices on glaciers entering the sea, and therefore they must have come from a higher to a lower level. It seems impossible, owing to the temperature of the water, that at any considerable depth, boulders could be frozen into the bottom of icebergs; and even if at lesser depths they did become so frozen* or mechanically wedged in, and if by the icebergs being overturned they were saved from being soon thawed out, yet they could be deposited above their former level only by so much as

* See some excellent remarks on this subject in Sir H. De la Beche's Anniversary Address for 1848, p. 68 *et seq.*

the ice under water had decreased in thickness in the interval of the boulders having been caught up and dropped. In any case the notion of icebergs having, in the States of New York, New England, and northern Pennsylvania, lifted up numerous boulders from a depth of between 1000 and 2000 feet, is quite inadmissible.

In my paper on the Boulders of the Southern hemisphere, read before this Society *, I pointed out that there were two methods, essentially distinct both in the requisite climate and in the results produced, by which fragments of rock are transported; namely, by icebergs and by coast-ice. Icebergs now transport fragments of rock on the west coast of South America, in the latitude of the central parts of Europe, under a temperate climate where the sea, even in protected bays, is never frozen. On the other hand, in the northern parts of the United States and in the Gulf of Bothnia, where the climate is excessive, but yet under a latitude where glaciers never descend to the level of the sea, fragments of rock are annually enclosed by the freezing of the coast-water, and are thus transported. In the polar regions both actions concur. Icebergs will transport such fragments of rock as fall on the parent glaciers, and these are generally quite angular. From the vast size of the bergs, the fragments will often be transported to great distances, and when deposited, it must be in deep water, and therefore (as well as from the original descending movement of the glacier) at a much lower level than the parent rock: when once dropped, they will probably never again be moved by ice. On the other hand, coast-ice will transport whatever fragments of rock or pebbles lie on or near the shore. These fragments, from being repeatedly caught in the ice and stranded with violence, and from being every summer exposed to common littoral action, will generally be much worn; and from being driven over rocky shoals, probably often scored. From the ice not being thick, they will, if not drifted out to sea, be landed in shallow places, and from the packing of the ice be sometimes driven high up the beach, or even left perched on ledges of rock. By this agency boulders will probably not be carried to such great distances as by icebergs, and the limit of their transportal will perhaps be more defined. In South America there is a considerable difference in the state of the boulders in Tierra del Fuego, where a large proportion are much rounded, and on the plains of Patagonia and in Chiloe further from the pole, where the boulders are larger and quite angular. I attributed the presence of these latter to the exclusive action of icebergs; whilst in Tierra del Fuego coast-ice appears formerly to have come into play. On Moel Tryfan † the well-rounded fragments of chalk-flints were in all probability transported by coast-ice: though I cannot doubt, from the extraordinary manner in which the laminæ of the slate rocks have there been shattered, that icebergs have likewise been driven against them when under water; so that both actions seem there to have concurred. Some other distinguishing characters between the action of coast-ice and of icebergs will presently be pointed

* Transactions of the Geol. Soc. vol. vi. (second series) p. 430.

† London Philosophical Journal, vol. xxi. p. 186.

out; and it is by coast-ice, as I believe, that boulders have been transported from a lower to a higher level.

To take the case of North America: Mr. Lyell* has shown, from an independent train of reasoning, that this country during the glacial period slowly subsided to a considerable amount: several American geologists have come to a similar conclusion, and they believe that the subsidence amounted to two or three thousand feet, or even more. Let us suppose a sinking movement to be now going on in the estuary of the St. Lawrence or on the coast of Labrador, where we know, from the observations of Lieut. Brown and Capt. Bayfield, as given by Mr. Lyell† (and illustrated by striking sketches), that annually an enormous number of boulders, both on and near the coast, are frozen into the coast-ice and transported to shorter or greater distances; can we doubt, that if during the year the land sunk a few inches or feet, the boulders, whilst actually frozen in or when refrozen during the ensuing winter, would be lifted up and landed so many inches or feet higher up on the coast? Capt. Bayfield, as stated by Mr. Lyell‡, saw masses of rock, "carried by ice through the straits of Belle Isle, between Newfoundland and the continent, which he conceives may have travelled in the course of years from Baffin's Bay." Now if during this probably long course of years,—for the boulders seem generally to be transported only a short distance each winter,—the land had subsided one or two hundred feet, is it not almost certain that they would have been landed so many feet higher up with respect to their former level, in the same manner as would have happened with so much drift timber? It is indeed paradoxical thus to speak of the boulders having been carried up, whilst the land has gone down; for, in fact, the boulders are merely kept by the floating ice at the same level, whilst the land sinks.

No doubt during this process some boulders would be dropped in water too deep to allow of their being refrozen, and they would be thus left behind. Scarcely any form of land would prevent the boulders from being annually landed on a temporary resting-place: even a line of perpendicular cliff, if not of very great length, would probably only cause the tidal currents to drift the coast-ice further onwards; a few more boulders, perhaps, being dropped there than elsewhere. I can see only one difficulty of any weight to this view, namely, that the boulders would be ground down into mud and destroyed from having been stranded such innumerable times, as must have happened with those which were kept up to the same absolute level during a sinking of the land of many hundred feet. On an exposed coast, where the breakers had power to dash pebbles against the boulders, I have no doubt that this would take place, more especially with boulders small enough to be themselves rolled over. But on a broken coast, amongst islands and in bays, I do not believe that this would happen. We may infer from the fact of scored rocks having been observed both in Scotland and in North Wales, dipping

* Travels in North America, vol. i. p. 99, and vol. ii. p. 48.

† Principles of Geology, 7th edit. p. 222.

‡ Ibid. p. 231.

under the surface of lakes, in a quite unaltered condition, that the action of simple water, and of such little waves as lakes can produce, even when prolonged from the glacial period to the present day, is absolutely as nothing; and in sheltered bays, the force of the waves is not very much greater than in lakes. Moreover, in South America I have seen many boulders lying on sea-beaches, exposed to the wash of rather open channels, and which, so far from having been destroyed, yet retained their angles perfect.

Nevertheless it might certainly be expected that boulders which had thus been buoyed up by coast-ice during long-continued ages would be well-rounded. According to Prof. H. D. Rogers, this is the case with the majority of the boulders in North America: those at Glen Roy were rounded, but they were composed of granite subject to disintegration; this likewise is the case with those in the Isle of Man: Mr. Cumming however informs me that the boulders, with some marked exceptions, "diminish in number and size the further we proceed" from the granitic boss. The boulders on Arthur's Seat, judging from the remarks of Messrs. Maclaren and Milne, are rounded. Those near Kirby Lonsdale, which now lie, according to Prof. Phillips, 500 feet above their parent rock, are not rounded; but they are composed of slate, a rock very little liable to be rounded, and they appear to lie in a sort of train up a valley surrounded by mountains, which must formerly have been a well-protected bay. It would be interesting to ascertain whether those boulders which now stand highest above the parent rock are more worn than those at a lower level, which latter I believe to have been dropped during the long-continued buoying-up process.

We have seen that, according to Mr. Lyell, the northern parts of the United States did actually subside during the glacial period. I am not aware that anyone has attempted to show that Great Britain was similarly affected during this same period. The following considerations, however, appear to me to render it in some degree probable: in Staffordshire there are many great and perfectly angular boulders of northern rocks, which almost every geologist believes were transported on icebergs, now lying at the height of above 800 feet above the sea; and on Moel Tryfan, at a height of nearly 1400 feet, there are stratified beds of the glacial epoch (as known by the included shells discovered by Mr. Trimmer), which beds, after careful examination, I cannot doubt were deposited in the ordinary manner under the sea. On the other hand, the character of the miocene formations, on the east coast of England, belonging to an epoch just antecedent to the glacial, lead to the conclusion that the land then did not hold a level widely different from the present one: if so, unless we suppose a great inequality in the changes of level between the east and west coasts of England, the land must have sunk after the miocene age to allow of the deposition of the glacial deposits at the heights above specified. This conclusion accords perfectly with Professor E. Forbes's statement*, that all the organic remains seen by him, from the glacial formation, indicate a depth of less than 25

* Memoirs of the Geological Survey, p. 376.

fathoms. As far then as these considerations can be at all trusted, we are, according to the view given in this paper, in a position to explain the transportal of the boulders from a lower to a higher level, in Great Britain as well as in the United States. I will make only one other remark on this head: though I believe that Great Britain subsided during the glacial period, yet I conceive it must also have subsequently attained during this same prolonged period a considerable portion of its present height. I infer this from the plain marks of true glacier action, low down the valleys in North Wales, within 300 feet of the present level of the sea*.

A second objection of apparently considerable weight has been advanced against the theory of floating ice; namely, that in some instances the blocks decrease very regularly in size in proceeding from their source. Prof. H. D. Rogers† says that this is markedly the case in going southward in the United States. According to Mr. Hopkins‡ it is also the case in the Lake district; "the blocks becoming smaller as we approach the coast of Yorkshire, till they degenerate into pebbles in the more remote localities, in which the Cumbrian rocks can be identified." He adds, "These facts are strongly in favour of those views which would refer the transport of these masses to diluvial currents." This sorting of the boulders does not always hold good: on the plains of Patagonia the two largest boulders which I saw were near the outskirts of the deposit. Sir R. Murchison also remarks on the vast size of the many boulders in the south-east parts of Shropshire, near the southern limit of his northern drift, though he elsewhere states that the boulders generally decrease in size in going from north to south. In these cases, if we look at the boulders as having all been transported on icebergs, there certainly appears no reason why they should have been dropped from such immense masses of ice, with any approach to order according to their size and to their distance from their source. But this does not hold good with boulders transported in sheets and fragments of coast-ice: here the buoying agent is not of disproportionate power to its burthen; as the ice decays, the heaviest fragments would naturally be apt to drop out first; and it would appear from the accounts given to us, that the largest boulders during some winters escape being moved at all, whilst the smaller ones are drifting onwards. Moreover, the boulders (and great stress may probably be laid on this point) which had travelled furthest, would, from having been repeatedly stranded, and necessarily so every summer, be most worn, and therefore would be smaller than those which had travelled to a shorter distance.

I have shown, in my volume on South America, that the sea has

* Since the above was written, I have found that Mr. Trimmer, in his interesting paper on the Geology of Norfolk (Journal of the Royal Agricultural Society, vol. vii. part 2), has shown that that district subsided at least 600 feet, and was likewise upraised during the boulder or glacial period.

† Address to the Association of American Geologists, 1844, p. 45.

‡ Journal of the Geological Society, vol. iv. p. 98.

the power by some means of sorting the pebbles which lie at the bottom, their size decreasing with surprising regularity, even till they pass into sand, with the increasing depth. There is some difficulty in understanding how this is effected: Playfair has suggested that the undulations of the sea propagated downwards from the surface, *tend* to lift up and down the pebbles at the bottom, and that such are liable, when thus quite or partially raised, to be moved onwards even by a very weak current. Should, therefore, a boulder formation be exposed during subsequent changes of level to the action of the sea, pebbles derived from it, and decreasing in size with perfect regularity according to their distance from their source, might be thus spread out. Hence I conceive that from a group of mountains, which had once existed as an island, boulders, decreasing in bulk with some degree of regularity, and beyond them pebbles degenerating with perfect regularity into sand, might be spread out, thus simulating the effects of a great debacle, which in rushing along had insensibly lost its power, and yet that both boulders and pebbles had been transported by the ordinary currents of the sea; aided, in the one case, by floating coast-ice, in the other, apparently by the undulatory movement of the water.

The two objections, therefore, which have been here discussed, cannot, I think, any longer be considered as absolutely fatal to the theory of floating ice; and thus far the hypothesis of a debacle is no longer necessary.

If the explanation here given of the transportal of boulders from a lower to a higher level be hereafter proved correct, we gain, in all cases where the horizontal distance between the boulders and the parent rock is not so great as to allow of the probability of subsequent unequal movements of elevation, a valuable measure of subsidence during a defined period. We are accustomed to precise measurements of elevation, from the ascertained heights of upraised marine remains; but it seemed quite hopeless to expect this, even in a lesser degree, with respect to subsidence,—that movement which hides under the sea the surface affected. It is marvellous that Nature should have thus marked by buoys made of stone, the former sinking of the earth's crust, and likewise, I may add, its subsequent elevation; and that on these blocks of stone the temperature, during the long period of their transportal, may be said to be plainly engraved. Moreover, it is thus shown that the subsidence during no one entire summer was so great as to carry the coast-boulders beneath that small limit of depth at which the salt water during each ensuing winter became frozen.

Note.—After this paper was read, Mr. Nicol objected that when the parent rock was once submerged, no further supply of boulders could be derived from it, and consequently if afterwards, each time they were afloat, only one boulder out of a hundred was dropped in water too deep for it to be refrozen in the coast-ice, after a certain time there would be none left to be carried up, during the continued subsidence, to the higher levels. This appears to me an objection of much force. I would, however, remark in the first place, that I do not suppose that the boulders over the whole area of subsidence are carried far up, but only those in certain favourable situations. Secondly, several Arctic voyagers have stated that the pack-ice frequently piles up and leaves masses of boulders at a height of even 20 and 30 feet above high-water mark; now after a subsidence, the ice during the first gale would drive these boulders still higher up, and so onwards and upwards, with scarcely any tendency to carry them out to sea. In a bay open to the prevailing winds, and without any river entering it, I should imagine that the coast-ice would rarely be drifted outwards. Thirdly, I believe that any floating object thrown into the water not far from an extensive coast-line, is generally driven *soon* on shore: this certainly seems to be the case with the wrecks of boats; and if so, any ice-borne boulders, carried by the wind off the land, would generally be again thrown on the coast.

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3. *On Scratched Boulders.* Part I. By JAMES SMITH, Esq. of Jordan Hill, F.R.S.L.&E., F.G.S.

[The publication of this paper is postponed in order that it may appear in connexion with the second part read at a subsequent meeting of the Society.]

PROCEEDINGS,

ETC.

POSTPONED PAPERS.

On the Geology of EGYPT. By Lieut. NEWBOLD, Madras Army, F.R.S.

[Read June 29, 1842.—Communicated by the President.]

I HAVE deemed it advisable to preface this paper with a brief notice of the geographical position, extent, and more prominent physical features of Egypt, remarking at the same time that although much still remains to be done in this most interesting, and comparatively unexplored field for the geologist, yet it may not be wholly useless to lay before the Society a summary of what has already been effected.

Geographical Position and Extent.—Egypt, with its desert tracts, embraces an area of about 100,000 square miles, having somewhat the shape of a parallelogram, the longest axis of which runs north and south. It is situated between 24° and 32° N. lat., and 27° and 31° E. long., and is bounded on the north by the Mediterranean, on the south by the mountains of Nubia, on the west by the Libyan desert, and on the east by the Red Sea and the Isthmus of Suez. It possesses a coast-line on the Mediterranean upwards of 200 miles long, and on the Red Sea of more than double that extent.

Physical Divisions.—Egypt consists of three great physical divisions: first, the mountainous region, extending between the Red Sea and the Nile; second, the desert tracts east and west of the Nile; third, the fertile valley of the Nile and its delta.

Aspect.—The general aspect of Egypt varies according to the divisions just laid down, and presents perhaps more striking contrasts of sterility and fertility than any other country in the world. The mountainous region exhibits, from deficiency of springs, rain, and dew, all the naked, dreary appearance of Arabia Petræa—an assemblage of bare or sand-covered rocks, intersected by deep ravines often obstructed by rocky debris, and the drifted sands of the desert, which frequently invade the sides and summits of lofty hills. The peculiarly flat, tabular aspect of Central, and part of Upper Egypt, is owing to the almost horizontal character of the stratification of the limestone rocks that for the most part prevail, supporting the desert tracts on each side of the Nile, and terminating near its banks in mural escarpments, which flank its course with some irregularity, from the vicinity of Esneh to Cairo. Between Kossier on the Red Sea and Ghennah on the Nile, where plutonic and hypogene rocks prevail, their pinnacles and dome-shaped masses render the aspect more varied and irregular.

The deserts present a series of undulating plains; sometimes studded with low irregular hilly clusters, and covered for the most part with unproductive saline, often calcareous and gypseous, sand, marl, and gravel, the layers of which are broken up by the drainage-channels of the unfrequent rains, and often denuded from causes no longer in action. The existence of springs of fresh water, both in the desert and mountainous tracts, is marked by spots of the most refreshing verdure, known under the term Oases. These I am induced to regard simply as valleys or depressions supplied either from such springs, or from the drainage-water of the desert, that finds its way below the surface of the sands, and lodges in the impervious marl or clay-covered bottoms of the oases, keeping up a scanty, though almost constant, supply of water. In a few places, at low levels, the water appears to be supplied by percolation from the Nile. In a climate like that of Egypt, water alone, even on the sands of a desert, rapidly produces vegetation, from the successive decay and reproduction of which a layer of vegetable mould results, that goes on increasing in depth and extent proportionate to the supply of water.

The height of the desert varies considerably: the extreme elevation attained between Suez and Cairo is about 700 feet above the ocean. Its general character between the Nile and Red Sea is that of an elevated plateau, with a flattish irregular superficies, rising towards the centre, and gradually sinking on either side till it terminates on the shores of the Red Sea and the borders of the Nile in abrupt escarpments or steep descents.

The levels taken through the marshy and flat extent between Suez and Pelusium give a depth of 24 feet below the sea-level*.

The aspect presented by the valley and delta of the Nile varies according to the seasons. During the inundation they exhibit a vast freshwater lake, whose surface is studded by a number of palm-shaded hamlets. After the subsidence of the waters, one sees a waving line of brilliant verdure winding through the sterile expanse of desert on either side of the upper part of the river, and girt in until it arrives at the verdant expanse of the delta, by white mural cliffs. The line of demarcation between the sandy desert and the dark alluvium of the Nile is abrupt and well-defined. After the grain is cut and carried off the ground, the charm is dispelled, and the eye turns away from the tedious prospect of one monotonous, brown, dusty, arid plain, through which the sluggish Nile slowly winds its straitened muddy course. The extreme flatness of the delta may be conceived from the circumstance of the canal, which unites Alexandria with the Nile, running its whole extent (about sixty miles) without a single lock: and the whole superficies of Egypt, from the first cataracts to the Mediterranean, presents an inclination to the north of only two inches per mile†. The descent a little north of Assuan is as much as seven inches, but lessens as it approaches the delta.

* Laborde, p. 263. † Mr. Wallace, quoted by Mr. St. John, Travels, p. 354.

Mountains and Valleys.—From the generally horizontal stratification of the rocks covering the greater part of Egypt, it is difficult to trace in them any particular lines of elevation. Mural cliffs, as has been already observed, flank the valley of the Nile in a northerly direction to the vicinity of Cairo, where they deviate severally towards the east and west. A similar range of cliffs, though not so abrupt in character, flanks both shores of the Red Sea. This formation is traversed by valleys and ravines that cross each other at right angles, running nearly north and south and east and west. Through the most considerable of the first of these classes of valleys flows the Nile; while the latter have long formed channels of communication and commerce between the valley of the Nile, the Red Sea, and the countries to the eastward of it. They are termed *Wadis* by the Arabs, and the deepest of the transverse valleys or ravines, *Makna't*, or places on which from their depth the sun cannot shine. In the eastern desert of Upper Egypt I traced these valleys to an anticlinal line running nearly north and south, and caused by plutonic rocks rising from the aqueous strata to the height of more than 1000 feet above the sea's level. Their upheaval forms the key to the systems of valleys by which Egypt is intersected, and illustrates forcibly the truth of Mr. Hopkins's observations on the laws of fracture, caused by expansive subterranean forces operating on strata under certain conditions. The aqueous deposits, though evincing considerable disturbance at the junction-line with the plutonic rocks and associated hypogene schists, have evidently, from their slightly inclined position at a considerable distance from them, been elevated to their present position above the ocean's bed, with no more force and abruptness than was necessary to produce in them the fissures by which they are intersected; and it is worthy of remark, that in proportion as the strata recover their horizontal position, the fissures become less frequent, deep and extensive.

Some of these fissures,—the valley of Kossier for instance, which has its origin in a line of dislocation,—appear to have been widened by aqueous causes no longer in operation. Others seem altogether formed by them, as for instance the Waterless river, the *Bahr bila Maieh* of the Arabs, westward of the delta, and the valley separating the petrified wood formation from the Red mountain, or Gebel Ahmar, near Cairo, as will be mentioned in a subsequent part of this paper when treating of "the petrified forest." The surface of these valleys is, for the most part, covered with drifted gravel, composed not only of the detritus of rocks in the vicinity, but of rolled pebbles of other formations transported from great distances, for whose presence the action of existing streams is not adequate to account, as these pebbles often rest on ledges and hills much elevated above the general drainage-level. The limestone valley of Kossier, near the Red Sea, is covered with a gravel—great part of which consists of pebbles from the plutonic rocks and hypogene schists in the interior. Few of these pebbles are found near the Nile west of the sites of the parent rocks, a fact indicating the easterly course of the retiring waters or current which transported them.

It has been supposed by some travellers that the valley called the Waterless river is nothing more than an ancient channel of the Nile, or, in part, an artificial work executed by the ancient Egyptians for receiving the waters of the river*. This singular valley is about six or seven miles broad, extending in a north-westerly direction from the west bank of the lake Mœris. It leads towards the Mediterranean, in the vicinity of the Mareotis lake, passing the western boundary of the alluvium of the delta in a direction almost parallel. Its sides are formed of low calcareous ridges and sand-hills. The bottom is covered with sand and a gravel consisting principally of rolled fragments of quartz, jasper, Egyptian pebble, petrosilex, and silicified wood, among which Andreossy discovered rolled stones from the primary ranges of Upper Egypt. The Abbé Sicard, and even more modern travellers, have asserted that petrified masts and wrecks of vessels occur in this gravel; but the specimens of petrified wood that have been brought thence resemble strongly those from the formation near Cairo.

No trace has been hitherto discovered in this valley of the rich dark-coloured alluvium that has from the earliest periods of history been deposited by the Nile in its course through Egypt, or of the mud usually thrown down by lakes or reservoirs of fresh water, facts strongly militating against the theories of this valley having been a receptacle for the superabundant waters of the Nile, or of its being hollowed out by the ancient stream of the river pursuing this course towards the Mediterranean. With regard to the present valley through which the Nile flows, I have little doubt of its having been enlarged and modified by the continued, though varied, action of the stream through a lapse of ages. I have myself witnessed during the rise of the river large masses of rock, particularly on the eastern bank, dislodged and precipitated into the eddying waters below. The fact of the rocks on the eastern flank of the Nile being usually more scarped and abrupt than those of the opposite or Libyan bank, may be attributed probably to the greater encroachment of the Nile on the former.

Drainage.—The system of natural drainage of the country is remarkably simple; but little rain, as is well known, falls in Central and Upper Egypt, and the supply of springs is extremely scanty. The greater portion of rain-water is absorbed by the thirsty sands of the desert, percolating and sinking through them until collected in some natural basin, like the oases, having an impervious bottom; the rest, after diminution by evaporation, which is very great, passes off on the eastern side of the great anticlinal axis already mentioned, by transverse cracks in the aqueous rocks to the Red Sea; and on its western side by similar cracks running in an opposite direction to the valley of the Nile. The Libyan desert, on the western bank of the Nile, is similarly drained into this great hollow, which runs with a gentle slope northerly to the Mediterranean. After all, the total amount of water carried into the Red Sea and the Nile from the surface of Egypt is exceedingly small. The rain-channels are dry

* Clot Bey, Aperçu générale sur l'Égypte, vol. i. p. 137.

during the greater part of the year; and the Nile may be said to be the only river of Egypt; one remarkable feature of this mighty stream, which from the earliest dawn of history, by the unfailing periodical floods of fertility it has poured upon Egypt, has exerted a powerful influence on the civilization of nations, being, that during the last 1350 miles of its course, in all 2600 miles, it rolls onward a broad, majestic stream, without receiving what may be termed a single tributary.

I shall now describe the rocks, commencing with the hypogene or metamorphic strata, and thence to the more recent deposits in their order of superposition, from the first cataracts and the anticlinal line in the Thebaid desert, which may be termed the great watershed of Egypt, to the Mediterranean (see figs. 1, 2).

Extent, Position, and Lithological Character.—Hypogene rocks (*g*) constitute but a small portion of the surface of Egypt. I observed them between the Red Sea and the Nile only in the latitude of Kossier (26° 8′ N.), resting in highly inclined and curved strata on the granite, (figs. 2, 7) forming a zone of about thirty miles in breadth east and west, running probably in a south by east direction, appearing at Gebel Zubára, lat. 24° 30′ N.* In a southerly direction they have been traced resting on the granite of the cataracts. In the southern part of Central, and in Lower Egypt they disappear altogether. Gneiss is usually found lowest in the group with micaceous, talcose, and hornblendic schists, clay-slate and quartzite, superimposed in conformable stratification. All these rocks, within the limits of the zone alluded to, are associated with dykes of basaltic greenstone, porphyry and serpentine. Thin veins of marble occur in the gneiss. Near Ambagi, west of Kossier, the greenstone rocks are of a massive cha-

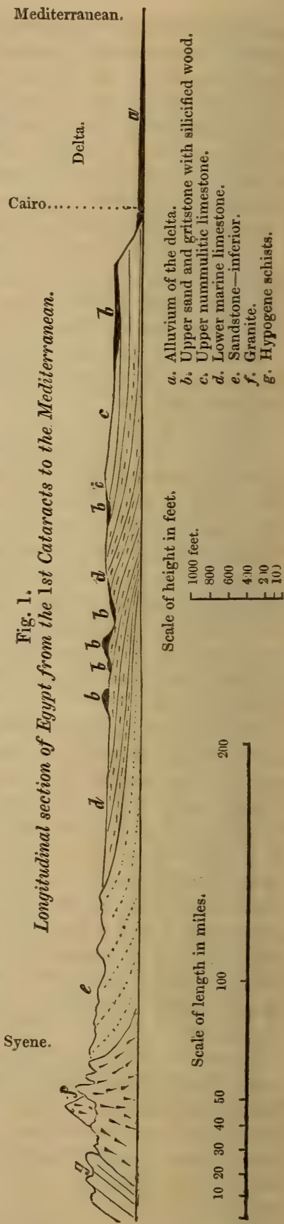


Fig. 1. *Longitudinal section of Egypt from the 1st Cataracts to the Mediterranean.*

* M. Caillaud found copper and lead ore near the emerald mines of Zubara, and also a sulphur-mine in Gebel Kebrit, but in what formation is not certain.

racter, indistinctly stratified, and resemble closely some varieties of basalt: they are here associated with syenite and porphyry, and rise in naked masses to the height of from 100 to 300 feet above the plain, dipping easterly at an angle of 34°. All the hypogene rocks near the contact with granite or trap exhibit a tendency to crystalline development;—the gneiss and hornblende become garnetiferous, and abound in crystallized actinolite, compact actinolitic felspar, and quartz of a beautiful pistachio green. The talcose schists pass into a semi-crystalline potstone and nephrite, as at Mount Baran, and exhibit cubic iron pyrites; while the micaceous schist at Gebel Zubára produces emeralds, avanturine, and hæmatitic and specular iron ore. The clay-slate, which is usually of a chocolate-brown colour, with silky green chloritic flakes, passes into basanite or flinty slate.

Economical purposes.—Cooking-vessels and images are made from the potstone of Mount Baran, and scarabæi of the nephrite and green actinolitic felspar.

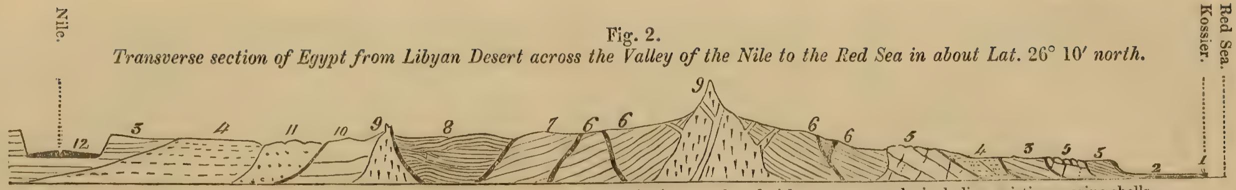
Breccia di Verde: Extent, Position, and Lithological Character.—Between the Red Sea and the Nile, in about lat. 26° 8′ N., the celebrated Breccia di verde (fig. 2, 11) rests on the slates in conformable thick-bedded strata, becoming more horizontal on receding from the granite. This rock appears to be destitute of fossils as far as hitherto known: it is a beautiful conglomerate, composed principally of angular and rounded pebbles of greenstone, gneiss, porphyry, clay and flinty slate, serpentine and marble, cemented together by a compact, slightly calcareous paste, varying from all shades of green to a purplish red. Pebbles of light green compact felspar, coloured by actinolite, and other pebbles derived from the hypogene rocks, sometimes occur.

Economical purposes of the Breccia.—Between Siddt and Hummamet this breccia has been quarried by the ancient Egyptians, whose chisel-marks and hieroglyphics are as sharp and legible as though only cut yesterday, evincing its little liability to weather. From the exceeding beauty of this breccia, works of art sculptured in it have been extensively removed to foreign lands, and more of them may be seen in the churches of Italy and the mosques of Constantinople, than in the temples and palaces of Egypt. One of the most perfect and beautiful sculptured specimens that remains in its native land is the celebrated sarcophagus, supposed by Dr. Clarke to have contained the body of Alexander the Great. The cliffs of this breccia rarely attain a height exceeding 200 feet above the level of the desert.

Lower Sandstone: Extent and Position.—Above the Breccia di verde rests a sandstone (4, fig. 2), which, as far as is at present known, occupies but a small portion of the superficies of Egypt, and that near its southern limits, thence passing into Nubia. No fossils have hitherto been found in it. It is seen on both flanks of the anticlinal axis between Kossier and Ghennah, and on the banks of the Nile: according to Lefevre it continues from a little south-west of Esneh, in about lat. 25° 10′ N., nearly to Syene or Assuan—a distance of about seventy miles—where both it and the superincumbent limestone are overthrown by the syenite and diorite. The

Fig. 2.

Transverse section of Egypt from Libyan Desert across the Valley of the Nile to the Red Sea in about Lat. 26° 10′ north.



Scale of length in miles.

5 10 15 20

Scale of height in feet.

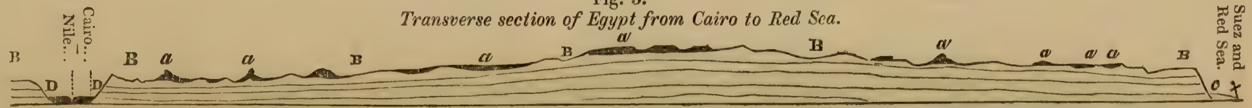
2000 feet.

1000
800
600
400
200

1. Ancient coral reef with gypseous marls, including existing marine shells.
2. Bed of gravel containing, chiefly, pebbles derived from plutonic and hypogene rocks overlying ancient coral reef.
3. Marine limestone.
4. Sandstone.
5. Indistinctly stratified greenstones associated with syenite and porphyry.
6. Basaltic dykes penetrating hypogene schists.
7. Hypogene schists associated with serpentines and penetrated by granite.
8. Greenish and chocolate coloured slates, argillaceous and siliceous.
9. Granite penetrated by veins of smaller-grained granite and eurite.
10. Quartzite.
11. Breccia di verde associated with red breccias.
12. Alluvium of the Nile.

Fig. 3.

Transverse section of Egypt from Cairo to Red Sea.



Scale of length in miles.

5 10 20

Scale of height in feet.

1000
800
600
400
200

a. Upper or overlying sandstone and grit imbedding petrified wood.
B. Marine limestone.
c. Raised beach of Red Sea.
D. Alluvium of valley of the Nile.

sandstone here, near its junction with these rocks, passes into pudding-stone and an agatiferous breccia. Near Bir Anglaise, in the Kossier desert, it reposes on the greenstone in conformable strata, dipping easterly: and west from this, on the opposite side of the anticlinal axis, it rests immediately on the Breccia di verde with a slight westerly dip. The sandstone breccias, near the junction-line with the plutonic rocks,—from the smallness of the fragments composing them, and their altered crystalline structure,—often resemble certain porphyries in lithological character, but at a greater distance in the higher beds their true nature is easily recognizable.

Lithological Character.—In lithological character the sandstone varies from a loose granular aggregate of quartz, held together by a felspathic, calcareous, or ferruginous cement, to a compact quartz rock. The pebbles in its interstratified breccias are usually of chert, flinty slate, agate or jasper, many of them evidently derived from the subjacent clay-slate. In some situations it contains thin beds of green and purple clay, in which occur gypsum and crystallized muriate of soda. Veins of crystallized quartz—white, brown, and amethystine—traverse it. Copper and specular iron ore are said by Mr. Burton to occur near Hummamet, which lies on the sandstone.

Economical Uses.—This stone entered largely into the construction of the temples of Upper Egypt and its colossi, for which purpose it was usually quarried at Hadjar Silsilis, a little to the north of Syene, in immense blocks. The colossal statue of the vocal Memnon was hewn from this rock, and many of the sphinxes that line the dromos of the temple of Carnac.

Age.—Ehrenberg* thought this sandstone formation identical with the Quader-sandstein of German geologists, and Russegger † with the Keuper, and the *marnes irisées* of French geologists; but until farther information be obtained regarding its organic remains, and those of the marine limestone above it, we must hesitate to class it with any known European formation, though in mineral character, and its saliferous and gypsiferous nature, it certainly resembles our new red sandstone.

Marine Limestone: Geographical Extent.—In conformable stratification, overlying the sandstone, extensive beds of marine limestone (*d*, fig. 1; 3, fig. 2) cover the greater part of Egypt, from the vicinity of Esneh on the south (lat. 25° 10′ N.) to below Cairo (lat. 30° 2′ N.) on the north; and, with some interruption from the intrusion of plutonic and hypogene rocks which rise from beneath them near Syene, and the centre of the Egyptian desert, stretch from the west shore of the Red Sea, across the valley of the Nile into the Libyan wastes, thus constituting, for the greater part, the basis of both deserts. From an examination of the cliffs on the eastern shore of the upper part of the Red Sea, and the similarity of the fossil and mineral character of the two rocks, I am inclined to think that the strata were once continuous over this gulf, extending to the base of the plutonic axis of Sinai, and far into the Arabian desert.

* Lond., Ed. and Dub. Phil. Mag. vol. xviii. p. 394.

† Bulletin de la Société Géologique, vol. x. pp. 144,

The dip varies in different localities, being considerable (32° in the valley of Kossier) in the vicinity of the plutonic rocks, but hardly perceptible on the banks of the Nile. It is usually more inclined on the shore of the Red Sea, owing to its greater vicinity to the plutonic belt. The direction of dip also varies: in the valley of Kossier, for instance, it is to the east and west of the anticlinal ridge, but its general direction is decidedly northerly.

Lithological Character and Economic Uses.—The upper beds of this great limestone region abound with nummulites, and differ lithologically from the lower, being generally of a hard, compact, waxy texture, and of a buff or fawn colour. They are often singularly honeycombed, as at Gebel Ataka, as if the substance of the imbedded shells had dropped out, or been absorbed by the rock. The limestone is often siliceous, and sometimes probably contains magnesia, effervescing feebly with acids. The lower beds have a cretaceous aspect; but whether the lithological distinction I have attempted to draw will be borne out by a more minute examination of the fossil contents of the beds remains to be proved. The lower strata are usually white, of an earthy chalk-like texture, imbedding nodular and tabular layers of chert, as in the vicinity of Thebes and Bir Anglaise. These layers range in regular succession from a foot and upwards asunder. The nodules are often covered with a white siliceous powder or coating, sometimes containing muriate of soda; and this siliceous powder enters largely into the composition of the earthy limestone. Besides chert, Egyptian jasper and agate, occasionally replacing the chert, these beds contain layers of earthy and crystallized sulphate of lime, muriate of soda, calc spar, arragonite, rock crystal, large deposits of the beautiful variety of stalagmite called Egyptian alabaster*, and stalactitic caverns†. The lower portions are interstratified with beds of faint greenish and light brown marls used in pottery, and for purposes of washing by both modern and ancient Egyptians. The more indurated portions are used as whetstones. Among other minerals, sulphate of barytes is said to occur in the limestone near Cairo. Lead ore (galena) was found in it at some old mines about thirty miles north and about a similar distance to the south of Kossier, in combination with silver, by Mr. Burton; crystallized sulphur, and nodules of carbonized vegetable matter, occur in the specimens of limestone

* The principal quarries of this beautiful mineral, so much used in the manufacture of antique vases, are situated in the eastern desert near Teb el Amara, in about 27° 43′ N. lat. The modern quarries lie in the Mokattem, about eight hours' distance from Benisuef. The mineral here presents layers of a faint translucent pink or amber colour, alternating curvilinearly with others of a pure opake white and of less thickness. The fracture of this mineral is between granular and splintery, obscurely conchoidal; and effervesces with acids. It is quarried in masses large enough for columns of considerable size, and has been lately largely employed by the Pacha in lining his baths, for the pillars of the magnificent new mosque at Cairo, and the fountain in the great square at Alexandria.

† The calc sinter found in the roofs of the caverns, for instance near Memphalút, affords the whitest alabaster of Egypt. The translucent sarcophagus brought by Belzoni to Egypt is composed of arragonite. These caverns, with their stalagmitic bottoms, afford an almost untrodden field for the geologist. It is probable they are rich in fossil bones.—Wellsted's Travels, vol. ii. p. 123.

presented to the Society by that gentleman from the vicinity of the petroleum deposits of Gebel Ezzeit, and also iron ore. It is not however clearly ascertained whether the specimens from Ezzeit belong to the limestone under consideration, or to the more recent formation. Captain Moresby found a hill abounding in sulphur within the limestone limits near Myos Hormus.

Organic Remains in the Limestone.—After a series of laborious researches, Ehrenberg* has concluded that the compact limestone rocks which bound the Nile in the whole of Upper Egypt (*i. e.* the lower beds of the limestone formation), and extend far into the Sahara, or desert, as well as the compact limestone rocks in the north of Arabia, are, in the mass, composed of the animalcules of the European chalk. The result of an examination of the chalk of Brighton and the limestone of Egypt showed that the principal microscopic forms in these rocks consist of 25 species of calcareous-shelled Polythalamia, 39 species of siliceous-shelled Infusoria, 7 species of soft-shelled Infusoria of the flints, and 5 species of siliceous plants. None of the forms of Polythalamia now living in the Red Sea are found among the animalcules of the chalk or limestone of Egypt and Arabia. It need hardly be observed, since the discoveries of Mr. Lonsdale, D'Orbigny and Tennant, that the existence of similar Polythalamia in the Egyptian rocks does not go to identify these beds in point of geological age with the European chalk.

Ammonites are stated by Clot Bey to be found in the limestone near the Pyramid†.

Lefevre‡ states that Echinites identical with those of Matta have been found at Esneh ; and Hippurites, Placuna, Vulsella and fossil fish, near Cairo, to which may be added Nautili of large dimensions, corallines, crabs, fishes' teeth and nummulites. There is a large bed of *Ostrea carinata*? between Kossier and Thebes. Mr. Nash§ found Cardia and a Turritella in the same locality, and states the flints in the limestone there to be all fossil sponges, Alcyoniæ, &c. The so-called Egyptian jaspers and agates, which occasionally replace the chert, have been pronounced by Mr. J. Bowerbank|| to be destitute of spongeous remains. He ascertained that they consisted of small, irregular, light-coloured grains imbedded in a banded semi-transparent matrix of silica, in a state very much like that in which it exists in chalk flints and greensand cherts, and that they contained vast numbers of Foraminifera, unequally distributed through the layers composing the agate, closely resembling those found in chalk flints, and often difficult to distinguish from the species found in the Grignon sand of the Calcaire grossier. In many of the variegated Egyptian jaspers the organic siliceous elements are no longer to be distinctly found, a fact ascribed by Ehrenberg¶ to the circumstance of their

* Lond., Edin. & Dub. Phil. Mag. vol. xviii. pp. 384, 389, 444.
† Aperçu Générale de l'Égypte, vol. i. p. 144.
‡ Bullet. Soc. Géol. de Paris, vol. x. pp. 144, 234.
§ Edin. Phil. Journ. vol. xxii. pp. 45–47.
|| Proc. Geol. Soc. of London, vol. iii. pp. 435, 436.
¶ Lond., Edin. & Dub. Phil. Mag. vol. xviii. pp. 395, 396.

intermixture with other substances, and their consequent opacity, giving rise to dendritic and other delineations. It seems, he goes on to say, as if the solution and conversion of the organic into the inorganic in the Egyptian pebbles, is throughout more perfect than it is in many flints, although the constituent elements of both kinds of stone are very probably quite the same.

Previous to passing to a notice of the organic contents of the limestone, I may briefly notice some singular siliceous bodies that occasionally occur imbedded in it, and are particularly numerous in the limestone rocks of Thebes on the Libyan bank of the Nile. They cover the debris at the foot of the cliffs in such profusion as to be termed by the Arabs *nuktah*, or drops, which they suppose to have been rained from heaven. They are also seen there *in situ*, disposed conformably in a horizontal layer of whitish marl in the earthy white limestone, which abounds with thin seams of crystallized gypsum, muriate of soda, and calc spar. These bodies usually assume the shape of spheroids encircled by a belt, resembling the delineations of a planet with its belt; two are sometimes connected together, while others assume various modifications of form. They have a thin whitish coating, and in the interior present a greyish or brownish chert, like the ordinary nodular chert already described. Ehrenberg*, who has lately examined these siliceous spheroids, terms them ocellated stones, or morpholites; he found no traces of organic structure, and is of opinion that they are the result of a crystalloidal or morpholitic force. Their structure does not present radiation from the centre; nor any appreciable crystalline development in their parallel planes of formation founded on uniform laws, which frequently, perhaps always, parted from many axes of formation. In the curious structure of these bodies Ehrenberg discovered foreign bodies, small stones, fragments of granite, &c.

Economical Uses of the Limestone.—It is remarkable that most of the earliest monuments of Egypt reared by human hands should be composed of this limestone, a formation, geologically speaking, but of yesterday. Most of the older temples, grottos, and tombs in Central and Lower Egypt—the great Sphinx and the Pyramids themselves—were formed of it. Soft and sectile, like the Portland stone, in the quarry, it hardens rapidly on exposure to the air and the sun's rays.

Upper or Overlying Sandstone (fig. 1, *b*; fig. 2, *a*).—A sandstone formation, associated with calcareous, gypseous, and saline marls, in horizontal layers, overlies the limestone just described in detached hummocks and patches stretching from the Mediterranean far into the Nubian and Libyan deserts, and has been traced into Abyssinia†. The discontinuance of its beds has evidently been caused by denudation, the softer portions having been swept away, and the debris scattered over the desert; while the more consolidated beds are left standing, as at Gebel Ahmar, near the petrified forest near Cairo, and are washed into abrupt, irregular, and fantastic shapes.

Lithological Character.—The sandstone varies from a compact crystalline rock of a blood-red, white or yellow colour, to a loose quartzose

* Edin. Phil. Journal for April 1841, pp. 356, 357.

† Lefevre.

grit and conglomerate, imbedding rounded and angular pebbles usually of a siliceous nature, viz. quartz, chert and jasper, and derived principally from the subjacent limestone. The cement agglutinating the grit is usually siliceous and ferruginous, mixed with decayed felspar, and sometimes lime. In many localities it imbeds silicified trunks and fragments of trees, particularly near Gebel Ahmar near Cairo, and Wadi Ansari, about eight hours' journey to the eastward. In this vicinity I observed in it casts of pelagic shells. Lefevre has traced it into the Bayúda desert, where it also contains silicified wood, and is composed of grains of quartz and rounded fragments of the sandstone, and felspathic rocks on which it rests.

The specimens of wood which I brought from the locality near Cairo were kindly examined, at my request, by Mr. Robert Brown, and all those which could be determined were pronounced to be dicotyledonous, and not coniferous; but a specimen of the latter was brought from Abusambel, by the Rev. Vere Monro*; and I observed another, of a reed, in the collection of Mr. R. Brown. A more detailed account of the fossil wood will be given in a subsequent part of this paper.

The beds of this sandstone are usually very thin, varying from a few inches to 180 or 200 feet in thickness. The associated marl-beds rarely exceed ten feet, and are often much thinner. They are of various shades of white, brown, and green; and, as before stated, are of an argillaceous, calcareous, and gypseous character. Those covering the great platform of the Libyan desert, from the Mediterranean to the Oasis of Ammon, are said by Ehrenberg† to contain known tertiary forms. They enclose layers of crystallized carbonate and sulphate of lime; the latter, as in European rock-salt formations, is associated with muriate of soda. These substances, acted upon by water and the atmosphere, afford the necessary chemical conditions for the natural production of muriate of lime, carbonate and sulphate of soda, which are found in the natron lakes that occur in this formation. The most celebrated are the six lagunes on the northern and eastern flank of the Waterless river, about fifty miles in a direct line south from Alexandria, and twenty-six from the western branch of the Nile. They present a chain of shallow pools, formed by water which percolates through the marl and sands on their banks, and is usually tinged of a red colour by a substance of which an accurate analysis is desirable. It is supposed to be of a vegeto-animal nature. The red water, in the hot season, has a highly fetid, ammoniacal odour, and a caustic alkaline taste. As the water evaporates, during the hot season, the newly-formed salts (except the portions that remain held in solution) are deposited in incrustations on the sides and banks of the lagunes, and collected.

From the circumstance of the supply of water in the natron lagunes varying with that in the Nile, it has been supposed that their beds are at a lower level than the river, and even below the surface-level of the Mediterranean, a fact however still to be ascertained.

* Edin. Phil. Journal, vol. xviii. p. 337.

† London Phil. Mag. June 1841, p. 445.

Economical Uses of the Sandstone.—The rock in the vicinity of Cairo has been quarried for ages past for grindstones. The more compact varieties have been lately employed by the Pacha for macadamizing the open squares of his palaces.

Calcareous Conglomerate.—Previous to passing to the tertiary beds on the shores of Egypt, I shall briefly mention a calcareous conglomerate which I found reposing horizontally on the inclined limestone of the Gebel Ataka range, skirting the shore of the Red Sea below Suez, at about 300 feet above the level of the sea. From the similarity of its imbedded pebbles, and position on the limestone, it may be probably referred to the overlying sandstone formation just described, though no silicified wood, nor pelagic remains, except such as had been derived from the subjacent limestone, were seen in it.

Post-Pleiocene: Extent and Position.—Around the head of the Gulf of Suez, and between the Red Sea and the cliffs that skirt its western shore, runs a fringe of elevated coast-land, rising in some localities to the height of sixty feet from the level of the ocean, and from four to five miles in extreme breadth. At a few points, however, the fringe is interrupted by the cliffs sweeping down to the water's edge. This coast has for its basis calcareous and gypseous marls, a loose calcareous sandstone and a coralline limestone, abounding with fossil shells, Echinidæ, Asterias, spines of Cidaris—all of recent species according to Mr. Lyell *, and agreeing in every instance with those now living in the Red Sea. Several towns, among others Kossier, stand on this coral reef, which, it is evident, must have been elevated subsequent to the Pleiocene period. It is more than suspected, from the obliteration and shallowing of harbours, known to have been deep in ancient times, that this elevating process is still in slow though gradual operation. It is worthy of remark, that though traces of volcanic agency are visible in the sulphuriferous rocks of Ezzeit, its petroleum wells, the hot springs of Hummam Feráon, and Tor on the opposite coast, the still active volcano of Gebel Teer, and the lavas of Aden, earthquakes are almost unknown in the history of Egypt;—I say almost, because it has been asserted that the vocal statue of Memnon was thrown down and broken by the shock of an earthquake.

The question however naturally occurs to the traveller, on casting his eyes on the unbroken form of its brother colossus only a few paces distant, why did not this statue share a similar fate? From the erect position of the pyramids, obelisks, and temples of ancient Egypt, and the little disturbance visible in the uplifted beds, it may be inferred that the forces which effected the upheaval of the shores of the Red Sea were exerted in a gentle and gradual manner. Many have supposed that the Isthmus of Suez, now dividing the Mediterranean and Red Seas, has been recently formed either by a process of submarine elevation, or by drift; but the great difference existing in the group of fishes, testacea and zoophytes inhabiting the two seas, though only distant seventy miles, militates strongly against such a theory. Ehrenberg† states that it appears probable that

* Principles, vol. iv. pp. 39, 40, 4th edition.

† Lond., Edin. and Dub. Phil. Journ., vol. xviii. pp. 380, 444.

the Red Sea, and the part of the Mediterranean so nearly adjoining on the Libyan coast, possess only two forms in common out of the 120 species of Anthozoa, viz. *Actinia Tapetum* and *A. Mesembryanthemum*; and he remarks, that among living genera of corals of the Red Sea, that of *Strombodes* excites peculiar interest, having previously been found only in the fossil state. It affords a key to the structure of the remarkable Cyathophylla, differing from the view hitherto entertained, and rendering it quite clear that the internal central star of the encased forms is not a young one, but the oldest, or mother-star, which is often surrounded by broad radiated mantle-folds, productive of buds. Out of fifty-four new species of Polythalamia derived from the two seas, twenty-seven are peculiar to the Red Sea, and seventeen only are common to both. On the other hand, the *Rotalia Beccarii*, which composes the Italian hills, only occurs singly, and very rarely in the Red Sea, and was nowhere found on the Libyan and Syrian coasts.

Recent Rocks in process of formation.—On the shores of the Red Sea and Mediterranean a rock-formation is still in progress, composed of sand, gravel, corallines, fragments of older rocks, weed, bits of wood and pottery washed up by the sea, and cemented together by carbonate of lime slightly coloured by oxide of iron. The stone thus formed varies from a loosely-agglutinated conglomerate to a light brown, compact travertin. It occurs from an inch to 3 or 4 feet in thickness, and sometimes alternates with thin, loose layers of shingle. On the west shore of the Red Sea I have observed it at five or six feet above the high-water level, overlying the raised coral beach. It sometimes encloses bones of camels, fish, &c., still containing animal matter. A considerable deposition of carbonate of lime appears to be at present going on in certain parts of the Mediterranean and Red Sea. At Alexandria, in the Saracenic fort of the Pharos, in 1840, I observed an old iron cannon, coated with rust, which, I was informed, had not many years back been dragged up from the bottom of the sea in the harbour. The bore, which was of considerable calibre, had been filled up with a compact, travertin-like limestone, coloured and hardened with the oxidized iron of the interior of the gun, which had become so corroded and intimately blended with the carbonate of lime as to assume the appearance of perfect fossilization. On the shores of Sicily, Greece, Asia Minor, and of Aden, near the Straits of Babelmandel, I have remarked similar marine calcareous formations in progress; and at Rhodes, six feet above the present high-water mark, I observed a calcareous conglomerate imbedding fragments of ancient pottery, shells, and littoral pebbles of scaglia limestone, gneiss, basalt, serpentine, and porphyry.

In the valley of the Nile, on the plain of Benihassan, myriads of nummulites, washed from the overhanging limestone cliffs, are partially re-cemented together by calcareous matter deposited by drainage- and spring-water, and alternate in horizontal layers with clay, sand, and gravel, having an aggregate thickness in some places of upwards of 30 feet. In the valley of Kossier, near the sea-coast, beds of gravel and detritus are in process of being cemented together by iron and lime deposited by infiltration from drainage-water, which derives the calcareous matter with which it is charged from the limestone rocks it passes over: portions of the gravel so agglutinated resemble a hard pudding-stone.

In several places, resting immediately on the calcareous cliffs skirting the Mediterranean between Alexandria and Aboukir, near Cæsar's Camp, I observed a bed a foot thick of bleached human bones, derived from the ancient Roman and Greek cemeteries, intermingled with the bones of those slain in the various modern sanguinary conflicts that have taken place among the neighbouring sand-hills. The bones are covered by a layer of sand and gravel, varying from a few inches to 3 or 4 feet in thickness. They appear to have been washed into their present position by the drainage-water running from the higher grounds to the sea, and, though in an excellent state of preservation, are not fossilized. The superincumbent sand and gravel has in some places been agglutinated, together with fragments of ancient buildings, by carbonate of lime and ferruginous matter deposited by the drainage-water.

Drift and Erratic Detritus.—The saline sands and gravel that constitute the deserts of Egypt, overspreading all the stratified formations, appear to have been deposited on a sea-bottom, as they cover marine formations. Pelagic remains have been found imbedded; and according to M. Linant, fossil bones: but it has not been clearly ascertained whether the former have not been derived from the subjacent fossiliferous rocks. This drift and detritus not only fill up chinks and hollows in the rocks below, but cover the tops and sides of mountains. In many places the pebbles composing them have been transported from considerable distances; for instance, the gravel beds from 1 to 10 feet thick covering the raised coral beach of Kossier, and the limestone cliffs of Abu Mungára skirting the Red Sea near the Jaffatine group, and the drift resting on the elevated platform of the Libyan desert near Dendera. In all these localities the gravel consists of rolled pebbles of the distant plutonic and metamorphic rocks, mingled with those from the rocks in the vicinity, such as quartz, chert, jasper, agate, silicified wood, &c. At Abu Mungára I observed a pebble of reddish marble, resembling that of Verona, with imbedded crystals of sahlite. From the great quantity of rolled, and partially rounded, fragments of silicified wood found scattered in the desert sands, I am inclined to believe that much of the detritus composing them was derived from the subjacent sandstone, whose continuity has been greatly impaired by denudation, as already stated, and in which the silicified wood is invariably found imbedded. It is further worthy of remark, that though beds of gravel and sand transported from great distances are not unfrequent (pebbles from the rocks of Upper Egypt and Nubia are found near the Mediterranean in the valley of the *Bahr bila Maieh*), still the nature of the composition, and sometimes the colour of each particular portion of the desert, is generally much influenced by the character of the rocks in the immediate vicinity. The sands of the Nubian desert, where granite and sandstone abound, are granitic and siliceous; and, according to the observations of Ehrenberg*, destitute of the

* Lond., Ed. and Dub. Phil. Journ. vol. xviii. pp. 385, 386.

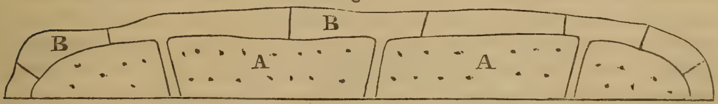
Bryozoa, or coral animalcules; which, though very small,—resembling grains of sand,—are yet, for the most part, larger than the chalk animalcules. Those singular beings constitute a large portion of the sand of the Libyan desert, and may perhaps be regarded,—should they be distinct, which M. Ehrenberg seems to suppose, from the animalcules of the calcareous rocks on which the sands repose,—as additional proofs of the submarine origin of the sands and gravel of the desert.

Volcanic Rocks.—Though the existence of thermal springs,—some of them containing sulphuretted hydrogen,—the petroleum wells and sulphur deposits of Ezzeit, E-gimseh, and Gebel Kebrit, denote the continuance of igneous action below the surface, in a line following the volcanic belt of the Red Sea, indicated by the outbursting of Gebel Teer and Aden, the absence of earthquakes proves that, within the historic period at least, this energy has not been exerted with violence.

M. Rochet d'Hericourt* informs us that he has noticed two old extinct volcanos in the desert between Cairo and Suez, and some small upheaved mounds of volcanic productions near Gebel Ahmar, on the Suez route: and Mr. St. John† states, that in the vicinity of Dakkeh, about 69 miles from Syene, in the Nubian desert on the left bank of the Nile, are numberless black cones, some higher than Vesuvius, supposed to be extinct volcanos, and covered with cinders and lava. But as yet our information of the nature and relations of these supposed volcanic tracts is of a meagre and undecided character.

Trap Dykes.—Dykes of augitic trap of the variety termed dolerite, sometimes imbedding iron pyrites, are seen within and on the borders of the plutonic and metamorphic area of Upper Egypt, penetrating all the rocks from the lower sandstone to the granite. The overlying sandstone is undisturbed, and sometimes contains imbedded pebbles of the trap, the relative age of which is hence determined. Its intrusion among the lower sandstone beds and clay-slate is marked near the junction-line by their conversion into jasper and jaspideous rock; and among the limestone rocks, by the formation of chert and agate, and a general tendency to silicification. Serpentines passing into verde antique are met with in the area just mentioned; but may rather be classed here with the hypogene series, to which they are confined, than with the trappean. Porphyritic dykes traverse the granite, consisting of felspar crystals in a reddish felspathic base. A black variety also occurs resembling melaphyre, its base being black augite with crystals of felspar. Between the plain and pass of Abu Zeyran between Kossier and Thebes, I observed dykes of a rock almost entirely composed of red felspar, imbedding dark brown shining crystals, penetrating and overlying a boss of granite, as shown in the annexed diagram, fig. 4.

Fig. 4.



A. Granite boss. B. Felspathic rock.

* Proc. Geol. Soc. of London, June 14th, 1841.

† Travels in Egypt.

Porphyry is said to occur at Gebel ed Dokhan in the eastern desert opposite Memphalút.

Economical Uses of Porphyry, Trappean and Serpentine Rocks.—Many of the vases and sarcophagi of the ancient Egyptians are composed of porphyry. Of the serpentine, verde antique and basaltic trap, scarabæi and other smaller articles of Egyptian sculpture are cut. Large statues of basalt are comparatively rare: a few of the largest may be still seen amid the ruins of Carnac. A dark-coloured granite has been mistaken for basalt.

Plutonic Rocks.—Granitic rocks occupy but a small portion of the superficies of Egypt, appearing at the cataracts of Syene and in the desert, where they constitute the anticlinal axis between the Nile and Red Sea, in the latitude of Kossier (about 26° N.). According to Mr. Trivin,* granite is seen farther north in the same desert, associated with porphyry about the latitude of Benisuef (29° 10′ N.), a locality which he thinks may have supplied the ancient Egyptians with materials for many of the monuments of Lower Egypt. Savary† mentions quarries of granite and marble between Benisuef and the convents of St. Antony and Paul, toward the north of the plain of El Araba; which probably are identical with the locality noticed by Mr. Trivin. Mr. Wilkinson has traced it to lat. 28° 26′ N., where it occurs in the peak of Gebel Tenaset, rising among the limestone rock not far west of the range that skirts the Red Sea. He states the extreme height attained by the granite in Gebel Gharib, lat. 28° 20′ N., at 5000 feet above the sea. The islands of Philæ and Elephantine near the first cataracts are almost entirely composed of granite, which thence extends into Nubia associated with greenstones, porphyries and metamorphic schists. It is penetrated by dykes of porphyry, trap, felspar, and eurite, passing into a small-grained granite.

Relative Age.—With respect to its age, the granite must have been elevated to the surface at a period subsequent to the deposition of the inferior sandstone and limestone rocks, which rest on its flanks in inclined strata, and prior to that of the superior horizontal sandstone. From the occurrence of breccias along the junction-line with the former rocks, and the entire absence of veins of granite penetrating them, and of effects of heat, it may be suspected that this plutonic rock was upheaved in a solid form through once-continuous strata of sandstone and limestone, and subsequently laid bare by denudation. I carefully examined the latter rocks for imbedded granite pebbles, but without success. It penetrates the gneiss in veins.

Lithological Character.—Lithologically speaking, the granite of Egypt passes into pegmatite and all the varieties termed syenitic, porphyritic, close-grained, grey and red. That from the celebrated quarries of Syene is usually a large-grained crystalline variety,—composed of crystals of pale red felspar, white transparent quartz in grains, dark scales of mica, and a few scattered crystals of hornblende. The granite of Egypt is freer from the decay, the *maladie du granite,* than that of India, arising probably from the peculiarly dry atmosphere of Egypt, which has been mainly instrumental in preser-

* Travels, vol. ii. p. 41.

† Egypt, vol. i. pp. 530–1.

ving almost in their original freshness, its magnificent sculptures and vivid frescos. Schorl, black and green, and actinolite are minerals occasionally found in the granite of Upper Egypt, as well as the chrysoberyl. Native gold* and iron ore are found near its junction with hypogene schists, in the Beshariyeh hills about ten days' journey in the eastern desert from Edfou.

Economical Uses†.—Most of the colossal statues, sarcophagi, columns and obelisks of the ancient Egyptians were quarried from this rock at Syene; and it was likewise applied to lining both the exterior and interior of the pyramids.

Alluvial Soils: Classification and Extent.—The alluvial soils of Egypt may be divided into four classes: 1st, the mud of the Nile and delta; 2nd, the soil of the Oases, resulting principally from the successive decay and reproduction of vegetation mixed with sand and marl; 3rd, detrital soil of circumscribed extent washed down from the rocks; and 4th, a greyish soil, which is found generally around the ruins of old cities; the result of decayed animal and vegetable matter, mixed with fragments of limestone, mortar, and other debris of the crumbling buildings. The nitric acid, disengaged from the animal matter combining with the vegetable or mineral alkalis, forms impure nitrates of potash, soda and lime. Both ammoniacal and nitrous salts are formed in certain places in the desert where camel-caravans usually halt; their presence is denoted by dark moist-looking patches on the surface, caused by the deliquescence of these salts, which have from the earliest times been collected and purified by the Egyptians.

Nature of the Mud of the Nile.—The mud of the Nile, as has been observed already of the sands of the desert, is slightly modified in character at various localities, according to the nature of the formation over which the Nile flows during its course to the sea. Above Thebes, below the granite and sandstone formations of Nubia, and on the southern limit of Egypt, it contains more silex and less calcareous and argillaceous matter than at Cairo and the delta, which are situated on the great limestone formation. The mud of the Nile is not the result of the spoils of Abyssinia alone, and hence, perhaps, the discrepancy of the analyses we possess of it. That of Regnault‡, which appears to have been the most minute, is as follows:—

Water	11
Carbon	9
Oxide of iron	6
Silica	4
Carbonate of magnesia	4
Carbonate of lime	18
Alumina	48=100.

* Gold-mines, according to Agatharcides, quoted by D'Anville, exist in the Ataka range on the coast of the Red Sea, about lat. 22° N., but the nature of the formation is not stated.

† For details regarding the method of quarrying this rock and its sculpture, *vide* my paper on this subject read before the Royal Asiatic Society.

‡ Regnault, Mémoires sur l'Égypte, tom. i. pp. 348, 382.

Girard's analysis gives one-fourth of carbonate of lime; but the localities from which the specimens examined were obtained are not specified,—a point that should always be attended to. At Thebes, the spangles of mica derived from the granites of Nubia and the first cataract were perfectly distinct to the naked eye; but at Adfeh in the delta they were less numerous, and so comminuted as to be barely discernible with the aid of a lens.

The composition and texture of the mud is also subject to variation from its proximity to, or distance from, the main channel of the stream, where the coarser, heavier and more siliceous particles are usually found; while the finer and more argillaceous portions are held in suspension, and carried out laterally towards the edges of the deposit by the gently overspreading waters. At particular points on the river's course, where the inclination of its bed is great, and the current consequently rapid, as at the cataracts, the alluvium consists only of the very heaviest portions of transported detritus, mingled with the debris of the subjacent rocks; and *vice versâ*, where the inclination of the river's bed is least, there we find the finest and most fertile deposit. It is a simple though remarkable truth in physical geography, that, had the surface of Egypt attained, in its upheaval from the waters of a former ocean, a greater inclination towards the Mediterranean, that fertile mud, which exerted so wonderful an influence upon the habits of the ancient population it attracted to the banks of the Nile, and which formed the foundation, the bed in fact of this ancient cradle of civilization to the modern world, would have been swept away, and buried beneath the waters of the sea,—useless at least to the races of mankind dwelling on the earth's surface under existing conditions.

Few pebbles or detritus of any size are found in the mud of Lower Egypt and the delta; and, as may be supposed, nothing but its finest and lightest ingredients escape into the Mediterranean, where I have observed the sea discoloured by them to the distance of forty miles from the shore.

The northerly or Etesian winds that blow from the sea, varying a little to the E. and W. of N., nearly nine months during the year, (commencing by a curious coincidence with the inundation—about May,) by retarding the downward freshes, contribute materially to prevent the mud's escaping to the Mediterranean, and to throw it upon the land. Added to this, these winds check the current at the estuaries of the Nile by raising up the waters of the Mediterranean: hence, as the result of the opposing waters, are formed the banks of sand and mud by which some of the ancient embouchures have been silted up, causing the chain of back-waters and marine lagoons that fringe the present coast, in some of which we see alternate deposits of land and fluviatile testacea with marine remains, caused by successive inroads of the sea after it had been silted out at intermediate periods of less or greater duration.

Striking evidence of the power of these winds in raising the waters of the Mediterranean on the coast of Egypt is afforded by General

Andreossy, who states* that, after they cease to blow, the sea falls back, leaving a shore of about 200 metres wholly uncovered.

The mud of the delta has been found to imbed human bones at considerable depths, remains of persons drowned in the extraordinarily high inundations to which the Nile has always been occasionally subject. These remains would have been of less rare occurrence had it not been a law† among the ancient Egyptians to take up, embalm, and inter the bodies of individuals drowned, and cast up by the Nile. Near the mouths of the Nile the alluvium is mingled with marine sand, and imbeds existing shells of the Mediterranean with terrestrial and fluviatile testacea. Rolled pebbles, but of small size, derived chiefly from the plutonic and igneous rocks,—jaspers, agates, &c.,—are found in it in Upper Egypt.

The finer kind of the mud of the Nile, for instance that of Ghennah, is, generally speaking, of a dark brown colour passing to lighter shades, highly tenacious and retentive of moisture, for which it has a great affinity; it effervesces with acids, and fuses *per se* with gaseous extrication into a greenish glass. It is deposited in regularly stratified, annual layers, varying from an inch to a few lines in thickness in the same situation. The upper part of each layer is of a lighter colour in general than the lower, and each layer is separable from that immediately above or below it. Exposed to the calorific action of the sun's rays, the surface-layers separate horizontally and peal off in curling laminæ, and the contracted mass is intersected by deep vertical fissures, which divide the superficies into shapes usually resembling the hexagon or pentagon. A similar phænomenon is presented by the Indian *Regur*, or black cotton soil. According to Ehrenberg, the mud of the Nile contains an immense number of animalcules.

Thickness of Nile Mud.—I am not aware that the thickness of the deposit in the centre of the river's bed has actually been ascertained; but I have measured cliffs of it overhanging the Nile at low water, in Upper Egypt, at 40 feet above the water's level; in Middle Egypt they average 30, and at the apex of the delta 18 feet. Sir G. Wilkinson‡ found that in Upper Egypt, at Elephantine, the deposit had increased, during the last 1700 years, 9 feet; at Thebes, 7 feet; at Heliopolis, in Central Egypt, 5 feet 10 inches, diminishing in a more rapid ratio towards the delta and Mediterranean: it appears evident therefore that, as a general rule, the deposit is thickest in Upper Egypt. It must however be remarked that, at particular places where the stream is retarded by the flatness of the country, or from other causes, the deposition is greater than at other localities. The deposition of one year is frequently stripped off by the flood of the next; the amount of one year's deposition varies from that of another, while the shifting of the river's bed from time to time renders this fluctuation of amount of deposit still greater, and

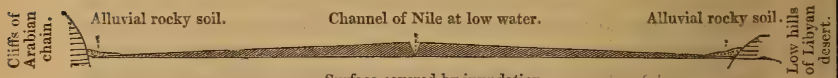
* Memoirs relative to Egypt, p. 200.
† Herod. Euterpe, 90.
‡ Journal of Royal Geograph. Soc. of London, vol. ix. p. 332.

farther removed from the reach of calculation. Near the edges of the alluvium, the sands of the desert, on the west bank of the Nile more particularly, are blown upon, and intermingle with, the deposit thrown down by the river. Hence the uncertainty of all calculations on the progressive rate of the increase of soil generally throughout Egypt within given periods of time, and grounded on the rate of its actual accumulation around the bases of certain buildings, statues, nilometers, &c., in particular localities. It may be added too, that the alluvium around the bases of most of these monuments has not remained undisturbed during its progressive increase for the last 3000 years by the annual plough or spade of succeeding generations of cultivators; nor has it, in most cases, been proved at what period the Nile actually reached these bases, whence the progressive amount of deposition must be dated, and not before.

Upon such uncertain data the French savans under Napoleon calculated the progressive vertical rise of the soil throughout Egypt at about four inches per century.

From the circumstance of the deposit being greater near the stream's channel than at a distance on each side, it presents a raised bed, the most elevated portions of which are not under water at high Nile, and of which the following diagram (fig. 5) may serve to convey an idea.

Fig. 5.



Gradual Extension of Nile Mud.—Judging from the thickness of the annual layers exposed in cliffs of Nile mud, of which I have counted upwards of 900, the amount of alluvium annually deposited has not varied in the aggregate for the last 1000 years, and it is highly probable that both the periods and amount of the inundations have not suffered any material change since the present physical conditions of the country were established. It is clear therefore that the surface, which the waters overspread, must be gradually elevated by such periodical depositions; and, as the surface rises, the level of the inundations must rise also, and continue to overspread, where not confined by vertical banks, a superficies gradually increasing with the amount of matter deposited by the floods.

Similar difficulties exist in attempting to calculate the progressive rate of the increasing superficial extent of alluvium throughout Egypt, as in determining that of its vertical rise; added to which, the effects of the drifted sands from the Libyan desert in curtailing its apparent limits, to be alluded to in the concluding portion of this paper, are to be satisfactorily ascertained and taken into consideration.

That such a progressive vertical and horizontal increase does actually occur, has been clearly proved by Sir G. Wilkinson* from the fact of the inundations now covering to some depth the bases of statues, &c., known at certain periods of history to have been be-

* Journal of Geograph. Soc. of London, vol. ix.

yond their reach, and from the inhabitants of the valley of Egypt having been obliged from time to time to raise their towns. They omitted however to raise their ancient nilometers correspondingly with the rising level of the alluvium at their base; hence the greater apparent height marked upon them by the inundation at present than formerly.

During the lapse of ages, the natural consequence of this slow heightening of level, in the lower parts of Egypt, will be to throw a greater depth of water into the upper parts of the river, which may in turn become so much elevated above the low parts of the Libyan desert as to force the stream to seek a new channel, probably by the low levels of the *Faioom* and *Bahr bila Maieh* valleys, to the Mediterranean, in the vicinity of the Mareotis lake, imparting a new physical aspect to the sterile wastes of Lower Egypt.

A tendency of the river at certain points to shift its bed easterly, towards the basis of the Arabian cliffs, will retard the probable effects of the raising of its bed just contemplated.

On the east bank many of the interesting monuments of Koum Ombos have been swept away, and the rest appear to await a similar fate*. Farther down, on the same bank, the ancient stone and brick quay at Luxor, and the temple itself, are in great danger. The interesting ruins of Gou-el-Kebir have disappeared, partly from the encroachments of the river, and partly from the depredations of the natives. An old inhabitant of the present village pointed out to me, from the summit of the high mud-cliff now overlooking this part of the river, its former traditional channel, nearly a mile to the westward. This tendency in the bed of the river to shift easterly arises principally from the lower comparative level of the surface at the base of the Arabian cliffs, which are of a more precipitous and continuous character than those on the Libyan bank. The strong prevalent west and north-westerly winds not only exert a direct influence in throwing the mass of water in an east and south-east direction, but also continually force upon its western bank the drifted sands of the desert.

Some change of the bed is effected every inundation, by the alteration the latter causes in the mud-banks of the preceding year; high projecting cliffs of which, hardened and cracked by the sun, are often loosened and toppled down into the eddying waters of the rising stream with great noise, their component parts again to be held in watery suspension, and distributed over the surface of the soil. When passing down the Nile in July, our boat narrowly escaped being swamped by the swell succeeding the fall of one of these mud-slips.

Delta of the Nile.—From the physical conformation of the country between Cairo and the Mediterranean, including the delta and its marine basis, it is evident that it once formed an inland bay, which Herodotus† supposed to have been filled by the Nile with mud, and thus raised above the sea. It is clear, however, from the absence of any marine remains (except such as have been derived from the sub-

* Vyse, vol. i. p. 65. † Euterpe, 10 & 11.

jacent limestone) in the mud covering the middle and upper portions of the delta, which are found in it in abundance, mingled with fluviatile and land testacea, on its arrival at the Mediterranean, that the present alluvium must have been deposited, for the most part, on a surface previously raised above the ocean's level, probably by subterranean forces.

The bulging-out aspect of the present coast-line indicates, however, the operation of other causes in the raising and extending its lower portions. When we come to examine the coast-line of the delta, we find that the deposit brought down by the Nile forms but an insignificant component in its structure; and that this elevated fringe consists almost entirely of banks of marine sand thrown up generally by the conflicting currents of the river freshes and tidal wave, and of a recent marine limestone, in whose formation the Nile could have had no share.

Ancient Alexandria stood on the calcareous rock of the Libyan desert immediately inland of modern Alexandria, which stands on sand-banks and a recent marine limestone, on a site over which the water of the great harbour formerly flowed*. The city of Foah, which, at the commencement of the fifteenth century, was on the Canopic mouth, and now more than a mile inland, Rosetta, Nicopolis, and Taposiris, all owe their present inland position in great measure to the intervention of marine sand-banks†. Over these newly thrown-up sands, in some low situations, the waters of the inundations either flow naturally or are conducted by art, and by deposition contribute to the fertility and to the permanent increase of land.

The increase of soil, by the Nile, in the delta is much slower than in the valley of Egypt, being spread over a much greater extent; and it must be borne in mind that a very considerable proportion of what remains in suspension in the water, after passing through the valley of Egypt in slow and serpentine windings, is carried off into the Mediterranean.

Rise of the Delta under the Mediterranean.—The rise of the delta from fluviatile deposition under the Mediterranean cannot be rapid, as will be readily conceded from what has been said already; and, besides this, we must take into consideration the effects of the ocean current, which flows from the Straits of Gibraltar, in carrying away toward the east the light mud of the Nile. We are assured of the little tendency of the deposit to spread westerly by the fact of the soundings to the westward of Rosetta being on sand, while those between Rosetta and Damietta are on mud. The depth of the Mediterranean off the delta at a short distance is about twelve fathoms; it increases gradually to fifty, and then suddenly descends to 380, which Mr. Lyell‡ thinks is perhaps the original depth of the sea

* Appendix to Denon's Travels, English edition, vol. ii.

† Sir H. de la Beche has shown that the present inland position of Damietta, two leagues from the sea, gave rise to very exaggerated ideas of the rapid advance of the land, until it was found that the sites of the ancient and modern towns are not identical, the inhabitants of the former having removed inland, partly from fear of maritime invasion (Manual, Third edition, p. 70).

‡ Lyell's Elements of Geology, vol. i. pp. 441, 442.

where not increased by fluviatile deposition. With regard to the assertion that the islet of Pharos, which is now close to Alexandria, was a day's sail distant from the coast of Egypt in the time of the Trojan war, I perfectly agree with Sir G. Wilkinson in thinking that Homer in the term *Αἴγυπτος* alludes to the Nile. That Pharos was formerly at a greater distance from the main than at present, is a fact noticed by Lucan*, Strabo†, Ovid ‡, and Pliny §.

Sand Drifts.—The shores of Egypt, both on the Red Sea and the Mediterranean, a short distance inland, are in several localities studded with hills of drifted sand derived chiefly from the sand-banks thrown up by the sea. Similar hills are observed in many parts of the desert, particularly near the Mecca route from Cairo, and in the Libyan wastes west of the Nile, whence, at certain exposed points, blown by the north-west and westerly winds, they move easterly on the fertile valley of the Nile.

The inference of M. de Luc of the recent origin of our continents from the fact of these sand-drifts having arrived only in modern times at the plains of the Nile has been justly questioned by Mr. Lyell ||, principally because M. de Luc has not demonstrated that the whole continent of Africa was raised above the level of the sea at one period; for unless this point was established, the region whence the sands began to move might have been the last addition made to Africa, and the commencement of the said flood might have been long posterior to the laying dry of the greater portion of that continent. M. de Luc supposed the desert on the western bank of the Nile to have been once a land remarkable for its fruitfulness, and overwhelmed in more modern times by sands transported thither by the western winds, so that now the oases alone remain as vestiges. This theory has been ably combated by Sir G. Wilkinson ¶, from whom (while I concur with him so far that the sands only encroach where the accidental positions of the hills and neighbouring ravines admit, and chiefly on deserted towns, where formerly the constant attentions of the inhabitants prevented their being encumbered by them,) I must differ, when he asserts that there is no increase of this encroachment, and that it has not curtailed on the whole the limits of the land formerly under cultivation.

We must first consider the effects of the strong north-west and westerly winds that blow during nearly nine months of the year, constantly drifting sand towards Egypt from the great western deserts of Libya, and second, that since the time of the Pharaohs until the accession of the present ruler, the artificial checks** opposed to these inroads have been gradually diminished, owing to the wane of human industry, agriculture, and population. Both in Upper and Middle

* Pharsal. x. 509.

† Lib. i. pp. 63 al. 37, et lib. xvii. p. 1140 al. 791.

‡ Met. lib. xv. pp. 287, 288.

§ Lib. ii. 85; xiii. 11.

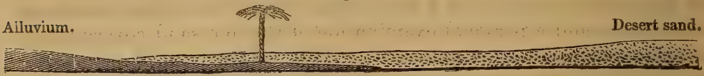
|| Principles of Geology, 4th edition, vol. iii. pp. 210, 211.

¶ Manners and Customs of the Ancient Egyptians, 1st series, vol. i. pp. 222, 223.

** Such as the planting of thickly-branching trees, the bushy tamarisk, the *Rāk*, or *Cissus arborea*, which by their roots and branches arrest the sand and collect it into a barrier.

Egypt I have seen trees apparently growing in the sandy desert, but which have been found to have their roots imbedded in the alluvium of the Nile below the drifted sand (fig. 6).

Fig. 6.



Many of the ruins of ancient Egypt, more especially those on the west bank of the Nile, have been covered with mounds of blown sand: the great temple of Abusambel was discovered by Burckhardt almost buried under a sand-drift, 31 feet of which were removed by Belzoni* before he could arrive at the entrance. The sites of Abydus, Memphis, Oxyrinchus, Bahnasa†, and the tract from Saccara to Abu Rehe, are now covered with sand; and its advance near Koum Ombos, Benisuef and Tapta is very evident. It has drifted so much‡ on the steep ridge on the western side of the Faioom, as to cover extensive ranges of desert mountains to such a depth that their rocky summits are the only objects perceptible in the undulating waste; and the plains and mountains near the ancient town of Dimay have been overwhelmed with this vast body of sand. At El Kerib, the supposed site of Hieracon, the mouths of the mummy-pits are completely closed with sand.

It has invaded the oases, and we are told by Henniker§ that the temple in that of Khargeh is nearly overwhelmed. The great Sphinx, which not thirty years back was disinterred from the drifted sand in which it lay buried up to the neck, is again covered to the shoulders.

It appears clear that so long as the prevailing winds continue to blow from the same quarter, or until the supply of sand from the great western desert becomes exhausted, the valley of Egypt must continue to suffer in an increasing ratio from the sand-floods, since the escarpments on its eastern limit present almost insurmountable natural obstacles to the further easterly progress of sand once lodged in it; and it would seem, from the rare mention of these sandy invasions in the old records of Egypt, that it anciently experienced less inconvenience from them than at present.

Many causes tend to retard this encroachment. Among these may be mentioned—the surface of the western desert, often rugged with ravines and cliffs, in and around which the sand collects and lingers for indefinite periods,—forming a barrier against its further progress; the stream of the Nile, which carries off the lighter particles that are blown into it or within its reach;—and the slowly increasing extension of the alluvium, as already noticed.

The numerous little whirlwinds that prevail, chiefly during the hot season, in the heated tracts bordering the Red Sea and the Nile have a considerable share in the transport of the finer superficial sands of the desert and the dusty alluvium of the river; they even carry up small marine, land and fluviatile shells, and seeds of plants, distri-

* Belzoni, p. 213.

† Denon, English edition, vol. i. p. 155.

‡ Vyse, vol. i. pp. 110, 168.

§ Travels, p. 187.

buting them over the surface of the land, and scattering them in the Nile, Red Sea and Mediterranean.

While navigating the centre of the Red Sea I have twice witnessed the deck and shrouds of the vessel covered with fine sand blown from the Egyptian desert; and I have little doubt, from the assertions of the Arabs and a personal examination of the fine sand covering the western slope of the mountain of the Bell, on the Sinaitic peninsula, from which such singular musical sounds are elicited, that in many instances the sand is transported completely across the Gulf of Suez. On a hot calm day in the desert on the borders of the Nile I have seen twenty of these whirlwinds traversing the plain, and raising up columns of sand, pebbles, sticks and straws as high as the pyramids.

Accounts of whole caravans having been overwhelmed by clouds of drifting desert-sand have been greatly exaggerated; but sick pilgrims on the road to Mecca, travellers, and animals, unable from fatigue or other causes to keep up with the caravan, have no doubt been occasionally buried by them. In the great Mecca caravan-track from Cairo across the Suez desert, and in that of the Thebaid, I have remarked many skeletons and carcases of camels and horses, with a few human remains interspersed, partially entombed in the sand. Many of the bodies had been dried up, with very great loss of weight, like mummies, the process of putrefaction having been anticipated by the scorching dryness of the hot wind. Many of the skeletons bore marks of having been stripped of their flesh by birds and beasts of prey. The drifting sand rapidly collects round and entombs carcases where left undisturbed.

On the Geological Position of the Silicified Wood of the Egyptian and Libyan Deserts, with a Description of the "Petrified Forest" near Cairo. By Lieut. Newbold, Madras Army, F.R.S. &c.

The occurrence of silicified wood in many parts of the Egyptian and Libyan deserts has from an early period attracted the attention of travellers. In 1778 Sonnini met with fragments between Honeze and the Natron lakes; and previous to his time petrifactions had been discovered in the bed of the Waterless river (the Bahr bila Maieh), a little to the north of the Natron lakes*. Horneman and others, who have subsequently visited this locality, have however referred these fossils to silicified trunks of trees and plants; and Burckhardt, who saw some specimens brought thence in 1812 by M. Boutin, a French officer, states that they resembled precisely those which he saw on the Suez road, and supposed to be petrified date-trees. Similar petrifactions have also been lately discovered in the sands of the great Nubian desert, a little south from Abusambel, by Mr. St. John; and at Haagbarlak, about eight miles west from Ambukol, by Mr. Holroyd. Some of the silicified trunks of Haagbarlak were fifty-one feet in length and twenty inches in diameter, and are referred by Mr. Holroyd to the Doom-palm (*Crucifera Thebaica*). The stratum was

* Savary's Letters on Egypt, Engl. Trans., vol. i. p. 14.

a coarse sandstone, and the trunks partially buried in the sand. Similar petrifactions were also remarked in the Bayudeh desert between Ambukol and El Hajir near Abu Samud.

In several parts of the Thebaid, the Libyan and Egyptian desert; in the saline sandy wastes lying between the head of the Red Sea and the Mediterranean, in the vicinity of the ancient canal of Bubastis, I have observed small scattered fragments, with edges more or less worn, of silicified wood. Similar fragments have been found in the sandy deserts of Abyssinia and Africa even to the vicinity of the Cape of Good Hope, and they are said to exist in those of Barbary and Morocco.

The most extensive accumulation known is that in the Suez desert near Cairo, which from the number, magnitude and perfect state of the fossil trunks has been called the "Petrified forest." Burckhardt has slightly noticed a portion of this tract near Wadi Anseri, where he found a great quantity of petrified wood upon one of the hills, amongst which was the entire trunk of a tree, supposed by him to be that of a date-palm. The latest, and indeed almost only scientific account of this interesting site has been given by M. Linant in the 'Bulletin de la Société de Géographie de Paris,' 2nd series, tom. xiii. p. 27. These descriptions would have rendered, perhaps, the present notice superfluous, had not the result of my observations differed so materially as to induce me to commit this trespass on the patience of my hearers.

M. Linant supposes a forest which stood on the spot where the trunks now lie, to have been inflamed by a volcanic eruption, and shortly afterwards submerged beneath boiling waters, by whose agency the trunks while still erect were silicified. The eruption continued interiorly and ejected sandstone, both in a fluid state and in vitrified blocks, upwards through the argillaceous and limestone strata on which they were deposited. This erupted matter reduced the petrified trees to a similar state of vitrification.

In support of this theory M. Linant adduces chiefly the vitrified appearance of the sandstone and pudding-stone in the vicinity; the loose fragments of these rocks scattered on the surface; the blackish aspect of some, as well as of certain portions of the fossil wood; and the crater-like aspect of the adjacent sandstone hills of Gebel Ahmar.

I will not take up the time of the Society in attempting to refute here by a train of argument, and in detail, these and similar views, which perhaps few practical geologists would at this æra of the science admit; but after remarking, *en passant*, that throughout the memoir the occurrence of any acknowledged volcanic product is not mentioned (nor was I able to discover such either *in situ* or in the private museums of Cairo), and that the general dark appearance of the sandstone and fossil wood is caused by ferruginous matter common to such formations, I will proceed to describe the result of my own observations made on the spot during the month of July 1840; apologising at the same time for their imperfect nature, and regretting that the task has not fallen into abler hands. Pressure of time and the want of proper instruments prevented my giving a more regular survey of the locality and its vicinity.

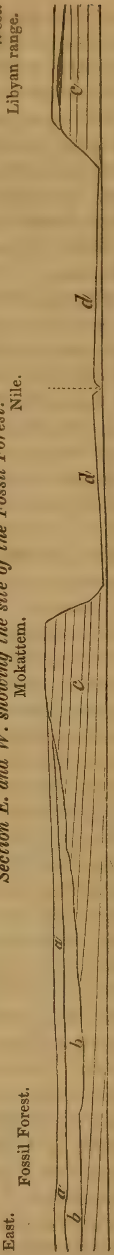
With regard to Burckhardt's theory of the modern origin of the petrifactions (since the time of Nechos, about 600 B.C.) and the process of silicification having been caused by the winter rains and torrents, I will content myself with observing that, in general, the largest and most perfect trunks are found on the sides and summits of hills, or in other positions, elevated above the level of existing streams and inundations, where the presence of springs is rarely known, and often imbedded in solid rock, containing in some situations pelagic remains.

The site of the petrifactions lies in the Suez desert about seven miles east by south from Cairo, between the usual caravan-track to Mecca, and the more southerly but less-frequented camel route that leads from the village immediately south of Old Cairo through the Valley of the Wanderings (*Wadi et-Tih*). The area over which they are scattered presents an irregular superficies, extending about three miles and a half southerly towards Wadi et-Tih, and about four miles in an easterly direction. The whole of this plateau is considerably elevated above the level of the Nile even during the highest inundations, lying on the slope of the Mokattem range as it recedes easterly from the river, where it presents the bold and precipitous escarpments that form the eastern limits of the valley of the Nile. The belt of desert that is passed between the petrifactions and Cairo rises gradually, but irregularly, from the city walls, and presents an undulating surface, here and there broken by low and irregular elevations, and covered with a light-coloured, quartzy sand, mingled with rolled pebbles of quartz, jasper, Egyptian pebble, silicified wood, chert, and fragments of crystallized sulphate, and carbonate of lime and muriate of soda.

Near the top of a broad shallow defile that leads up to the table-land skirting the site of the petrifactions, the fragments of silicified wood become more numerous, and their edges less worn. Another shorter but steeper ascent to the right being gained, the traveller stands upon the edge of the fossil forest—one dreary, arid expanse of sand, treeless and almost shrubless, rugged with dark-coloured knolls, and intersected by a few dry rain-channels.

Fig. 7.

Section E. and W. showing the site of the Fossil Forest.



a, a. Sand and gravel covering surface of desert.
b, b. Sandstone and pudding-stone imbedding silicified trees.
c, c. Marine limestone of the Mokattem and Libyan ranges.
d, d. Alluvium covering valley of the Nile.

The whole presents a blacker aspect than the surrounding desert, caused, as we found subsequently, by the ferruginous character of the grit and conglomerate forming these knolls, in which much of the silicified wood lay partially imbedded, the ends protruding from the superjacent sand. The sandstone, in one specimen presented to the Society, exhibits marks of marine shells, which from the circumstance of their being casts, and those in the subjacent limestone being casts also, cannot have been derived from the limestone, an observation for which I am indebted to Mr. Lonsdale.

Many of the trunks lie scattered loosely over the surface, amid rolled and angular fragments of the dark grit, pebbles of jasper, chert, quartz, and sharp-edged bits of silicified wood; but they were not in so perfect a state of preservation as the imbedded trunks. The site which they occupy slopes gradually in a southerly direction towards Wadi et-Tih, and is drained by the shallow channels previously mentioned, which run into a ravine following the general slope of the land: at the time of our visit they were perfectly dry. The prospect is bounded to the south by the low calcareous ridge that skirts the valley of Et-Tih, separating it from the wastes of Báccara, and runs westerly to the Nile. To the east lies the monotonous expanse of the Suez desert; to the west the mural limestone ridge of the Mokattem; and to the north the valley separating the petrifaction-bed from the once continuous stratum forming the sandstone heights of the Red Mountain (*Gebel Ahmar*).

The largest trunks are seen in the greatest abundance on or in the vicinity of the scattered knolls, particularly towards the south-east portion of the area, where they lie, like the broken stems of a fallen forest, crossing each other at various angles. The majority of the larger trunks had a north-west direction. Two of the largest observed measured, severally, 48 and 61 feet in length, and 2½ and 3 feet in diameter. They resemble in external aspect the present palm of Egypt, but internally the wood has the annular concentric structure of exogenous stems. A few exhibited, externally, longitudinal fibres intersected, at intervals from two to three feet asunder, by transverse divisions, giving the trunk the appearance of a gigantic Calamite, although the internal structure is that of dicotyledonous wood, and is pronounced by Mr. Robert Brown, who kindly examined the specimens, not coniferous. One of these trunks had a circumference of thirty inches. The jointed appearance it is possible may have been caused by contraction during the process of silicification, but may it not be the original structure of a tree now no longer known? The greater portion of the trunks visible lie scattered loosely in and on the sand and gravel, in broken fragments from 1 to 3 feet long, and from 4 to 12 inches in diameter. A few are yet seen imbedded horizontally in the sand and pudding-stone, and still fewer preserve a vertical position, not rising higher than from 12 to 20 inches above the present surface of the sand. From one of these stumps I cleared away the sand and gravel, as far as was practicable with no better instruments than a hammer and my hands, and clearly traced it to the subjacent pudding-stone in which it stood imbedded. No traces of roots were found at this depth, but several loose masses imbedded in the sand bore strong resemblance to the bulbous base of palms; while others, again, assimilated to the tortuous structure of the roots of exogenous trees. No branches remained attached to any of the trunks that fell under my observation; the places of their insertion were to be traced, and also knots; but in general the stems were straight, knotless, and with a longitudinally striated superficies.

Some appear to have been in a state of decay at the time of their being imbedded, having a hollow interior partially filled up with grit and pudding-stone. A specimen from this locality, shown me by M. Linant at Cairo, had the hollow lined with a white calcedony-like siliceous substance full of small cells resembling those of a honey-comb.

Many of the silicified trunks, both with regard to external and internal structure, closely assimilate to the petrifactions found on the Coromandel coast near Pondicherry, and the imbedding rocks are similar in character and in their geognostic position. The respective ages of the two subjacent marine limestones have not, however, been determined. Of the Egyptian limestone specimens have been already furnished. The hardness of the silicified wood varies from a whitish mealy opake crust, that crumbles between the finger and thumb, to that of translucent agate and flint; and in colour from white cornelian to red jasper, variegated with every shade of brown and grey. In some specimens all appearance of ligneous structure has been destroyed, the woody matter having been replaced by grains of sand agglutinated together, but preserving in a great degree the external form of the tree; like the fossil trees found at Dixon Fold, near Manchester, which are composed of the sandstone and shale of the coal-measures, and many other fossils of the coal-field sandstone of Europe.

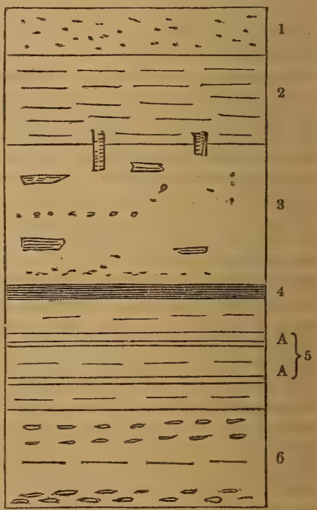
I was unable to detect decisively either the fruit-seeds or leaves of the fossil trees, but picked up one or two spherical ferruginous-looking nodules, from the size of a hazel-nut to that of an orange, which have been considered by many travellers, probably from shape merely, to be the petrified fruits of the date, doom-palm, and other trees. They resemble strongly similar substances which I found in the petrifaction-bed near Pondicherry just alluded to, and are usually composed of grains of quartz cemented by a mixture of ferruginous, siliceous, and argillaceous matter, sometimes hollow in the centre, like a geode, sometimes lined with minute drusy crystals of quartz, but more frequently containing a yellowish or rust-coloured ochreous powder. The sandstone and fossil wood contain cells similarly lined.

It must not be omitted to mention that in many of the fractured trunks, which lie on the sand-hills broken transversely, the edges of the fractured portions are still sharp and in nice adaptation. Some lie several feet apart, like the fragments of a fallen column of marble separated by the heaviness of its fall, in such a manner as not to be explained by any theory of contraction or superincumbent pressure having occasioned their division. They appear to have fallen subsequently to fossilization. After the consolidation of the lower beds of this deposit and the silicification of the trees, its upper and looser layers were removed by denuding aqueous action, evidence of which will be adduced hereafter: the trunks, thus left unsupported, either fell by their own weight increased by silicification, or were laid prostrate by the action of the current, and their smaller fragments, mingled with sand and gravel-detritus of the subjacent rock, scattered to considerable distances, contributing to the formation of the present surface of the desert.

The imbedded fossil stems are rarely flattened, and do not bear any vestiges of ever having been covered with the thin coating of coal we see enveloping some of the trunks of Dixon Fold,—a circumstance easily explained when we consider the more perfect process of silicification to which the former have been subjected, exhibiting often the finest anatomical structure of the interior with a perfection equalling that of the tree in a state of nature, converted into silex, and rivalling oriental agate and cornelian in transparency and colour. Mr. Robert Brown has kindly examined the specimens I brought with me from Egypt, and reports that the three whose characters he could determine are dicotyledonous and not coniferous*.

Geognostic position.—The basis on which repose the strata of sand and pudding-stone imbedding the fossil trunks, and indeed that of the whole of this portion of the Egyptian desert, is the ordinary marine limestone of the Mokattem in nearly horizontal beds having a scarcely perceptible westerly dip. The inferior beds (6, fig. 8) of the limestone in this vicinity have a chalk-like colour and texture, imbedding nodules of brown, grey and blackish chert, covered by a thin white coating in regular layers. The upper beds (5) are more compact, interstratified with thin layers (from 2 to 12 inches in thickness) of a dull greenish gypseous and saliferous marl (A, A, 5), and contain, among other pelagic remains, nummulites, nautili, crabs, corallines, fishes' teeth, [these beds have been referred by some French geologists to the chalk period.] (4) is a thin argillaceous bed varying in colour from red to a dull green. (3) is the sand and pudding-stone stratum imbedding the petrifactions. On it, in some positions, rests a bed of argillaceous and gypseous marl with rock-salt (2), underlying the sand and gravel of the desert (1). This bed however is generally wanting, having been carried away by aqueous action.

Fig. 8.



* A specimen of coniferous wood has been brought from the Nubian desert by the Rev. Vere Monro, found in a deposit analogous to that near Cairo, which is

Gebel Ahmar.—I shall now proceed to give the result of the examination of Gebel Ahmar (A, fig. 9), which lies on the northern limit of the fossil forest, and of the shallow valley that separates them. The former is an irregular dark-coloured ridge that rises to the apparent height of about 150 feet from the general level of the surrounding desert, about a mile in length and half a mile in breadth. The rugged and conical shapes of portions of this ridge have been caused chiefly by a number of excavations and mounds of rubbish consisting of fragments of quarried rock. The lower portions of these quarries are often basin-shaped and partially filled with the finer sand of the

thus described by Mr. Jameson Torrie, whose notice I did not see till this paper had been written:—"The breccia containing fragments of a conifera is from the neighbourhood of Aboosambal or Ipsambul in Nubia. The rocks of that district are sandstones and conglomerates which form hills presenting very remarkable conical and pyramidal shapes. Many of the specimens of sandstone are highly ferruginous and much indurated. The colour of these fragments is brown internally but brownish-black externally, and the external shapes rendered apparent by the decomposition of the softer sandstone, are singular, being stalactitic, botryoidal perforated, vesicular, &c. The wood breccia is from a bed at the edge of a large chasm, which traverses for a considerable distance sandstone strata, to the south-east of the ruined town and castle of Kalat Addé, and about a league and a half from Ipsambul." Mr. Nicol affords the following note on the structure of the conifera:—"The mass containing the conifera is an aggregate, consisting of fragments of the fossil wood and grains of quartz, united by a cement, consisting chiefly of carbonate of lime with a little iron and clay. The fragments of wood are of an elongated form and of various dimensions, the largest being little more than an inch in length. Externally, the woody portions are of a greyish-black, but internally the colour, at least of one of the specimens, was hair-brown. By reflected light, the hair-brown fragment shows no appearance of organization even when polished; but when a transverse section of it was reduced to the proper thickness, it showed distinctly the reticulated texture of the recent coniferæ. From the faintness of the partitions it is not likely that the longitudinal sections would exhibit discs so as to enable us to determine whether the fossil belongs to the Pine or Araucarian division of Coniferæ, and I have accordingly not attempted to make a longitudinal section."—*Edin. New Phil. Journ.* vol. xviii. p. 336.

Fig. 9. *Section showing valley of erosion.*

a, a. Sandstone and pudding-stone imbedding silicified trunks, partially covered with sand and gravel of the desert.
b, b. Hard masses of *a, a,* left on surface of the valley.
c, c. Marine limestone of the Mokattem.

desert, drifted chiefly by the khamsin and the whirlwinds that frequently raise it up in vast moving columns from the surface of the surrounding wastes. These excavations and mounds are so numerous as to have obliterated the original outline of the ridge, a circumstance which, coupled with the dark colour of the rock and crystalline aspect of some varieties, has probably induced M. Linant to consider it of volcanic origin. The rock is composed of beds of pudding-stone and grit (*a*, *a*, fig. 9) passing into a compact crystalline sandstone, varying from a deep blood-red to yellow and white. From its generally dark red aspect this ridge has obtained the Arab name of "*Gebel Ahmar*," i. e. the Red Mountain. The pudding-stone imbeds pebbles of the same size and nature as those found in the bed containing the fossil wood, fragments of which are here found among the quarries. It once formed, doubtless, a continuous portion now separated by the valley (B, fig. 9) just alluded to.

Near the southern extremity of the ridge stand two cliffs of sandstone higher than the rest; the one of a deep red and yellow colour and compact; the other white, more granular, and crystalline. In the former, one of those vertical clefts often seen in sandstones, produced probably by contraction during the process of consolidation, has caused the displacement of a large mass of rock, but there is nothing resembling the effect of volcanic agency. The rock reposes in horizontal beds on the surface of the limestone already mentioned (*c*, *c*, fig. 9). The sandstone near the junction-line passes into an ochreous reddish and yellow clay containing veins of fibrous gypsum, incrustations of muriate of soda, and selenite. Barytes are said to be found in this layer.

Both the limestone and sandstone abound in caverns, the resort of the hyænas that nightly prowl among the burial-grounds without the walls of Cairo. One of these dens into which I descended contained the recent dung of this animal, intermingled with human and other bones.

The shallow valley (B, fig. 9), already mentioned, appears to have been hollowed out by the erosive action of water, which has not however been so great as to destroy the entire bed of sandstone, portions of which, firmer than the rest (*b*, *b*), have successfully resisted the current. The softer intermediate parts of the bed have been carried away, leaving the subjacent limestone denuded in some places. Around these and some waterworn blocks of the same rock the drifted sand has collected, forming dome-shaped and conical knolls, which impart a somewhat volcanic aspect to the surface. Around others was found a deposit of a stiff gypseous marl. Many of these knolls have not escaped the hands of the Egyptian quarriers. The harder and more compact varieties were used for statuary and architectural purposes, while the looser gritty beds were hewn into millstones. The more argillaceous beds in the limestone are broken up for whetstones, while a fine greyish variety of clay is used by the women of Cairo for washing.

I shall now conclude with a few remarks drawn from a consideration of the geological position of the petrifaction-bed.

1st. That this part of Egypt has twice formed a portion of the ocean's bed, elevated at distinct periods above its surface.

2nd. That the fossil trees existed in a vegetating state between these two epochs, or after the first appearance above the ocean of the marine limestone,—were submerged or carried into the sea—covered with a bed of rolled pebbles and sand, and raised with this bed to their present position above the general drainage-level of the country and the reach of existing springs.

The consolidation of the ocean's bed and silicification of the trees probably went on together prior to, or perhaps contemporaneous with, the *soulèvement*.

3rd. That the elevation of these beds was attended with no violent disturbing cause, but effected gently and gradually, as appears from their nearly horizontal position.

4th. That it is probable that the retiring waters of the last ocean swept away the looser portions of this and other once continuous beds of sandstone,—denuding in places the subjacent limestone, scattering the debris of pebbles, sand and fragments of silicified wood over a vast extent, and forming the present gravel and saline sands that cover the surfaces of the Egyptian and Libyan deserts.

5th. From what has been already stated respecting the manner in which some of the fossil stems near Cairo have been broken,—their little-worn aspect,—the angularity and nice adaptation of many of the fractured portions, it is reasonable to infer, in that locality at least, that they rest at no great distance from the spot on which they were silicified. From the fact of the vertical position of a few of the trunks, it might be still further presumed they are now seen where they originally vegetated; but until these vertical stems be traced down to roots fixed in a given stratum or on certain levels, marking, like the Portland dirt-bed, the ancient surface of dry land (facts which it is extremely desirable to ascertain or disprove), we must hesitate to admit the hypothesis of the Cairo petrifaction-bed being the site of a submerged forest.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

April 1st to June 30th, 1848.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

AMERICAN Academy of Arts and Sciences, Proceedings for 1847.

——— Journal of Science. Second Series, vol. v. nos. 14 and 15.

——— Philosophical Society, Transactions. New Series, vol. x. part 1. Proceedings, vol. iv. nos. 36–39.

Athenæum Journal. April to June.

Boston Journal of Natural History. Vol. v. no. 2.

British Association, Report of the Seventeenth Meeting held at Oxford in June 1847.

Chemical Society, Memoirs and Proceedings, Part 23, Quarterly Journal of, no. 1.

Cornwall Polytechnic Society (Royal), Annual Report, 1847.

France, Société Géologique de, Bulletin. Deux. Série, tome v. feuilles 1–3.

Genève, Société de Physique de, Mémoires. Tome xi. partie 2.

Horticultural Society, Journal. Vols. i. ii., and parts 1 and 2 of vol. iii.

Indian Archipelago, Journal. Vol. ii. nos. 1 and 2.

Littell's Living Age. No. 201.

Munich Academy (Royal), Abhandlungen. Vol. v. part 1.

———, Bulletin. Nos. 1–35, 1847.

Philadelphia Academy of Natural Sciences, Journal. New Series, vol. i. part 1. Proceedings, vol. iii. no. 12, and vol. iv. no. 1.

Philosophical Magazine, April to June. *From R. Taylor, Esq., F.G.S.*

Zoological Society, Transactions. Vol. iii. part 5. Proceedings, nos. 177–180.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Austin, Thomas, and Thomas Austin, Jun. Monograph on Recent and Fossil Crinoidea. No. 7.

Binney, E. W. Glance at the Geology of Low Furness.

Carpenter, W., M.D. Report on the Microscopic Structure of Shells. Part 2.

Corbaux, Fanny. On the Comparative Physical Geography of the Arabian Frontier of Egypt. 2nd part.

Cumming, Rev. J. G. The Isle of Man; its History, Physical, Ecclesiastical, Civil and Legendary.

Favre, Alphonse. Recherches Géologiques faites dans les Environs de Chamounix en Savoie.

Flügel, Dr. J. G. Literarische Sympathien oder industrielle Buchmacherei.

———————. A Call of Redress, &c.

———————. Extra-Impression of the Preface to Dr. Flügel's Practical Dictionary.

Hall, James. Palæontology of New York. Vol. i. (Part 6 of the Natural History of New York.)

Howard, Luke. Barometrographia: Twenty years' variation of the Barometer in the Climate of Britain, exhibited in Autographic Curves. *From E. W. Brayley, Esq., F.G.S.*

Leidy, Joseph, M.D. On a New Fossil Genus and Species of Ruminantoid Pachydermata.

———————. On a New Genus and Species of Fossil Ruminantia.

Martins, Ch. Mémoire sur les Températures de la Mer glaciale, à la Surface, à de grandes Profondeurs, et dans le Voisinage des Glaciers du Spitzberg.

Nattali, M. A. Catalogue of Books for 1848.

Penny Cyclopædia, Supplement. Vols. i. and ii. *From James Tennant, Esq., F.G.S.*

Reeve, Lovell. Conchologia Iconica: Monographs of the Genera Turbo, Chitonellus, Turbinella, Pyrula, Paludomus, Fusus, Ficula, Fasciolaria and Chiton.

———————. Elements of Conchology. Part 8.

Ritter, Carl. Vergleichende Erdkunde von Arabien. 2 vols. *From Dr. W. Twining, F.G.S.*

Smith, J. Toulmin. The Ventriculidæ of the Chalk.

Sowerby, G. B. A Catalogue of the Shells in the Collection of the late Earl of Tankerville.

Swedenborg, Emanuel. The Economy of the Animal Kingdom. 2 vols.

————————. The Principia. 2 vols.

————————. On the Principles of Chemistry.

————————. Outlines of a Philosophical Argument on the Infinite.

————————. Œconomia Regni Animalis.

————————. Posthumous Tracts.

————————. Miscellaneous Observations connected with the Physical Sciences. *From the Swedenborg Association, by the hands of L. S. Coxe, Esq., F.G.S.*

Von Meyer, Herman. Zur Fauna der Vorwelt. Zweite Abth. Die Saurier des Muschelkalkes mit Rücksicht auf die Saurier aus Buntem Sandstein und Keuper.

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VOLUME THE FOURTH.

1848.

PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the probable Eruptive Origin of several Kinds of GNEISS *and of* GNEISS-GRANITE. By Prof. C. F. NAUMANN.

[From Leonhard and Bronn's Neues Jahrbuch für Mineralogie &c., Jahrgang 1847, 3tes Heft.]

IT is particularly satisfactory to find, that at length opinions have been expressed by English geologists respecting a mode of formation of gneiss and foliated granite, which may have the effect of restricting within just limits the hypothesis of the metamorphic origin of these rocks; an hypothesis which certainly met with a remarkably ready adoption, and which has been very extensively applied. It is at least to be hoped that the geologists of Germany will now give some attention to these views, coming to us, as they do, from the other side of the Channel, sanctioned by so high an authority as that of Mr. Charles Darwin.

The hypothesis that gneiss and similar rocks are in all cases only altered sedimentary deposits, is founded essentially on the parallelism in their texture and structure, and on their being frequently found interstratified with clay-slate, grauwacke, and other sedimentary rocks. It has been assumed as an undoubted axiom, that all such parallelism of structure must have resulted from sedimentary deposition, and this axiom has been applied far too generally,—*Multa fiunt eadem, sed aliter*. There were not wanting, in truth, examples enough of rocks with a remarkable parallelism of structure, as to which no one could assert that they were of sedimentary origin. I will not advert to the numerous and well-known examples of vesicular lavas and amygdaloids, in which the flattened and elongated vesicles are arranged in parallel lines, although these afford the most striking proofs of the origin of such parallel structure; but I will take leave to call to the recollection of the reader some other cases of this nature.

In the classical description of *Piperno*, which Leopold von Buch published nearly forty years ago*, we have a very remarkable instance of a trachytic rock having a parallelism of structure; and in his instructive memoir on Trap-porphyry or Trachyte†, he pointed out that which has since been so frequently observed, viz. that beds of trachyte not unfrequently occur in which the crystals of felspar assume a parallel arrangement. He mentions still more remarkable examples of this structure in his work on the Canary Islands. Thus, at p. 215, he describes a dyke of trachyte near Angostura in Teneriffe, the rock of which is composed of thin parallel layers of crystalline plates of felspar, so that it has quite a slaty texture, and has been taken for white silvery mica-slate; and at p. 244 he refers to a similar slaty trachyte in the vicinity of Perexil on the Cumbre; and at p. 274 he speaks of a trachyte from the Caldera of Tiraxana, which is so slaty that at every step one fancies it a mica-slate.

This peculiar structure, which Von Buch was the first to describe, in the case of trachyte, was afterwards pointed out by Beudant, in his excellent work on Hungary, as occurring in Perlite‡. He describes this parallelism of structure as a very remarkable appearance, shown by an alternation of stony and glassy layers; and it is perceptible in hand specimens as well as in the mass of the rock. The stratification of the latter, which is parallel to the slaty structure, is often horizontal, often contorted in various ways, and often combined with a disposition to separate into slabs, or at least to split into such forms. Afterwards Poulett Scrope, when examining M. Beudant's specimens of Hungarian perlite at Paris, came to the very just conclusion, that their parallelism of structure must be ascribed "to the substance of the rock having been drawn out in the direction of the zones," as also "to the flowing of the matter in obedience to the impulse of its own gravity§," just as happens with the obsidian-lava of Lipari, Teneriffe, and Iceland, which respectively exhibit a similar bedded structure.

Scrope, in the above-mentioned memoir, also describes a rock in the island of Ponza, which he calls a prismatic trachyte, and speaks of its parallel structure. This trachyte, when viewed in mass, exhibits a striped appearance, derived from a kind of stratiform alternation of texture and colour, combined with a corresponding extension of all the pores of the stone; the brighter layers being porous and softer, the duller being compact and harder, more siliceous, and sometimes almost like hornstone. This parallelism of structure passes right across the prisms of the rock; and as the axes of these prisms are always at right angles to the plane of the bed or of the dyke, so it may be seen that the direction of the structure-planes depends upon that of the resisting surfaces.

In the island of Palmarola the stratiform structure of the trachyte is still more remarkable; the layers in it are more continuous, and

* Geognost. Beobacht. auf Reisen durch Deutschland und Italien, 1809, ii. s. 209.

† Abhandlungen d. Berlin. Akademie d. Wissenschaften, 1816, 127.

‡ Voyages en Hongrie, tome iii. p. 403, 1822.

§ Transactions of the Geol. Soc., 2nd Series, vol. ii. p. 225.

their contortions resemble those of gneiss or mica-slate. Scrope moreover remarks, that the layers are more frequently vertical than horizontal, and may have been caused by the protrusion of the masses, exactly like those of the perlites of Oyamel in Mexico, the stripes of which are also vertical. The author makes the following striking remark :—that many similar appearances, as, for example, the parallel structure of phonolites, and the very frequent elongations and contortions in gneiss and mica-slate, may owe their origin to similar causes.

These observations and views of Scrope were afterwards fully confirmed by Abich*. He distinctly calls the rock of which the great dykes in Palmarola consist, a schistose rock, the layers of which are often as thin as paper.

What Scrope and Abich found in the island of Palmarola, was seen by Hoffmann in the small island of Basiluzzo, one of the Lipari group, where he found a trachyte composed of a reddish base, including many small crystals of glassy felspar, scales of mica, and quartz-like grains; these grains are however arranged in parallel stripes, which not only impart to the stone a perfect foliaceous texture, but also give the rock a distinct laminar structure, and cleavage†.

The crater of elevation in the island of Pantellaria, between Sicily and Tunis, is composed, according to Hoffmann‡, of a trachytic lava, which throughout has a foliated texture resembling gneiss, and occurs in beds that dip regularly outwards from the centre of the island.

While so many instances were known of the existence of parallelism of structure, often in a most remarkable degree, in volcanic, and therefore unquestionably eruptive rocks, it was hardly to have been expected that there should have been so unconditional and so general an admission of the hypothesis that all parallelism of structure is a proof that the rock must originally have been formed by sedimentary deposit.

It is moreover perfectly well known, that many erupted rocks, not of volcanic but of plutonic origin, have this same parallel texture and bedded structure. I need only refer to the cases of phonolite, the structure of which, especially when weathered, sometimes approaches very near to that of clay-slate ;—of the foliated porphyry described by Heim§, consisting of alternate layers of reddish clay-stone and quartz, so thin that the rock might appropriately be called paper-porphyry ;—of the similar kind of porphyry found in several parts of Saxony, especially in the neighbourhood of the Triebisch valley ;—of the porphyry of Frejus, described by Elie de Beaumont as having a riband and even schistose structure‖ ;—of the slaty porphyry of Deville in the Ardennes, which, from its structure, has been held to be an altered slate ;—of the porphyry of the Wagenberg on the Berg-

* Natur u. Zusammenhang der Vulcanischen Bildungen, 1841, s. 19.

† This is also confirmed by Abich in the same work, p. 85.

‡ Poggendorf's Ann. Bd. 24. s. 68; and Geognost. Beobacht. auf einer Reise durch Italien, 1839, s. 108.

§ Geol. Beschreib. des Thüringer Waldes, Th. ii. s. 159.

‖ Explication de la Carte géologique de la France, vol. i. p. 479.

strasse, described by Gustav Leonhard*, in parts of which the layers of the stone are not thicker than card†;—and of the slaty and foliated porphyry in the neighbourhood of the Lenne valley, of which we have an account in an interesting memoir by Von Dechen‡, but respecting which it may certainly be said that its nature is as yet very obscure. In general, porphyries more especially supply examples of the kind of structure now under consideration; and although in many instances they may be satisfactorily shown to be metamorphic slates, it is no less true that in many others it is unnecessary to have recourse to that theory to account for their structure.

It may therefore be considered as proved, that many rocks, which are undoubtedly of plutonic origin, have a most distinct parallelism of structure; and consequently, that the existence of such a structure is in all cases by no means a proof that the rock had originally been sedimentary. This truth has a very important bearing upon those rocks, which, from their mineral composition and their frequently passing by insensible degrees into other rocks of acknowledged plutonic nature, give rise to doubts whether they have had a sedimentary origin or not. Gneiss, gneiss-granite, and granulite belong especially to this class.

It is unquestionably true, that clay-slate and mica-slate, when in the vicinity of large granitic beds, very frequently exhibit a more or less remarkable gneiss-like structure; and also, that genuine metamorphic gneiss is met with; but in all such cases the gneiss is very subordinate in importance; and generally the metamorphic change is to be recognized in a very distinct, indubitable manner by a gradual passage from the original rock into the altered structure: moreover, the existence of large masses of plutonic rocks in the immediate vicinity indicates the cause of the metamorphism.

On the other hand, under what totally different circumstances do those colossal beds of gneiss-like rocks present themselves which are spread over vast regions; such, for example, as those in Saxony, Scandinavia, Finland, North America and Brazil! how different, too, the gneiss-granite of the Alps and the Riesengebirge! and how little are we justified in setting all these down as metamorphic sedimentary deposits!

When we reflect on the numerous instances recorded by the most trustworthy observers of the above-mentioned transition of some granites into gneiss, on those oscillations in texture which are not unfrequently seen many times repeated in the same bed, one can scarcely come to any other conclusion than this, that gneiss and

* Beiträge zur Geologie der Umgegend von Heidelberg, 1844, s. 29.

† This appearance of the porphyry of the Wagenberg was first observed by me, and was described in 1827 in Moné's Badischem Archive, ii., was the subject of a communication to the Meeting of Naturalists in Heidelberg in 1829, and was afterwards noticed in 1830 in my 'Gæa Heidelbergensis,' s. 75. The rock being in globular concretions and the layers concentric, it could not be ascribed to a sedimentary mode of formation.—*Note by Professor Bronn, one of the editors of the Jahrbuch.*

‡ Karsten und v. Dechen's Archiv, Bd. 19. s. 367.

granite have very often had one common origin, and are in fact twin brothers.

It has been well remarked by De la Beche, while treating of the gneiss-granites, in which the very close affinity between gneiss-like and granite-like rocks is manifested by the transitions and alternations of beds, that in such cases one common origin must be assigned to both extremes—the gneiss and the granite; for to derive them from two sources would be in opposition to the phænomena exhibited*. The difference between the two rocks is no other than this, that the one has a foliated, the other a granular texture, with probably a variable proportion of mica. Instead however of endeavouring to trace the possible causes of this difference of texture, some have been rather disposed to maintain that the gneiss-like parts, merely on account of their texture, are metamorphic sedimentary deposits, and, to be consistent in their hypothesis, even assign the same origin to the associated granite-like parts, while they hold that the greater proportion of other granites are undoubtedly of plutonic origin. For this metamorphic action, the existence of vast internal seas of red-hot molten matter is assumed, and penetrations of the heat, impregnations, cementations and other processes are called into action, in order to solve in some degree the physico-chemical riddle, how a presupposed region of grauwacke had been changed into one of granite and gneiss. And all this is maintained without consideration either of the magnitude of the scale on which these formations occur, or of the entire absence of any distinct assignable cause of the metamorphic action. But if we are to suppose plutonic powers and agencies so energetic as to have elaborated the whole rocky pavement of Finnland or Scandinavia in such a manner that the presumed sedimentary beds have been converted into the crystalline siliceous rocks that now exist there, we must equally suppose that they were exerting the same activity immediately under the whole of the sedimentary crust; and their contemporaneous action over so very considerable a space must have been attended with the most stupendous effects; effects of such a nature, that it is altogether inconceivable how the different strata should still so perfectly retain their several differences, and the individual beds their parallelism of structure.

But there are still several other important circumstances to be taken into account. In the first place, there is the highly inclined position of the parallel masses or strata in many extensive gneiss districts, in which we find them in an almost vertical position, and preserving their parallelism throughout so extensive a range of country, that a system of such vertical beds, with a united thickness of many geographical miles, will stretch to a distance of ten times that extent. In the next place, we frequently meet with such beds having a fan-shaped arrangement, the central parts being vertical, and the exterior parts falling towards the centre with a gradually increasing slope. Then again we meet with beds of gneiss in some countries with wavings and twistings so fantastic, that they can only be com-

* Handbuch der Geognosie, bearbeitet von v. Dechen, p. 548.

pared to the forms we see on marbled paper or speckled woods*. Lastly, the very remarkable condition of texture, that stretching of the gneiss and gneiss-granite, demands our closest attention, a phænomenon, which, however often it has been observed, has not hitherto met with due consideration.

In my 'Hints towards the establishment of a doctrine of the nature of rocks†,' I long ago pointed out the fact, to which I have repeatedly since called attention, that the parallel texture of rocks must be understood in a twofold sense, and that they are very different, the one the plane parallel texture or flattening (lamination or foliation), and the other a linear parallel texture or stretching (tension). I also endeavoured to show in a subsequent memoir‡, that in the crystalline siliceous rocks the lamination is the result of pressure; whereas the strike is to be explained by a drawing-out or protrusion of the mass; an explanation adopted by all geologists with respect to the flattened and elongated vesicular cavities in lavas and amygdaloids, and which appears no less applicable to many kinds of long foliated gneiss and granular foliaceous gneiss-granite.

In the well-known memoir of Sedgwick on the structure of large mineral masses§, reference is made to this appearance, which he calls *the grain*; and under that term it has in later times been frequently brought into notice. Fournet, in particular, in his beautiful memoir on the Alps between the Vallais and Oisans||, enters very fully into the question of the mode of formation of the planes of lamination and of linear parallel structure in gneiss and granite. "When a viscid molten mass," he says, "free from all external influence, crystallizes, a granitic structure is produced; but if it be acted upon by certain forces, as, for example, by the lateral pressure of the wall of a fissure, in that part of the mass which is in contact with the wall, there will be a regular separation of the constituent parts; and this process may be so often repeated, that at last the whole mass may consist of a succession of alternating beds." Farther on he proceeds to say, "An eruptive mass, by being forced through a more or less narrow fissure, may undergo an extension or flattening, by which its different constituent parts will be squeezed flat and drawn out lengthways, producing a rock having a striped or riband structure, even a true gneiss. It is therefore quite conceivable that gneiss and granite may have one common origin, and it will often be very difficult to recognise in them two distinctly different kinds of rock."

But the most important observations and consequences deduced from them, with which I am acquainted, are indeed those communicated

* As, for example, frequently seen in the granite-gneiss of Norway.—See my 'Beiträge zur Kenntniss Norwegens,' Bd. ii. s. 166, and Scheerer im Neuen Jahrb. 1843, s. 632, 638, u. a. o.

† Andeutungen zu einer Gesteins-Lehre, Leipzig, 1824, s. 57.

‡ Karsten und v. Dechen's Archiv, Bd. xii., 1838, s. 23.

§ Trans. of Geol. Soc. 2nd Ser. iii. 461.

|| Ann. des Sciences Physiques et Naturelles publiées par la Soc. Roy. d'Agriculture de Lyon, t. iv. p. 105.

to us by Darwin in his two works, 'Geological Observations on Volcanic Islands,' and 'Geological Observations on South America.' He saw in the island of Ascension a volcanic rock, composed of felspar, diopside and quartz, having a perfect gneiss-like texture and structure, the alternating layers of the component parts being extremely fine, and extending parallel to the direction of the lava-stream. The explanation he gives of this is a very correct one; viz. that flowing slowly downwards in a viscid state, the mass was subjected to an internal stretching of all its constituent parts, while at the same time it was subject to pressure from the mere force of gravity; and he refers to Forbes's description and explanation of the parallel structure of glacier ice*.

Darwin informs us, that in the Cordillera of Chili, great beds of a red granite occur, which must be viewed as an eruptive rock; but that it nevertheless exhibits, in parts, a decidedly parallel structure. In the gneiss of Bahia he observed included angular masses of a hornblende rock, which are indubitably fragments. The gneiss in the neighbourhood of Rio Janeiro has a porphyritic structure with imbedded crystals of felspar three or four inches long; and although there be no parallel alternation of the constituent parts, still it has a parallel structure or *grain* in the mass, and in some places it does alternate with true gneiss beds. Darwin on this occasion says expressly that the parallel structure, and even the foliations, afford in his opinion no valid objection to this gneiss-granite being considered rather as an eruptive rock than as a metamorphic formation. In Botofogo Bay, not far from Rio, a colossal fragment with sharp edges of another variety of gneiss, containing much mica, is found imbedded in the same gneiss-granite. In a subsequent passage he mentions the great dyke of gneiss in the mica-slate of Venezuela, formerly described by Humboldt, and in reference to the theory of its formation comes to the conclusion, that the parallel structure of crystalline siliceous rocks must very frequently have been modified by the tension to which they had been subjected throughout the whole area of eruption, before their final consolidation†.

When a geologist of so high authority as Darwin announces such an opinion on the formation of gneiss-granite, it may seem almost superfluous for me to refer to the instances of fragments of grauwacke-slate pointed out by myself as occurring in the gneiss of the Striegis valley, close by the place where it abuts against the grauwacke formation;—to the great masses of clay-slate in the gneiss of the Castle Hill of Frankenberg, as also to the grauwacke fragments observed by Cotta in the gneiss of the Goldberg near Goldkronach;—or to mention that Hoffmann had already called our attention to the remarkable conditions of the beds of gneiss in the Münchberg, observations afterwards fully confirmed by what I myself saw in that locality, which can in no way permit us to consider that formation as meta-

* The interesting comparison by Forbes between the structure of glaciers and lava-streams will be found in the Edin. New Phil. Journal, vol. xxxvii. 1844, p. 231.

† Compare, in this view, my memoir in Karsten's Archiv, Bd. xii. 1838, s. 23.

morphic. The inferences to which these observations naturally lead are the same as those which Darwin drew from the phænomena he observed in the gneiss formation of America above alluded to. The gneiss-granite of the Alps and the granulite formation of Saxony may also be adduced as very striking instances in support of the view that many kinds of gneiss must be considered rather as eruptive than as metamorphic formations.

It is well known that the central chain of the Alps contains very massive and widely-extended beds of a peculiar gneiss-granite, exhibiting in many places not only a very distinctly recognizable parallel texture or foliation, but also separating into tabular masses or strata, parallel to that foliated texture. Lardy therefore calls this rock in this place, as well as where it occurs in St. Gothard, unhesitatingly gneiss; and Studer describes it as a peculiar variety of granitic rocks, under the name of Alpine granite*.

On the road over the Grimsel, from Guttannen to Obergestelen, and from Airolo by Hospenthal to Amsteg, I had an opportunity of examining this remarkable formation of gneiss-granite. The rock, it is true, is very like granite, but it usually shows a tendency to a short foliated texture, and is separated into very regular beds, the surfaces of which often exhibit an appearance quite like that of gneiss, and even occasionally that of mica-slate, and between these there frequently occur regular beds of true gneiss, and even of mica-slate. In some localities, as for example near Gestinen, the foliated texture and stratification disappear, and the rock becomes a perfect granular granite, without any trace of being separable into beds.

From Airolo to Hospenthal we pass over, as is well known, a fan-shaped or synclinal system of beds, the most northerly wing of which, having a dip to the south, may be followed much farther, and the gneiss-granite from Guttannen to Obergestelen forms a similar system of beds. The axis of each system is marked by vertical beds, from which those on both sides have a gradual fall to an angle of 70°. The beds thus always exhibit a tendency to assume a vertical position.

If the rock be more closely examined, we find that where it is foliated, it shows a more or less distinct strike; this may be perceived even in the granite-like gneiss, but it may be most clearly seen on the long foliated surfaces where the rock is split into flags. The direction of this stretching coincides everywhere very nearly with the dip, or, what is the same thing, with the rise of the beds. The rock exhibits therefore, not only in its general structure but also in its texture and in all the minute details of its constituent parts, a decided tendency to a vertical position.

Every theory of the formation of this gneiss-granite in the Alps, may assuredly be required to explain in some measure a condition of texture at once so general and so regular. The doctrine of metamorphism may perhaps find a poor support in the stratification and foliation of the rock, but certainly is not able to assign any sufficient cause for the stretching or tension. This appearance,

* Lehrbuch der physikalischen Geographie, s. 331.

as well as the fan-shaped disposition of the stratification of these masses cf gneiss-granite, and also their position in the axis of the whole chain of the Alps, between totally distinct, slaty, gneissose, or granitic rocks, on which, farther from the centre, the Alpine limestone is superimposed unconformably, but without disturbance*, whilst large masses of these underlying siliceous rocks have again been pushed upwards and outwards above this limestone—all these facts, as well as many others, indicate that these gneiss-granites in the Alps have had an eruptive rather than a metamorphic mode of origin.

Among the older felspathic rocks, I know none which have a finer and more regular parallel texture, or a more decided bedded structure, than the granulite of Saxony. When examined with the magnifying glass, we may frequently see the very delicate plates of quartz intercalated among the fine-grained felspar with wonderful regularity, and in several localities the most beautiful slabs are obtained. We are taught therefore by the whole architecture, the position and the limitation of the Saxon granulite formation, that it is absolutely impossible that its beds were originally sedimentary deposits, subsequently changed into masses of felspar rock †. On the contrary, we are almost forced to adhere to the view long since announced by Weiss, that it is of eruptive origin. If this be so, then does the granulite formation of Saxony afford one of the most remarkable examples of an eruptive rock exhibiting throughout parallelism of texture and a bedded structure. It points further to the probability, that certain gneiss formations have had a similar origin, for the varieties of granulite which contain much mica are so like gneiss, that it is impossible, in fact, to distinguish the one from the other.

The opinion that, besides metamorphic and hypogene gneiss, there also exists eruptive gneiss, cannot therefore be longer considered as a wholly unfounded hypothesis.

[L. H.]

On the Position in which the Mammoth *and* Rhinoceros *have been found in* Siberia, *from a Letter to* Baron A. von Humboldt *from* Professor Brandt *of St. Petersburg.*

[From the Monatsbericht der Akademie der Wissenschaften zu Berlin, 1846, p. 222.]

Except the individual procured by Adams, no complete specimen of the mammoth has ever reached St. Petersburg; for the skeleton in the museum of the Mining Corps, chiefly made up of wood, can

* That is, without being disturbed by the inferior gneiss, for at a later period both rocks have undoubtedly been raised up together. Let any one, for example, examine the section of the limestone above Lauterbrun, from Stachelberg to the Upper Rotthal, where the lowest beds of the intermediate formation consist of a sandstone formed from the collected quartzy detritus of the *same* gneiss on which they rest.

† The vouchers for these assertions will be found fully set forth in the Geognostical Description of the Kingdom of Saxony, Parts 1st and 2nd.

hardly be taken into consideration. It was indeed reported in 1845 that the merchant Traphinow in Beresow had sent a mammoth skeleton, found at the mouth of the Jenesei, to the Moscow museum; but I understand that on this there are only a few ill-preserved remnants of the soft parts; and unfortunately nothing is known of the geognostic conditions in which it occurred, no competent person having seen it in the place where it was discovered.

The following observations on Adams's mammoth and the Wilui rhinoceros (*Rh. tichorhinus*) may, however, not be without interest, as I have paid particular attention to the state of preservation of these relics. I regard it as especially important that the head and foot of the Wilui rhinoceros, as well as the soft parts of the mammoth, are still covered with an uninjured skin on which hair grows, as this part is very soon destroyed and separated from the body by putrefaction. This seems a proof that the bodies of the mammoth and rhinoceros have not been brought by floods from the far-distant south to this northern region.

The thick covering of hair on both animals also shows that a tropical climate was not absolutely essential for their existence. Its dense coat of wool especially adapted the mammoth for a cold climate; and though the rhinoceros, which wants this defence, may appear less qualified for living in the north, yet other circumstances prove that this was also its true abode. I have been so fortunate as to extract from the cavities in the molar teeth of the Wilui rhinoceros a small quantity of its half-chewed food, among which fragments of pine leaves, one half of the seed of a polygonaceous plant, and very minute portions of wood with porous cells (that is, small fragments of coniferous wood), were still recognizable. My colleague M. Meyer has undertaken the further investigation of these singular remains.

It was also remarkable, on a close investigation of this head, that the blood-vessels discovered in the interior of the mass appeared filled, even to the capillary vessels, with a brown mass (coagulated blood), which in many places still showed the red colour of blood. On observing these vessels in the head, so completely filled with the remains of blood-globules, I could not repress the idea that the animal to which they belonged had met its fate from asphyxia, probably during drowning.

In order to complete the earlier, very imperfect, observations of Arganow and Pallas on the geognostic position of the Wilui rhinoceros, it seemed to me of importance to examine the portions of earth still adhering to it in some places. I therefore not only had them examined by my friend Helmersen, but also made microscopical observations on them myself. We found on the rhinoceros remains two kinds of earth. By far the most abundant consisted of microscopic grains of quartz, enveloped in a fine clayey mud with small fragments of mica. Its colour, probably from iron, is brownish grey, sometimes with a bluish tinge. It feels somewhat greasy, and contains fragments of hair and other animal matter. It does not effervesce with acids. The animal matter easily takes fire, and burns with a bright flame, emitting a fatty odour. In the microscopic investigation of the earth, detached vegetable fragments with yellowish dotted cells, similar to those of coniferæ, were found. Occasionally I succeeded in discovering greenish fragments of plants, which I considered as indications of freshwater algæ. I have not as yet observed any remains of infusoria. The other kind of earth, of a bluish grey colour and very friable, occurs in spots on particular parts of the head, and from Helmersen's observations is blue iron-earth (phosphate of iron or vivianite). The earth attached to the remains of the rhinoceros may therefore be considered as a deposit from fresh water which has enveloped the body of the animal sunk in the mud. This is more probable, from the fact that the Siberian rivers are well-known to carry down large quantities of mud.

The earth adhering to the soft parts of the mammoth is in every respect similar, except that I have found no blue iron-earth. Adams's mammoth, therefore, was assuredly buried in the frozen earth, and not merely enclosed in a block of ice. The belief so prevalent among various nations in Northern Siberia, that the mammoth lives under the earth, also confirms this view of the occurrence of its remains in the frozen soil.

This opinion, that the bodies of these Siberian pachyderms were covered with mud by streams of fresh water, seems, at first sight, to be contradicted by the fact, that M. von Middendorf found in Siberia, 300 versts from the Polar Sea, along with the fragments of a mammoth skeleton, remains of sea-shells of species still living in the Arctic ocean. But this mammoth skeleton might have been washed out of its original place by the sea, and again imbedded along with the remains of these mollusca.

The circumstance that we know of three distinct mammoth carcases or skeletons, found at different times and in different places in an upright position, may well induce us to believe that these great pachyderms had first sunk in the mud and were afterwards gradually more and more covered up by subsequent deposits. If this is a true view of the case, it follows that they were destroyed, not by a flood from the south, but rather by one from the north; if indeed, which perhaps is not fully proved, an inundation of the ocean is at all necessary.

I am acquainted with the following notices, mostly unpublished, of mammoths found in an upright position, which I now mention, as the mode of their occurrence may appear of interest to you.

Saritschew * relates that the carcase of the mammoth, at least partially covered with skin and hair, which was discovered by him washed out of the sandy bank of the river Alasseja, was originally in an upright position. According to a verbal communication of M. von Pander, the fragments of the mammoth skeleton found some twenty years ago on the bank of a river near St. Petersburg had also an upright position. The worthy Conservator of the Herbarium of the Academy, Dr. Ruprecht, heard, during his journey to the

* Reise, Bd. i. s. 106.

peninsula of Lomin, from M. Okladnikow, a citizen of Mesen, that in the year 1839 he found near Lake Lohaloto, 50 versts from the mouth of the Yarumbe, on the Obi peninsula, a mammoth skeleton in an upright position.

The thick coat of mud that evidently enclosed the bodies of the Wilui rhinoceros and Adams's mammoth was probably sufficient to protect them completely from the influence of the atmosphere, and consequently from putrefaction, until they were subsequently frozen and thus preserved for thousands of years as a puzzle to naturalists. It is thus not necessary to imagine a sudden, inexplicable, irruption of a glacial epoch, and a no less inexplicable instantaneous cooling down of the northern hemisphere, in order to explain the occurrence of the carcases of these pachyderms, which were probably killed by asphyxia (drowned). In consequence of the former higher temperature of the globe, Siberia, when it was the abode of these pachyderms, may indeed have been warmer than at present; but the fragments of food from the teeth of the rhinoceros above-mentioned do not indicate the vegetation of a warm region.

[J. N.]

On the Rock-Salt *Deposit at* Stassfurth, *and on the occurrence of* Boracite *as a Mountain Rock in that Formation.* By M. Karsten.

[From the Berlin Monatsbericht for 1847, p. 14.]

The richness of the salt springs at Stassfurth, which contain 17·16 per cent. of saline matter, and the character of the rocks in the vicinity, left no doubt that the salt deposit by which they are fed existed at no great distance. The principal well is 171½ feet deep, of which 34½ feet are in the alluvial soil and the detritus accumulated by the Bode, the spring lying close to the right bank of this river. The remaining 137 feet pass through soft, clayey, red-coloured beds of sandstone, belonging to the variegated sandstone formation (Bunter Sandstein). About 170 feet from this well a bore was commenced in 1839, in search of the salt deposit. The opening of the bore is 221 feet above the sea, and the following beds were passed through in descending order: 26 feet alluvium, 556 feet 2 inches variegated sandstone, 67 feet 5½ inches gypsum, 147 feet 9½ inches anhydrite, in which the first traces of rock-salt appeared at the depth of 790 and 794 feet. A deposit 28 feet 10½ inches thick followed, apparently consisting of bluish grey marl, white and red coloured gypsum and grey limestone, alternating in rapid succession, but without any definite order. This bed apparently belongs to the rock-salt formation, though this mineral did not appear in the fragments brought up by the borer, having probably been dissolved in the water. The bed of rock-salt was reached at a depth of 826 feet 3½ inches, or 605¼ feet below the sea-level, and the boring has been continued in it for 154 feet 5½ inches; so that in December 1846 the bore had a total depth of 980 feet 9 inches.

Even in the first 60 feet of depth, salt water with 7·9 per cent. saline matter (Rohsalz) was found, which rose to within 18 feet of the surface. At 550 feet depth in the sandstone, the salts had increased to 12·7 per cent., and rose rapidly to 18·3 per cent. in the soft white gypsum, and in the anhydrite beds to 21·8 per cent. Unfortunately these salts were not compared chemically with those of the neighbouring salt spring, which contain only 5·507 per cent. of impure salts, and consequently 94·493 of pure chloride of sodium. This is especially to be regretted, because in the firm compact anhydrite at 776 feet 9 inches the saline matter suddenly rose to 27·401 per cent., or nearly to saturation.

The joy at the discovery of this rich salt spring, whose specific gravity and consequently saline contents further increased in the rock-salt, was however disturbed by the discovery that in the 31·1 per cent. of saline matter it then contained, there was only 15·815 per cent. of common salt, and consequently more than a half was foreign salts, of which 12·99 per cent. was chloride of magnesium. This well therefore contained less common salt than even the neighbouring spring with only 1·13 of specific gravity. This unexpected event caused the investigation of the rock-salt first bored through, when it appeared that it consisted of common salt and epsomite (Bittersalz) in very variable proportions, they being probably altered and partially dissolved by the water of the spring before reaching the surface. Only once some fragments of the rock-salt were obtained apparently in an unaltered condition. Analysis showed the very peculiar composition of this salt, in which 10 atoms of common salt (chloride of sodium) were combined with 1 atom anhydrous epsomite (sulphate of magnesia), so that the *Martinsite* consists of 90·73 of the former and 9·27 of the latter; three analyses having given 90·98 and 9·02 respectively, not taking into account 0·3 per cent. of matter insoluble in water, which was at first supposed to be gypsum, but on further investigation found to be chiefly boracite. The Martinsite yields a bituminous odour when rubbed, and crackles when dissolved in water, like the decrepitating salt of Wieliczka.

As the boring proceeded in the rock-salt, the saline matter, contrary to expectation, became more impure, the water not only containing a larger proportion of epsomite, but also of earthy matter insoluble in water. The water from the depth of 963 feet yielded 33·28 per cent. of saline matter; but in this there was only 7·15 per cent. of common salt, the essential constituents being epsomite and chloride of magnesium. The water was also very impure with gypsum and other substances. In the salts obtained by evaporation hydrous peroxide of iron occurs, which seems to exist in the water, not as the protoxide combined with carbonic acid, but as a muriate of the protoxide of iron, as the clear water, after remaining long exposed to the air, deposits a basal muriate of the peroxide of iron. The great diversity in the nature of the salts in this well and in the original spring only 170 feet distant, is however very difficult of explanation.

Great quantities of debris falling into the bore from the bed

28 feet 10½ inches thick, immediately below the anhydrite, it became necessary to clean it out thoroughly. In this process fragments of a compact mineral, remarkable for its pure, almost snow-white colour, were brought to the surface. Here it soon assumed a dirty white, or rather pale yellowish white colour. Its specific gravity is 2·9134 (at 12° C.), and its hardness between 4 and 5. In external appearance it agrees with white limestone. On analysis it was found to consist of the following substances:—

29·48	magnesia.
69·49	boracic acid.
1·03	carbonate of protoxide of iron with traces of carbonate of protoxide of manganese and of hydrous peroxide of iron.
100·00	

The mineral has consequently the exact composition of the boracite, hitherto only found crystallized in the gypsum at Luneburg and at Segeberg in Holstein. The large quantity of compact boracite brought up from the small bore, only 4 inches in diameter, renders it probable that it forms an essential portion of the rock-salt formation at Stassfurth. This fact is not only interesting in itself, but also as furnishing an explanation of the vapours of boracic acid that escape from the earth in some parts of Italy and of the borax lakes of Thibet. It is probable that compact boracite may be found in other rock-salt deposits, since, from its great similarity in external characters to limestone, it may easily have been mistaken for this, or overlooked.

[J. N.]

The Cephalopods *of the* Salzkammerguts, *from the collection of* His Excellency the Prince von Metternich; *a contribution to the Palæontology of the Alps.* By Franz von Hauer (Die Cephalopoden des Salzkammergutes, etc.), with a Preface by William Haidinger. Vienna, 1846, 4to. pp. 48, eleven plates.

In this work, published at the expense of Prince Metternich, the son of the Privy Counsellor, Von Hauer, whose collection of fossil foraminiferæ is now so well known from the description of D'Orbigny, gives an account of some of the remarkable Ammonites and other fossils found in the neighbourhood of Hallstatt. These remains were often seen in collections, but had rarely been described or figured. In this work the following species are fully noticed and represented in the accompanying plates:—*Ammonites Metternichii*; *A. neojurensis,* Quenstedt; *A. debilis*; *A. galeatus*; *A. subumbilicatus,* Bronn; *A. amœnus*; *A. Ramsaueri,* Quenstedt; *A. angustilobatus*; *A. tornatus*; *A. bicrenatus*; *A. salinarius*; *A. Johannis Austriæ,* v. Klipstein; *A. discoides,* Ziethen; *A. respondens,* Quenstedt; *A. bicarinatus,* Münster; *A. angustatus,* Bronn; with some doubtful species. Of Goniatites, only one species, the *G. decoratus,* from the red marble of Hallstatt, is noticed. A fragment, too imperfect to permit of the genus being certainly determined, is referred to Clymenia, of which it would evidently form a new species. Nautilus is represented by three species, *N. mesodicus*, Quenstedt, *N. reticulatus* and *N. acutus*, with some doubtful fragments, one of which much resembles in form the *N. elegans*, Sow., and like this, has the surface covered with fine transverse wrinkles, but the siphon perfectly central. Of Orthoceras three species are certainly found, *O. alveolare*, Quenstedt, *O. latiseptatum* and *O. salinarium*, besides some doubtful species, the specimens being imperfect, but probably *O. regulare*, *O. striatulum*, v. Münster, and *O. ellipticum*, v. Münster. There are probably two species of Belemnites, which cannot be definitely determined. One has an arrow-shaped sheath, exactly like the *B. hastatus*, Blainville, and is above two inches long and four lines thick ; the other, about as long, has a very sharp-pointed conical sheath, and may be compared with the *B. unisulcatus*, Blainville. On a polished specimen of marble from the Steinbergkogel, some oblique sections of Belemnites are visible, but the species cannot be determined. As, notwithstanding the observations of Dr. A. Boué, the occurrence of Orthoceratites and Belemnites in the same formation with Ammonites has been frequently doubted, and is of considerable geological interest, we give the following notices on this subject. In the royal Montanistic Museum is a slab of marble, on one side of which is a specimen of the *Ammonites Metternichii* 24 inches in diameter, figured in pl. 2 of the work before us. In consequence of decomposition the markings of the lobes are well seen. The chambers are filled with red marble, whilst the remaining portions of the shell are converted into white calcspar. In this specimen the whole shell is full of dividing septa, so that the last chamber in which the animal lived must be wanting. Were this added in proper proportion, the whole shell would be nearly three feet in diameter.

On the same slab there are an extraordinary number of other fossil organisms, exposed by the weathering of the stone. This specimen alone is sufficient to remove the doubts so often expressed regarding the union of Ammonites and Orthoceratites in the limestone of the Austrian Alps. On it three distinctly recognizable Orthoceratites appear. The first, near the umbilicus of the large Ammonite, is but imperfectly represented in the figure. Its point is broken off, but there may still be perceived three of the usual chambers, then one considerably smaller, and then the last large chamber in which the animal lived. According to M. von Barante, who has recently examined the numerous Orthoceratites of the Bohemian transition formation in a very careful manner, the frequent occurrence of a chamber considerably smaller than the others immediately before the last may be thus explained, as he stated personally when inspecting the specimen now under consideration. The last partition continues to move forward by a constant deposition of calcareous matter on its outer surface towards the opening of the shell, and a removal of it from the inner surface till the cavity has attained its normal size, when it remains fixed, and a new septum is formed close on the former, which is moved forward in a similar manner. This mode of increase reminds us of some inorganic formations in which deposition on the one side is conjoined with solution on the other. Even in the large Ammonite the last chamber visible is considerably smaller than the previous ones. A second Orthoceratite, not seen in the plate, is found on the corner of the slab, and belongs to another species. A third, of which a cross section is visible, appears near the side, the rather excentric siphon being distinctly recognizable.

Further we find, and all on the same side with the large Ammonite, forty to fifty smaller Ammonites, from a line to three inches in diameter, which belong to various species, the most common being the *A. galeatus*, then the *A. tornatus*, Bronn, whilst many others, from their imperfect preservation, are no longer to be determined.

A third genus of Cephalopod, the Belemnites, is found on this remarkable slab in considerable abundance, one of them being represented in the figure. This confirms a statement of Von Lill which has often been doubted. The species of these Belemnites cannot however be determined till other specimens render a more accurate examination possible.

On the same specimen are many Gasteropods which cannot be determined, then bivalves, among which is a tolerably distinct *Nucula*, and lastly a multitude of crinoidal stems and many other organic remains whose true nature has not yet been made out.

This specimen was found on the summit of the Steinbergkogel near Hallstatt by M. Ramsauer. On the age of the formation in which it occurs geologists and palæontologists have expressed various opinions, of which only the more recent, by a few distinguished naturalists, require to be noticed. Lill v. Lilienbach, whose two sections in the northern Alps must still be classed among the best geological works on this region, depending chiefly on petrographical grounds, considers this formation as jurassic. Professor H. Bronn, who examined accurately the petrifactions collected by Von Lill, is of opinion it must be classed in the lias, which here however contains transition fossils (*Uebergangs-Petrefacten*). Professor Quenstedt finally, who has himself visited the district of Hallstatt, examined the rich collections of MM. Ramsauer and F. Simony, and himself collected a great number of its fossils, and at a later period obtained others from M. P. Mohr, believes himself justified in declaring these beds to be the lower chalk or Néocomien.

On pure palæontological grounds either of these analogies may justly be preferred to the others; and if, for instance, Prof. Quenstedt assumes that the species of the transition period had here anew revived in the chalk, we may with equal probability assert that forms peculiar to the chalk had in the Alps already existed in the Jurassic or Lias epoch.

Perhaps it would be expedient, before attempting to assign to the particular deposits of the Alps a special place in the series of stratified formations as they exist in other parts of Europe, to study with more exactness each of the deposits in this chain and the petrifactions which they contain. When the succession of the formations in the eastern Alps is once established with complete certainty, and the fossils peculiar to each are known, then their greater or less similarity to the formations of northern and western Europe will appear of itself, whereas the attempt to find a parallelism between individual beds has always led to very unsatisfactory results. The limestone of the eastern Alps contains a far greater number of fossils than is usually supposed, and every day brings new discoveries. Assuredly here more than in almost any other place, accurate palæontological study is the indispensable assistance to unravel the very various and highly-developed formations that are comprised under the collective name of the Alpine limestone.

The relations of the Hallstatt marble beds to the neighbouring formations are as yet but imperfectly investigated. They occur, in almost vertical strata, on the summit of the Sommerau and Steinberg-kogels in the Hallstatt Salzberg, immediately on the border of the salt-formation. Their relation to this deposit, whose mode of origin is still very doubtful, is not certainly determined. V. Lill considers them as lying below the salt-formation, but this opinion still requires more thorough examination.

The lower portion of the Salzberg, towards the Echernthal, as well as all the other mountains surrounding the Hallstatt lake, consist of a grey, very distinctly stratified, limestone, forming the lower beds of the so-called older group of Alpine limestone, and especially characterized by the frequent occurrence of a large bivalved shell. The same shell, which will assuredly in future form one of the most important means of recognizing a peculiar horizon (*étage*) in the Alpine limestone, occurs in many places in the Alps, as, among others, at the waterfall near Golling, well-known under the name of the Salza-öfen, and on the summit of the Dachstein, where M. Simony says it is found in innumerable specimens. This grey limestone is developed to a vast extent near Hallstatt, but lies under the marble. Below the grey limestone, but whether immediately or separated by strata of a different character is still undecided, follow the beds which V. Lill has named the red slate of Werfen, and still deeper greywacke, in which the mining director Erlach has recently found, at Dienten in Salzburg, true transition petrifactions. Among them are Orthoceratites, *Cardium priscum*, Goldf., as near Beraun in Bohemia, and other fossils, all changed into iron pyrites.

An exactly analogous succession of strata to that in the vicinity of Hallstatt exists in the southern Alps in the district of Bleiberg. The geognostic relations of this region, partly exhibited in the lead-mines which have been wrought there for many centuries, were first thoroughly explored by L. von Buch. The opalescent shell marble, well-known in all mineral collections, which forms a thin bed in a black-coloured clay-slate, known in the Bleiberg under the name of *Lagerschiefer*, contains beautiful specimens of the *Ammonites Johannis Austriæ*, V. Klipstein, and consequently corresponds to the marble beds of Hallstatt; but not, as V. Lill supposes, to what he calls the slaty sandstone group of the Alpine limestone. Below it, and distinctly stratified, lies the Bleiberg limestone, in which lead ores are found. This again contains the same bivalve shell with the grey limestone near Hallstatt. It was distinguished by Boué as an *Isocardia,* and occurs here in smaller but better-preserved specimens than at Hallstatt.

Below the limestone with lead ore follows red sandstone, which is found both north of Bleiberg in the Drauthal and also on the south-west in the so-called Windische Graben. Still lower is greywacke and greywacke-slate with numerous petrifactions, among which M. Lipold very recently detected Trilobites. Count Keyserling and M. Barrande, who lately examined these fossils when in Vienna, discovered among them several forms peculiar to the coal formation. The series of strata therefore from below upwards appears in both localities to be this:—

1. Greywacke and greywacke-slate.
2. Red sandstone.
3. Grey stratified limestone with Isocardia.
4. Cephalopod strata.

Since the above work appeared F. von Hauer has published* a description of some additional species of Cephalopods from the red marble of Aussee. To the three Orthoceratites formerly described he now adds three new species also associated with Ammonites. This younger generation of that ancient family presents no general characteristic distinction from the older species, except perhaps in the greater width of the chambers. In three species the siphon is central, in other three close on the margin. The species described are, *O. reticulatum, O. alveolare,* Quenstedt, *O. convergens,* with marginal siphon, and *O. dubium,* with perfectly central siphon. The *Nautilus mesodicus,* Quenstedt, he now considers as probably a mere variety of the *N. giganteus* of D'Orbigny (Terrains Jurassiques, pl. 36). To this he now adds *N. Sauperi, N. Breunneri, N. Barrandi.* The latter belongs to the division (*N. Imperfecti* of Quenstedt) with perforated umbilicus, of which only one, *N. excavatus,* Sowerby, has hitherto been found in the lias; the others, according to De Koninck, being all palæozoic. The only new Goniatite is the *G. Haidingeri.* Of Ammonites ten species are noticed, *A. Gaytani,* v. Klipstein, *A. Ausseeanus, A. Johannis Austriæ,* v. Klipstein, *A. Layeri, A. Simonyi, A. Jarbas, A. noduloso-costatus,* v. Klipstein, *A. striato-falcatus, A. Credneri,* v. Klipstein, and *A. tornatus.*

This addition to the fauna of the formation does not tend more to decide its age than the species already known from the vicinity of St. Cassian, Hallstatt, Bleiberg, &c. For whilst a series of Ammonites with uneven margin (*ringsgezacten*) and two of the Nautili (*N. Sauperi* and *N. Breunneri*) have in general partly the aspect of jurassic, partly of cretaceous species, on the other hand the new Orthoceratites, the *N. Barrandi* and *G. Haidingeri,* increase the

* In Haidinger's Naturwissenschaftliche Abhandlungen, Bd. i. (Wien, 1847), p. 257–277. Compare also Ib. p. 21–30, On the Cephalopods of the Shell-marble of Bleiberg.

similarity to the fauna of the transition period, and strengthen the view that this is a formation peculiar to the chain of the Alps and Carpathians.

The connection of the beds on the north and south sides of the Alps is much strengthened by these researches, as many species have recently been found at Aussee identical with those of St. Cassian and Bleiberg. There is indeed a closer resemblance between these places and Aussee than between them and Hallstatt, nay even than between Aussee and Hallstatt, which lie so near each other. Thus the most common species in Aussee, *A. Johannis Austriæ* and *A. Gaytani*, have never been found in Hallstatt, whilst the species common to both localities, as *O. alveolare*, *A. tornatus*, show many variations.

[J. N.]

On Organic Substances, recognizable by the microscope, found in the Meteoric Ashes which fell on the 1st of May 1812 *in the Island of* Barbadoes, *and changed the day into night.* By Professor Ehrenberg.

[Monatsbericht der K. P. Akademie der Wissenschaften zu Berlin, 1847, p. 152.]

The mixture of organic matter and of very minute but still entire and distinctly recognizable organic beings in deposits of meteoric and volcanic dust has already, by various communications made by me to the Academy, been shown to be of extensive occurrence, and is evidently a matter of great and varied scientific interest. The well-known shower of dust in Barbadoes, which in 1812 occurred simultaneously with the violent eruption of the volcano on the island of St. Vincent, and shortly after the terrible earthquake of Caraccas, is one of the most remarkable of volcanic phænomena, and every new fact connected with an event so extraordinary and so opposed to the common order of nature seems well-deserving of attention. In order to appreciate the new observations, it will be necessary to give a short summary of the circumstances in which this shower of dust took place*.

On the evening of the 30th of April 1812, a noise so like a violent discharge of artillery was heard for some time in the island of Barbadoes, that the garrison of Fort St. Anne remained all night under arms. On the morning of the 1st of May the eastern horizon of the ocean was clear and with a distinct outline, but immediately above it there appeared a black cloud, which soon covered the remaining part of the sky, and spread over that part of the sky where the day was beginning to break. The darkness was soon so great, that in a room it was impossible to distinguish where the windows were, and several persons in the open air could not discern either the trees close at

* The occurrences in Barbadoes were first noticed in the 'Edinburgh Monthly Magazine,' from which the notice in the 'Annales de Chimie et de Physique,' 1818, t. ix. p. 216, was taken. The first account of the events in Barbadoes is found in the 'New England Journal of Medicine,' vol. ii. No. 1, Jan. 1813, whence it is copied into the 'Trans. of New York Philos. Soc.' 1815, vol. i. p. 318.

hand or the outline of the houses. At five inches from the eye even a white handkerchief was no longer perceptible. This appearance arose from a thick shower of volcanic ashes from an eruption on the neighbouring island of St. Vincent. This peculiar rain and the darkness it produced ceased between twelve and one o'clock in the middle of the day, but by the aid of a lantern, the dust had been observed to fall several times in the forenoon in particular abundance. Some trees bent under the weight, others broke, the crash of the branches forming a remarkable contrast with the perfect stillness of the air. The sugar-canes were completely crushed down, and the whole island was covered an inch thick with a layer of greenish ashes.

The relative position of the islands of Barbadoes and St. Vincent gives peculiar interest to this occurrence. The latter island, as is well-known, lies twenty leagues west of the former. In that region the trade-wind, especially in April and May, blows uniformly and without interruption from the east, with a slight deviation to the north. We must therefore admit that the volcano of St. Vincent threw up the immense mass of dust that fell on Barbadoes and the surrounding sea, not only to such a height as to be beyond the influence of the predominating trade-wind, but also into a region where one in an opposite direction prevailed. This is an exceedingly welcome fact to natural philosophers, according to whose theory of the trades there must be a constant return-current above from west to east, since it is exactly this current which, on the 1st of May 1812, brought the volcanic dust from St. Vincent to Barbadoes, thus establishing the existence of the aërial current which is required to explain the phænomena.

The chemical analysis of a specimen of these ashes brought to England, of which Dr. Thomson published a short notice in the fourth volume of his Journal in the year 1814, gave in 100 parts: 1 of iron peroxide, 8 of lime, and 90 of silica and alumina.

The phænomena on the island of St. Vincent were shortly the following:—

The Souffrier Mountain, or Morne Garou, the most northern and highest summit of the lofty chain which traverses the island from north to south, though constantly emitting smoke, had yet never been in a state of eruption from 1718 to 1812. About 2000 feet above the sea, and scarcely more than two-thirds of its whole height, there was a circular ravine about half a mile in diameter and 400 to 500 feet deep. In the centre of this wide cavity a conical hill, about 200 feet in diameter, rose to the height of 260 to 300 feet, its lower half being thickly covered with brushwood and vines, whilst the upper half to the summit was bare and strewed with natural sulphur. From fissures in the cone and the intervals of the stones a thin white smoke incessantly escaped, sometimes coloured by a bluish flame. At the southern and northern base of the cone were two cavities full, the one of perfectly pure water, the other of water strongly impregnated with sulphur and alum.

On Monday the 27th of April 1812, exactly at twelve o'clock, a tremendous crashing of the mountain, with violent earthquakes, threw the whole neighbourhood into consternation. An immense pillar of thick, black, clammy-like smoke was seen rising up into the sky, and throwing down small fragments of burnt earth and ashes mixed with sand on the country around. This shower of sand and ashes, driven by the wind towards Wallibon and Morne Ronde, darkened the heavens like a thunder-cloud, and covered everything with pale grey ashes like dirty snow. This shower of ashes quickly destroyed every trace of vegetation. On the 28th the fall of ashes increased; the pitch-black pillar rose perpendicularly from the crater, with a continuous noise as of violent thunder. On the 29th the sun was darkened so that at midday it seemed only twilight. On the 30th of April these phænomena were still more increased; birds and cattle were killed by the ashes and the want of food. Soon after seven in the evening, electric flames and lightning were seen quivering through the dark cloud above the crater in an indescribable manner, and the glowing lava overflowed. In about four hours it had reached the sea. About half-past one a huge lava-stream burst out on the east towards Rabocca. About two o'clock a shower of small cinders fell, and about three o'clock larger stones mixed with fire. Some of the stones were as large as a man's head, but were not heavy. This continued about an hour, when the cinders again began to fall. The oscillation of the ground was incessant.

On the 1st of May the darkness continued to eight o'clock. An impenetrable, dark, black cloud enveloped the mountain and hung over the sea. The thundering of the mountain first ceased after midday.

Of the so-called May-dust or ashes which was deposited on Barbadoes in these circumstances, Sir Robert Schomburgk has sent me several packets, at the same time expressing a wish that I would submit them to microscopic investigation.

I have received four separate packets of this dust, but with no further account of its origin than that it was collected in Barbadoes on the 1st of May 1812. On an accompanying memorandum it is said: "May Dust. Different kinds of ashes which fell in Barbadoes on the 1st of May 1812, after the eruption of the Souffrier in the island of St. Vincent."

All the varieties of dust are mealy, but of high specific gravity. Nos. 1, 2, 3, greyish-brown, No. 3 being somewhat darker and with an olive-green play of colour. No. 4 is paler than the others, approaching to yellow, and sensibly coarser in the grain. All the four varieties are, however, homogeneous and fine, but not so fine as the yellow Atlantic dust of the Cape Verd islands. They grate between the teeth, but without being hard, as if a slight pressure sufficed to crush still more the fine particles. According to outward appearance, these specimens of ashes have been preserved from intermixture with foreign matter since 1812, and are still in their original purity, on which point perhaps Sir Robert Schomburgk can give some special information.

Microscopic analysis showed that the dust consisted chiefly of glassy, translucent, but often rounded (fused) particles, which by transmitted light had often a brownish and yellow, sometimes a reddish-brown or black colour. Among these are cellular particles perfectly similar to pumice-stone rubbed down; and often small crystals, which appear like pyroxene crystals, and show a greenish colour, but many are colourless. In form they are constantly prismatic, with an obtuse acumination. Consequently molten, baked, and merely mechanically divided siliceous portions with crystals form the chief part of the mass, which is predominantly vitreous.

Besides these inorganic substances, there is found in each portion as large as a pin-head ($\frac{1}{4}$–$\frac{1}{3}$ of a line) a trace of distinctly organized matter in the form of small siliceous shells of animals or fragments of plants (Phytolitharia), and also carbonized soft parts of plants.

In fifty accurate analyses of such small portions, nineteen distinct organic bodies, some in several specimens, have been recognized, as in the following table:—

	I.	II.	III.	IV.	Times observed.
A. Polygastrica.					
1. Achnanthes exilis?	–	–	+	–	1
2. Arcella hyalina	–	+	+	–	8
3. vulgaris?	–	+	–	–	3
4. Difflugia areolata	–	+	+	–	6
5. Eunotia	–	+	–	–	1
B. Phytolitharia.					
6. Lithasteriscus tuberculatus	–	+	+	–	3
7. Lithodontium furcatum	–	+	–	–	1
8. nasutum	–	+	–	–	1
9. platyodon	+	...	...	...	1
10. rostratum	–	+	–	–	2
11. Lithostylidium amphiodon	–	+	–	–	2
12. rude	–	+	+	–	10
13. Serra	–	+	–	–	1
14. unidentatum	–	–	+	–	1
15. Trabecula	–	–	+	–	1
C. *Doubtful Organic Siliceous particles.*					
16. ?	–	+	–	–	1
17. ?	–	–	–	+	1
D. *Soft parts of Plants carbonized.*					
18. Hairs of plants	–	–	+	–	1
19. Cellular tissue of plants	–	–	+	+	2

Of the fifty analyses, 2 referred to No. I.; 13 to No. II.; 23 to No. III.; and 12 to No. IV. All the packets exhibited similar organic mixtures, but they were fewest in No. IV., which is the coarsest. On washing a portion of No. II. I found the finer parts richer in organisms. On the whole, no portion of No. II. as large as a pin-head was found without organic matter. In No. III., of 20 such portions, 7 were barren. The number of times that each of the above forms recurred is given in the fifth column of the table.

From these facts the following conclusions may be drawn:—

1. The May-dust of Barbadoes in 1812, which formerly was only conjecturally derived from the island of St. Vincent, and which even Thomson's analysis did not characterize as volcanic, has now, by my method of precise microscopic analysis, been scientifically determined to consist of pumice-dust and of crystals (very probably of pyroxene), so that its connection with the eruption on St. Vincent is now proved from the substance itself.

2. One of the greatest and most interesting showers of volcanic dust which can be traced back to its origin, has now been shown to contain organic matter.

3. The organic bodies in volcanic ashes are not only always found in the commencement of an eruption, but appear in this majestic outburst even at its conclusion, and consequently are probably not derived from the mere external surface. They are also, though the molten and baked condition of the ejected matter is very unfavourable to the observation of its original condition, probably intimately and abundantly mixed with it.

4. The organic portions of the Barbadoes' May-dust present no such peculiarity of form as to withdraw them from the middle or more recent periods in the formation of the earth, and to consign them to a more ancient period in which other laws prevailed. They are chiefly forms well-known since the tertiary period, and still existing.

5. The distinct organic bodies are *entirely* and *solely* species known as freshwater and continental forms. There does not occur among them a single marine form.

6. As the island of St. Vincent has no snow mountains, also no large rivers or marshes, which could furnish an abundant superficial supply of this muddy matter, it appears in this case that the matter which could by any possibility be drawn in from the surface bears no proportion to that thrown out, so that this method of explaining it is not applicable.

7. The access of sea-water in order to excite the activity of the volcano on St. Vincent's is decided in the negative, by the absence of all marine organisms in the ejected matter, which contains so many of freshwater origin. But, in like manner, there is no probability of the infiltration of meteoric water from the arid vicinity of the volcano. But how wide do its roots extend? Must we not actually imagine a direct subterranean communication with the remote Quito, or at least with Venezuela? The great geologist of those lands, Alexander von Humboldt, has long expressed this opinion on general grounds:—Relation Histor. vol. ii. p. 15. Compare L. von Buch, Canar. Inseln, pp. 313, 399, 400.

8. Is there a deposit of moist coal, or turf, or bituminous tripoli under Morne Garou, which the lava, forcing its way from the interior, continued to eject from the beginning to the end of the eruption?

[J. N.]

On the Formation of Mineral Phosphates (*Ueber die Bildung phosphorsaurer Mineralien*). By Prof. G. Bischof of Bonn.

[Verhandlung. der Niederrhein. Geselsch. zu Bonn vom 15 Dez. 1846. From an abstract in L. and B.'s Neues Jahrbuch, 1847, p. 367.]

Apatite, the most widely distributed of the minerals containing phosphoric acid, is very probably the source whence not only the greater number of other similar minerals, as for instance the phosphate of copper, the green phosphate of lead, &c., have been produced as secondary formations, but also from which the phosphoric acid so very generally diffused in the vegetable and animal kingdoms has been and still continues to be obtained. Prof. Bischof found that the apatite is soluble in water containing carbonic acid, although requiring a larger quantity of it than the phosphate of lime prepared as an artificial salt, or even than the bones. The apatite is extracted from mountain rocks by water of this nature, and such very weak solutions either produce new mineral phosphates, or are imbibed byplants and the acid thus conveyed to the animal kingdom. M. Bischof mentions the occurrence of vivianite in the bones of the human skeleton. When this substance is once received into the realm of organic nature, an uninterrupted circulation takes place; the decaying animal restores its phosphate of lime to the vegetable world, and the animals again receive it in their food. Its solubility in water, even when this contains only a small proportion of carbonic acid, explains why animal bones, when exposed to moisture, in the course of time altogether disappear, whilst those in dry situations may endure for thousands of years, as the Egyptian mummies and the bones of extinct animals buried in beds impervious to water clearly show. He then refers to the experiments recently made by many chemists, which establish that phosphoric acid is far more widely diffused in the mineral kingdom than was formerly suspected. Traces of it have been found in various crystalline rocks, for instance in granite, gneiss, mica-slate, and basalt; and also in the lava from Niedermendig. The occurrence of this acid in sedimentary formations will appear less remarkable, when it is remembered, that most of them contain more or less abundant remains of organic bodies, from which water may have conveyed phosphate of lime into the rock. The importance of phosphoric acid to the vegetable kingdom has been long known, and also that manures owe no small part, burnt bones the whole, of their value to the presence of this acid. The more generally therefore it is found in the mineral kingdom, the more easily explicable does its wide diffusion in the organic world become, and the more means are presented for improving cultivation and increasing the fertility of the soil. The continual decomposition of mountain rocks constantly renews the supply of phosphoric acid to the vegetable kingdom. This fact must also throw still more into the background the opinion, long ago regarded at the tribunal of chemistry as without foundation, that organic nature could produce phosphoric acid or phosphorus, or any other elementary body. In conclusion Prof. Bischof calls attention to the frequent conjunction of the phosphoric and fluoric acids, which may be followed from the mineral even into the animal kingdom, and which led to the discovery of phosphoric acid in springs. The tendency of these two acids to enter into common combinations is observable in apatite and most of the other minerals, and is also the reason why bones take up a larger proportion of fluoric acid the longer they remain buried in the ground. This is not to be wondered at, for fluoric acid is as universally distributed as water: it is found even in the sea.

[J. N.]

Produce of GOLD *in the* URAL *and* SIBERIA *in the year* 1846.—ERMAN'S Russ. Archiv. 1847, Bd. vi. p. 318.

ACCORDING to a notice in the 'Kommertscheskaja Gaseta,' or Russian Commercial Journal, published by the Ministry of Finance, in February 1847, there had been remitted to the Mint at St. Petersburg 1397.378 pud of gold, the produce of the Imperial and private mines in the Ural and Siberia during the year 1846. There was still expected 325.368 pud of gold, the produce of these mines in that year.

The total produce therefore of Russian gold in 1846 was 1722.746 pud, or about 62,792 lbs. avoirdupois, whilst in the previous year (1845) it was only 1371.800 pud, or 49,522 lbs. avoirdupois. The annual increase, which had fallen in the last two years to 47 and 30 pud, has consequently risen to 351 pud, or 12,670 lbs. avoirdupois, which much surpasses any previous increase; the largest formerly, or that between 1842 and 1843, being only 323.80 pud.

[J. N.]

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TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Structure of the Schwarzwald. Extracted from a Letter to PROFESSOR LEONHARD. By M. FROMHERZ.

[From Leonhard and Bronn's Jahrbuch, 1847, p. 813.]

THE transition formations have a considerable extent in the southern Schwarzwald. They do not form, as was at one time supposed, three separate, altogether isolated deposits, but a connected, though highly dislocated range, passing across the mountains from Badenweiler to Lenzkirch, only interrupted by granite between the valleys of the Menzenschwand and the Aha. In this tract the transition rocks consist of clay-slate, mostly metamorphic; of greywacke-slate, formed by the fine attrition of the materials of which the transition conglomerates were formed; and lastly of these conglomerates or the so-called greywackes. Beds of anthracite have been observed in several places in the transition formation of the southern Schwarzwald, but have never been found worth working. Limestone is entirely wanting.

Whether these beds are Silurian or Devonian cannot, from the total absence of a fauna, be determined; but that they are transition, the remains of plants in the anthracite beds, together with the mineralogical character of the rocks and the occurrence of anthracite, leave no doubt. The following facts, from which some important deductions relative to the mode of formation of the Schwarzwald may be drawn, seem deserving of notice.

1. The rolled fragments in the Schwarzwald greywacke prove that before the deposition of the transition strata plutonic masses existed there, and that consequently a portion of the Schwarzwald belongs to the most ancient geological periods. Among the pebbles of the greywacke of the southern Schwarzwald there occur granites of very many varieties; coarse or fine granular, porphyritic, with white or red felspar, with mica of various colours, &c. The greater number of these granites are still found in the present Schwarzwald moun-

tains or in the vicinity of the transition rocks. Further, rolled masses of felspar (eurite) porphyry, near Badenweiler and Schonau with grey, near Lenzkirch with red felspar. These rocks are also found *in situ* in the vicinity of the transition formations. Gneiss is not common among the fragments in the Schwarzwald transition rocks, probably because the conglomerates lie wholly in the region of the granites.

We perceive from these facts that a portion of the granite, of the felspar porphyries, and of the gneiss, not to mention less remarkable rocks, already existed before the deposition of the transition formations, and consequently belong to the oldest plutonic productions.

2. Clay-slate and greywacke-slate occur very frequently among the rolled masses of the greywacke. This fact, together with the relative position of the beds, proves that these rocks were among the most ancient neptunian formations of the Schwarzwald, and deposited before the great currents which formed the transition conglomerates.

3. The geological relations of these transition strata furnish the clearest proofs, that after their deposition very important geological catastrophes have occurred in the Schwarzwald, remarkable outbursts of plutonic rocks forming whole hills and mountain chains. We find, for example, veins of granite and quartzose porphyry in the transition rocks. Very distinct granite veins occur on the Windgfäll-Hoff near Lenzkirch and on the summit of the Spiesshorn at Bernau near St. Blasien; and the most beautiful vein of quartz porphyry is found in the clay-slate at Hof Bernau on the declivity of the Herzogenhorn. In various places also large masses of granite or quartzose porphyry project amidst the transition strata; of the former, for instance, in the Spiesshorn and the Bildstein in the Aha valley; of the latter on the Schnelling, the Köhlgarten and other places.

The entire absence among the rolled masses of the greywacke of certain kinds of granite, although they compose whole mountains in the immediate vicinity of these formations, and also of fragments of the quartzose porphyry, is a proof that these rocks burst forth after the deposition of the transition beds, and consequently belong to the more recent plutonic formations.

The very remarkable dislocations which the transition rocks of the southern Schwarzwald have experienced furnish further proofs that after their deposition elevations and eruptions of plutonic rocks have taken place on a very large scale in the Schwarzwald. Whilst a considerable portion of these deposits still occur in the bottom of the valleys, other portions have been torn from their original connection and are now found raised up and isolated on the top of the mountains, so that the deposits in the valleys and those on the heights are divided by whole mountains of plutonic rocks. Thus the transition strata are found in the bottom of the valley near Oberweiler and Schweighof, and then after being interrupted by granite and porphyry on the neighbouring summits of the Sirnitz-Kopf and even of the Köhlgarten. In the Albthal near Bernau they form the valley, and then appear near the summit of the Blösslings and on the very top of the Spiesshorn. Other instances might be given. These immense dislocations closely resemble the not less remarkable ones to which the Bunter sandstone has been subjected in the lower Schwarzwald.

4. The geological phænomena of the transition formations finally yield a proof that the great outburst of the more recent granite and quartzose porphyry in the Schwarzwald took place during the period after the deposition of the transition strata and before that of the lower New Red Sandstone (Todtliegende). The veins of granite and porphyry which traverse the former are not found in the latter nor in the Bunter sandstone. In the boulders of the greywacke fragments of these recent granites and porphyries are entirely wanting, whilst among the rolled pebbles of the new red conglomerates they are very abundant.

[J. N.]

On the Formation of Peat in the North of Europe. By M. Léo Lesquereux.

[Bulletin de la Société des Sciences Naturelles de Neuchatel, 1847, vol. i. p. 471.]

The Vosges, the Rhön and Harz mountains have a great similarity in their phanerogamous vegetation. The Vosges, in consequence of the diversity of geological character, and the numerous habitats (*stations*) it presents, is much the richest, especially compared to the Rhön mountains, which, almost entirely basaltic, only support plants peculiar to a calcareous soil of a mean elevation. In the Vosges and Harz the tops of the mountains are covered with most of the alpine plants that characterise the summits of the Jura. The anemones are even found on the Kreutzberg, the culminating point of the Rhön mountains. A great number of plants must be enumerated before distinctive characters can be established for these local floras; and these characters bear but little relation to the nature of the soil. It is very different with cryptogamous plants. The granites, basalts, limestones, support mosses and lichens of a perfectly distinct physiognomy; and according to the author, botanical geography can here attain to such severe and precise laws, that it is sufficient to know a few of the cryptogames attached to a rock to determine its real nature.

In studying river basins, the author has arrived at the same distinction. Singularly enough, the mode of dissemination of the phanerogames is more difficult to establish than that of the cryptogames, especially the mosses. From a single specimen found on the bank of a stream, the author has indicated the existence of the plant in more elevated regions, even where the species did not grow in the immediate vicinity of running water. These considerations explain the occurrence of peat-deposits in the vicinity of certain streams, and their absence near others in similar hygrometric circumstances.

The formations of peat are divided into two very distinct classes: immersed formations, produced by the accumulation of aquatic plants, like the reeds and carices; and the emerged formations, caused principally by the sphagnum. In the Vosges and Harz, as in granitic formations in general, which are less permeable to humidity than limestones, emerged peat-mosses are not uncommon on highly inclined slopes. They rise even to the culminating point of the Brocken. This important fact proves that they do not originate in any particular acid, or in any other agent prepared beforehand. It is the most positive proof possible of the hygroscopic action of the sphagnum, both in absorbing water and favouring the preservation of the woody fibre in the moistened tufts.

Many of the vast peat-mosses in the plains of Northern Germany, that of Neumünster, for instance, near Kiel, show the two formations superimposed. The peat has first grown in a basin several feet deep, and on reaching the surface of the water the emerged formation has commenced. This fact is easily proved, both by the nature of the fuel and by the plants found in these different portions.

A third mode of growth has been observed in some parts of the Vosges, but more especially in Scania and Denmark, where in deep basins of small extent the peat-forming plants have begun to grow at the surface of the water, and the basin been gradually filled by the immersion of the floating turf, continually thickened by the growth of new plants. Such abysses, concealed by verdure, have often proved dangerous; and these kinds of peat-mosses in the north are filled with numerous bones and instruments of various kinds, both ancient and modern, which may aid in establishing different epochs in their formation.

The relation between the mineral combustibles, coal, lignite and peat, is shown, according to the author, by the dépôts of lignite of the Rhön mountains and of Thuringia, and by the coal of Ilmenau. The lignites of Bischoffsheim, inclosed in basalt, are a mass of semicarbonized wood, dug out with hatchets. The beds of clay on which they rest, or by which they are covered, frequently exhibit impressions of the leaves of the elm, the birch, the willow, or other trees. The lignites of Mächsterstädt are mixed with an immense number of pine cones. Those of Lützen, which should rather be described as peat, are covered by a bed of sand and gravel thirty feet thick. The combustible matter is black and brittle, some fragments of aquatic mosses may still be recognised in it, and it lies above trunks of trees, of which the wood, completely blackened, is reduced to a soft paste like clay. It is in a state of decomposition intermediate between peat, properly so called, and the lignites or coals. This softening of the largest vegetables explains perfectly the flattening of all the remains of plants that can be recognised in mineral fuel.

Some curious observations have been made relative to the great antiquity of certain peat-mosses in the environs of Helsingör, where excavations have exposed three forests placed one above the other, and separated by beds of peat of considerable thickness. The author explains this singular phænomenon by successive sinkings of the overloaded surface, and its renewal by the growth of the peat. But these formations must have required a considerable space of time, since of these three forests, each composed of different species of trees, one, of oaks, shows trunks not less than two or three feet in diameter.

The author, in conclusion, affirms that he has never observed deposits of peat truly marine. On the shores of the Baltic and the Ocean, lagunes are filled with peat, but produced by the same aquatic plants as grow on the margin of lakes. He has nowhere met with peat-mosses composed of fuci. The marine Zostera, sometimes thrown up on the shore in great masses, remains for an indefinite length of time exposed to all the changes of the atmosphere without undergoing any change in its nature or form. But these are not true formations; and it is impossible to compare such mere accidents to the slow but constant operations which nature employs for the production of deposits of peat.

[J. N.]

On the Ejection of Leucite Crystals from Vesuvius. By A. SCACCHI.

[From Annali civili, fasc. lxxxvii. L. and B.'s Jahrbuch, 1848, p. 97.]

IN the year 1839 Vesuvius ejected many crystals of pyroxene, which fell at a great distance from the crater. On the 22nd of April 1845, on the 10th of February and 22nd of June of the last year [1847?], the last time during the presence of the author, ejections of leucite crystals took place. After 1839 only small cones of smoke rose from a deep fissure in the crater, but the lava gradually rose up and at length, in 1845, flowed over the fissure, and hardening, rose in the form of a cone so high that the top could be seen at Naples over the edge of the crater. Only occasionally, when the force was most intense, lava was thrown up into the air, and along with it many leucite crystals sometimes quite free from lava. They were as large as peas, single, or rarely united in pairs, but according to no regular law, were translucent or transparent, striated in certain directions, somewhat rounded on the edges, but otherwise very pure forms of crystals. On those of the 22nd of June, however, the edges and angles are often less acute, and then the form is more spherical, and the whole crystal sometimes compressed on the sides which form the trigonal angles, these sides also being more extended. On the 22nd of April 1845 the guide conducted the author to the place where the leucite crystals had been thrown out in February; and he succeeded in reaching on a hard bed of lava, which had flowed out on the day mentioned, the summit of the burning cone, which was frequently ejecting red-hot stones and lapilli. He then saw that the slaggy lapilli were mixed with small groups of minute leucite crystals more or less free from the substance of the lava. These crystals were translucent, 0·5—2 millimeters large, whilst the groups had a diameter of 5—13 millimeters.

If we now consider that the ejected lapilli and lava fragments were so soft when they fell that an impression could be made on the latter with a stick; further, that the leucite is more fusible than the mass of the lava itself, that the angles and edges of the ejected leucite crystals were rounded, and that the lava sometimes formed a varnish-like coating over them—it is evident that the power which projected both of them upwards must have found in the interior of the mountain an ancient mass of leucite lava in a soft condition, have torn it to pieces, and separated the more infusible leucite crystals from the softer lava paste, and ejected both separately. And in reality there occur on the Punta dei Minatori on Monte Somma, as well as under the town of Pompeii, old easily comminuted leucite porphyries, containing crystals exactly similar in form and size; whilst the author does not remember to have seen such in the newer beds. Hence the opinion is easily refuted that the leucite mass was ejected in a fluid state, and first formed into crystals in passing through the atmosphere. Equally erroneous is the assertion that Vesuvius, on the 22nd of April 1845, threw out pyroxene crystals affected by acids: pyroxene in this state could only come from the crater itself.

[J. N.]

Present and Former Extent of the Island of Heligoland. By M. Wiebel.

[From the Proceedings of the Association of German Naturalists at Kiel in 1846. L. and B.'s Jahrbuch, 1848, p. 82.]

It appears (1.) that the well-known map of Heligoland by Meyer, according to which the island once contained nine parishes, is entirely a work of the imagination; (2.) that on comparing the map made in the year 1793 by the Danish engineer Wessel, of which however only a three-inch reduction remains, with the author's own measurements, "the coefficient of destruction in a century for the whole circumference of the rock washed by the sea does not on the average amount to more than three feet;" (3.) that in the time of Adam of Bremen (an extended description by whom is still in existence), and of Charlemagne, the island was only a little larger than at present.

[J. N.]

Travels in Northern Persia. By M. Woskoboinikow.

[Erman's Archiv. für Russland, vol. v. p. 671. Jahrbuch, 1848, p. 96.]

The following are the chief geological results regarding the northern half of Persia examined by the author.

1. The system of limestone beds with marls, and of subordinate green sandy marls, appears to be the oldest of the formations occurring here, and indeed to be older than the mountain limestone. From the want of petrefactions, however, their character cannot be more precisely determined.

2. The beds of the coal formation and the metamorphic strata dip mostly to the W.S.W. In the mountains on the coast, however, all the beds of the other formations are inclined towards the sea.

3. The cretaceous and nummulite strata only appear on the

northern declivity of the mountain chain, and even there only at a small elevation. On the southern declivity they are entirely absent.

These facts seem to show that the first elevation of the Alburs mountains immediately succeeded the Jura formation, and that a second elevation took place after the cretaceous beds and the nummulite limestone were deposited on its northern declivity. This second event gave their dip to the last-named beds. Their inclination may however be ascribed to the falling in of the basin in which the Caspian sea now exists, since the whole extensive plain which lies opposite the mountain chain has a very unusual elevation above the level of the Caspian.

4. As the mountain limestone in general occupies the highest points of that portion of these mountains in which the coal formation occurs, we may expect to find the latter also in Russian Trans-Caucasia, for in the province of Karabach the mountain limestone with the lithographic stones overlying it forms immense mountains. The fortress Schuscha is placed on one of these mountains ; and the rock is seen in the district of Jelisawetopol, near the village Saglik, in the neighbourhood of the alum quarries.

[J. N.]

On the Occurrence of Ores of Mercury in the Coal Formation of Saarbrück. By Herr von Dechen.

[Kolnische Zeitung, Feb. 1847. Extracted in Leonhard and Bronn's Jahrbuch, 1847, p. 866.]

In a lecture before the Society of the Lower Rhine, Herr von Dechen notices this singular fact. These ores are in general very rare ; and in this place occur in the upper division of the carboniferous group, in beds belonging to the productive coal formation, or even to a higher part of the series, in which previously they were not known to be found in any part of the earth. In this district they are confined to its eastern portion ; Baumholder in the district of St. Wendel being the most western point where they have been found, the Kellerberg near Weinsheim the most northern, Nack near Erbesbüdesheim the most eastern. They occur in veins in the normal beds of the coal formation, in the melaphyres, the amygdaloids and the felspar porphyries ; these massive rocks lying within the range of the carboniferous strata. They are also found disseminated and in fissures in beds of sandstone of this formation, as at Münster-Appel and Waldgrehweiler, wholly unconnected with true veins. The association with the ores of mercury of certain claystones and hornstones, which are not in general found so much developed in this formation, is very remarkable. Within the limits mentioned ores of mercury have been observed in thirteen different localities, some of which range in straight lines. The longest of these lines reaches from Katzenbach, over the Stahlberg, Landsberg near Obermoschel to the Kellerberg, and is about fourteen (three German) miles in extent.

[J. N.]

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TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

Report on the Palæontological Researches of M. Marie Rouault *in* Brittany *and* Anjou. By M. Milne-Edwards.

[From the Comptes Rendus for 1847, tom. xxiv. p. 593.]

The author of these researches, a man of humble birth, animated by a taste for study, has instructed himself without aid from teachers, and has become a man of science by devoting to the observation of nature the few moments of leisure left him by the manual labour necessary to procure his living. It is only by submitting to the most severe privations, that he has been able to satisfy his intellectual wants; and the spectacle of his studious and disinterested life might have sufficed to secure him the sympathy of every generous heart, even although his labours had remained barren of results to the science which he has pursued with such persevering ardour. But it is not on this ground alone that M. Rouault merits the indulgence of the Academy; his claims to consideration rest on real services rendered to geology and to the history of fossil animals. In reality his observations furnish useful data for determining the age of certain formations which have hitherto been incompletely studied, and throw new light on a great family of Crustaceans, of which there is no representative in our actual fauna, and whose characters are only imperfectly known.

The researches of M. Rouault, begun in 1845, have been carried on at Gahard, Poligné, Bain, Vitré and Hunaudière; and he has collected at these localities, whose palæontological wealth was not even suspected, more than six thousand specimens of trilobites and fossil shells, and has discovered many species which formerly had not been found in France, and some even wholly new to science. The collections previously made could give no idea of the abundance of these animals in the seas of the Silurian period. Thus, when M. Brongniart, by the publication of his beautiful work on fossil Crustaceans, drew the attention of geologists to the family of the Trilobites, only a very small number of individuals were known, and it might have been supposed that they had always been rare. Since that epoch many new species have been discovered, some in Sweden and England, others in North America, and others even in the vicinity of the Cape of Good Hope, but the individuals in each locality were always far from being abundant. The researches of M. Rouault, however, show that in certain points at least Trilobites were formerly as common as the crabs on our coasts are at present; for in examining, during a few weeks only, the environs of Poligné, that skilful collector has succeeded in obtaining more than two thousand specimens of one species, *Trinucleus Pongerardii.*

The fossils found so abundantly in these localities are not all in the same state of preservation. In some the shell is wholly transformed into sulphuret of iron; in others a portion only of the tegumentary skeleton has undergone a change of this nature; whilst in others again sulphuret of iron forms no part whatever of the solid envelope. M. Rouault has sought for the reason of these differences, and on comparing the structure of recent shells with that of the remains of molluscs thus modified, he finds that the species, in which the process of fossilization has been accompanied with a molecular deposition of sulphuret of iron in the substance of the tissues, are those into whose composition a large amount of carbonate of lime entered; whilst those whose original texture was horny have not undergone a similar change. Then, applying these data to the study of Trilobites, he has endeavoured to determine the original structure of the external skeleton of these animals from the nature of the transformations it has undergone in the interior of the earth.

Calymene and Phacops always appear with a shell formed of sulphuret of iron; Nileus, Illænus, Ogygia, Cheirurus and Prionocheilus never offer any trace of a similar transformation. Lastly, in Trinucleus M. Rouault has constantly found certain parts converted into sulphuret of iron, whilst other parts have suffered no analogous modification. Hence he concludes that in Calymene and Phacops the shell was calcareous, like the carapace of our crabs and lobsters; whilst in Nileus, Illænus, Ogygia, &c., the tegumentary skeleton was membranous or horny; and in the Trinucleus the greater portion of the body had a structure analogous to that of the existing Apus or Branchipus, whilst the spiniform prolongations of the cephalic buckler were calcareous. The author also considers these differences as corresponding to the natural divisions in the great family of the Trilobites; and he adds to his memoir a table, in which he classes these fossils from the characters we have now mentioned. We do not wholly participate in the opinion of M. Rouault on this point; but we agree with him that the indications furnished by the presence or the absence of sulphuret of iron in the shells of fossil animals deserve the close attention of zoologists, and may aid us in determining the kind of structure peculiar to different species.

M. Rouault's observations also throw some new light on the anatomical constitution of the eyes of Trilobites. It is well known that in Calymene [Phacops?] and several other genera of the same family, there exists, on each side in front, a large reticulated or compound eye. The specimens collected by M. Rouault show that these compound eyes were provided with a transparent reticulated cornea, with a layer of lenses; and deeper still, with a layer of reversed cones with concave bases serving as supports for these kinds of crystalline lenses. M. Rouault directs the attention of zoologists to the differences that exist in the forms of the cornea, of the lenses, or of the cones, according to the species, and insists with much reason on that character being employed in the specific determination of Trilobites.

The author has also made known the manner in which the Trinucleus rolled itself up, which was altogether different from what is observed in the Calymene or the Nileus. Lastly, he adds several curious details relative to the anatomical history of these animals.

The fossils collected by M. Rouault also enable the geologist to determine precisely the age of the formation from which he has procured them; and on this point confirm the results already obtained by MM. de Verneuil and d'Archiac. We may thence infer that the slates of Angers, Hunaudière, Bain, Poligné and Vitré, are contemporaneous, and belong to the lower Silurian system, whilst the limestones and the slates of Gahard, near Rennes, appear to be of the same age with the Devonian formations of the Eifel.

This short exposition shows that the researches of M. Rouault should interest us in more than one point of view; and we are persuaded, from the results he has already obtained, that if this young naturalist is enabled to pursue those geological studies to which he has devoted himself with so much zeal, he cannot fail to render new services to palæontology. [J. N.]

To the above report of Professor Milne-Edwards we add a few extracts from the original memoir now published in the Bulletin of the Geological Society of France, tom. iv. p. 309.

Trinucleus Pongerardi, l. c. pl. iii. fig. 1.—Buckler truly semicircular, nearly straight behind; glabella and cheeks smooth, the former largest; fringe [bourrelet] hollow, formed of a double membrane, more separated in the centre than the edges, like a double convex lens, and pierced by six rows of pores, of which two rows are absent in front, the sides of the pores forming hollow pillars to keep the surfaces apart (probably a floating organ). Head spines longer than the entire body, slightly bent towards the end, quadrangular, the outer angle continued from the outer edge of the fringe, the inner from the corresponding edge, and two others from a ridge between the first and second rows of pores; the spines apparently hollow all along, bifurcate in two out of five specimens of all ages, and either on the right or left spine, or both; on any part of the spine, but generally at two-thirds its length; the bifurcation of the spine varies, sometimes the two ends are equally divaricate, sometimes there is an outer, sometimes an inner branch.

Abdomen and post-abdomen so much smaller than the head, that although a five-franc piece would scarcely cover the head, a five-centimes would more than cover body and tail. Axal lobe of the abdomen equal to the side lobes; six furrowed segments; post-abdomen four times as broad as long, axis not very strongly marked, tolerably convex, with a few indistinct ribs: sides flat, their margins subsigmoid. Post-abdomen in rolling applied to the underside of the abdomen, and then both to the underside of the head.

As to the mineral condition of the specimens, the buckler always presented (and more than 2000 specimens have been examined) a quantity of sulphuret of iron covered by a layer of sulphate of lime; of these minerals the spines showed always a larger quantity than the fringe, and this again than the remainder of the head; on the abdomen and post-abdomen, when extended, no trace of these could be found, but in one case, when the body was rolled up and so applied to the head, a small quantity appeared.

The state of preservation in which the parts of the body were found indicated also the greater or less proportion of lime in them. The spines were constant in shape and direction, or when altered, a decided fracture was visible. The fringe appeared to have been capable of considerable flexure, but when the two sides of the body had been compressed together a fracture with a clean edge took place towards the outer border, but irregularly torn near the central parts of the head, which were apparently capable of bending in all directions. The abdomen and post-abdomen were generally deformed, the former most so, probably on account of a thinner texture.

Therefore, the indications presented by the presence of the minerals which are substituted for calcareous matter, and by the degree of flexibility, tend the same way, and confirm each other; the strong probability being, that the head was more calcareous than the rest of the body, the largest quântity of lime being accumulated in the appendages, especially the strong spines; nor is the exception noted above, of a rolled-up specimen showing traces of the pyrites, a real objection, since the attraction must have been continued a short distance from the calciferous portions.

Then follows a table comparing the mineral condition of the crust in the following genera (at Rennes):—

Calymene	much pyrites, in slate.
Proetus	calcareous, in muddy limestones.
Phacops	little pyrites, in slate.
Cryphæus	calcareous, in muddy limestones.
Polyeres, n. g.....	little pyrites, in slate.
Prionocheilus, n. g.	no pyrites, even while it is present near it.
Cheirurus	no pyrites.
Illænus	no pyrites.
Nileus	no pyrites.
Ogygia	no pyrites.
Trinucleus	pyrites in buckler only.

In the table these genera are also compared, with respect to the relative dimensions, the form and armature, and firmness of substance of the buckler, the character of the eyes, size and number of segments of the abdomen (thorax, Burm.) ; also the size, form and substance of the post-abdomen (caudal shield, Burm.) ; and the author deduces from the whole review the conclusion that—

The five first-named genera have had their organization very perfect, and had probably an active life, their protection consisting in numerous moveable *hard* segments, with a considerable quantity therefore of calcareous matter in them, represented in the fossil state by the sulphate of lime and sulphuret of iron.

The next four he considers of inferior organization, and their protection to have consisted in the size of the terminal shields, the crust not containing much calcareous matter.

In the two last the organs of vision were imperfect or absent, the protection being afforded by the buckler only, which alone contained calcareous matter.

M. De Verneuil had examined the fossils collected by M. Rouault, and the lists from Devonian and Silurian rocks appended to the paper derive much additional value from his revision ; they are too extended for insertion here.

The characters of a few new species of Trilobites and one or two genera are also given (with figures) :

Calymene Tournemini, very like *Calymene Fischeri*, Eichw., and belonging to the genus *Amphion*, Pander.

Phacops Dujardini, allied to *P. Murchisoni*, Portlock.

Polyeres, n. g. From the description this would seem to belong to *Odontopleura* ?

Prionocheilus, n. g. According to De Verneuil this is probably identical with *Calym. pulchra*, Barrande, *C. brevicapitata*, Portlock.

Cheirurus Durocheri.

Nileus Beaumontii, allied to *N. Armadillo.*

Ogygia Edwardsii, more elliptical than *O. Buchii.*

The author in conclusion offers a few observations on the structure of the eye ; but the structure he describes has been already indicated by Prof. Burmeister (Organiz. der Trilobiten) ; the employment of the variations, however, as specific characters is new and probably will be useful.

The cornea shows some curious variations in the genus *Phacops* ; in *P. macrophthalmus* the thickness is such between the lenses, that the latter lie in hollows between the meshes which rise above them and protect them from abrasion ; in *P. Downingiæ*, on the contrary, it is a thin film, the lenses themselves projecting a little ; in *P. longicaudatus*, again, it is very thick. The size of the lenses, again, is greatest in the first of these three, and least in the last,—another good specific character.

[J. W. S.]

The SAURIANS *of the* MUSCHELKALK (Die Saurier des Muschelkalkes mit Rücksicht auf die Saurier aus buntem Sandstein und Keuper: Zur Fauna der Vorwelt, Zweite Abtheilung), by HERMANN VON MEYER. 1ste Lief. Frankfurt, 1847. Folio.

THIS portion of the work contains the first five sheets of the text and twelve folio plates. The introduction gives an account of the trias formation; followed by a general description of the skull of the Nothosaurus figured in plate 1; and specially of the *Nothosaurus mirabilis*, and of the *N. Münsteri*, of which figures are also given. These remains are from the Muschelkalk of Bayreuth, where they were discovered by the well-known Count Münster, who also first distinguished them from Plesiosaurus, with which genus they had been confounded. This account of the Saurians of the Muschelkalk will be continued in other numbers of the work, and will be succeeded by similar monographs of the saurians of the keuper and bunter sandstone, thus forming a connected view of the whole saurian world of the trias. The remains are described according to the localities where they occur, it not being possible as yet to describe them systematically according to species, there being many remains which could not be assigned to particular species, but yet too important to be passed over. The following are some general remarks on the trias formation (die Triasgebilde) and the remains of vertebrated animals found in it, from the introductory part of the work.

As in the living creation we must not only define the species with accuracy but also determine their geographical distribution and their vertical distance from the surface of the sea, so also in reference to fossil beings it is necessary to know in what locality they were found and to which section in the history of the earth they belong. Geology can alone give an account of the latter—of the date of these beings in the chronology of the world. Hence it is indispensable, in a work treating of the saurians of the muschelkalk, to take a review of the formation in which their remains are found. It appears that the muschelkalk is no independent, isolated formation, but the central member of three formations intimately connected together, the representatives of only one period in the history of the earth, and hence designated by the name of the Trias. The Councillor of Mines, V. Alberti, has proved this most convincingly, though at that time the saurian remains of the formation had not been accurately examined. I have since been much employed in researches on these animals, and the results are highly favourable to this view. The three formations are the Bunter sandstein, the Muschelkalk, and the Keuper. The remains contained in them belong to saurians, of types not previously represented on the earth, and of which only one family, the Macrotracheli (in consequence of the occurrence of the Plesiosaurus in the lias of England), extends into the following geological period. It must however be observed in reference to this point, that the genus Plesiosaurus has not yet been certainly proved to occur in the trias formation, so that the peculiarity of the trias-saurians is scarcely affected by the appearance of a related genus in the period that immediately follows. The geological age of the trias is sufficiently fixed, by stating that its oldest member, the bunter sandstone, rests on the zechstein, and that its newest, the keuper, is covered by the Jura or oolite group.

In reference to the geographical distribution of the trias formations, they are found to form, with slight interruptions, a mass of very considerable extent in central Europe. They prevail in Alsace and Lorraine, in eastern France, and extend over a great part of south-western and north-western Germany; where cropping out from below the jurassic beds in the Swiss Jura, they traverse the whole region of Bâle, Würtemberg and Baden, to the slate mountains on the Rhine, and in great part fill the space between these mountains and the Harz, the Thuringerwald, and the Voigtland. The trias of eastern France is no doubt divided from that of south-western Germany by the broad valley of the Rhine, stretching from Bâle to Mainz or Bingen. A more accurate comparison, however, of these two districts shows that they properly form only one whole, on whose external border the bunter sandstone appears from below the muschelkalk, which in its turn dips below the keuper; whilst the mass of the latter formation occupying the centre, is traversed nearly in a direction from south to north by the broad Rhine valley, whereas the Main, almost from its sources in the Fichtelgebirge, intersects in deep curves the whole trias formations which it meets in its course from the east towards the Rhine.

The keuper, the most recent of the trias formations, was named by Humboldt, 'grès de Königstein,' the Königstein sandstone, and under the name of the quadersandstein, was often confounded, partly with the bunter sandstone, partly with tertiary sandstones. This formation is also designated the 'variegated marls,' marnes irisées. Raumer found that the keuper was separated from the bunter sandstone by the muschelkalk. Where this is not the case, the two formations are so intimately united that they can scarcely be distinguished from each other. In Schwabia and Franconia the keuper covers the two older formations, which it also accompanies in other places.

The keuper of Würtemberg, which is about 1000 feet thick, is arranged by Alberti* in three divisions, which are in ascending order, carbonaceous slate-clay (Lettenköhle), keuper gypsum, and keuper sandstone. The first division consists of slaty clays passing into marls, marl-slates, sandstone, dolomite, limestone and gypsum. In it at Gaildorf, where the slate-clays approach to alum-slate, there were found considerable remains of the Mastodonsaurus, with plants, fishes and shells. The marl-slates also contain reptilian remains with plants, fishes and shells; in the sandstone at Sulz remains of reptiles and fishes were met with, for instance, a beautiful tooth of the so-called Lüneville reptile; whilst at Rietheim and Bieberfeld, near Hall, a bed was discovered entirely composed of bones and teeth of reptiles, remains of fishes and coprolites; and reptiles are also mentioned among the petrifactions of the limestone, so that their remains seem to pervade the whole division.

* Monog. des Bunten Sandsteins, etc., p. 111.

Alberti separates the variegated marls with gypsum, under the name of keuper gypsum, from the keuper sandstone, only for convenience. The carbonaceous slates are generally covered by dolomite, the higher part of which is rich in petrifactions; otherwise this group consists of gypsum with marls also containing dolomitic rocks. Alberti conjoins with the dolomite between the slates and the gypsum, which only differs from the dolomite of the muschelkalk by its position and greater richness in fossils, the 'Reptilian-breccia,' the lower 'Gang-breccia' of Plieninger, which accompanies it, and consists of marl six feet thick and full of remains of fish and coprolites (Gölsdorf, Rottenmünster). As representing the saurians the Lüneville reptile is named, under which title the Nothosaurus must rather be understood than the Simosaurus, which more rarely occurs in Würtemberg. In the gypsum also, above the dolomite, remains of reptiles, fishes and coprolites occur.

The division of the keuper sandstone consists of marls, of fine-grained or argillaceous sandstone (the Schilfsandstein of Jäger), of siliceous sandstone, of coarse-grained sandstone (Stubensandstein), and of a sandstone very rich in petrifactions. The fine-grained sandstone, well known for its vegetable remains, furnished near Heilbronn the impression of the jaw deprived of the teeth, and the osseous plates (Knochenplatten) of a large reptile. I have not myself seen these remains and only follow the statement of Alberti. In the coarse-grained sandstone at Waldenbuch and Dürrheim bones were found, said to be those of a reptile; and from the same sandstone the bones found near Rübgarten, and described by Jäger as Phytosaurus, were also derived. The sandstone rich in organic remains, often named the sandstone of Tübingen, is frequently so full of osseous remains of saurians and fishes, along with coprolites, as to form a bone-breccia, and Alberti quotes from it large teeth of the Lüneville reptile. This sandstone forms the highest bed of the keuper. It must not be confounded with the bone-breccia resting upon it, in which at Stuttgart, Bebenhausen and other places, remains of fish, teeth, scales and coprolites are found, for this breccia forms the transition to the lias, and must be considered the lower lias sandstone. Reptiles are not mentioned from it. This is the highest of the beds of bone-breccia, already discovered by Alberti on the two limits of the keuper formation. Plieninger* names it the 'Upper Gang-breccia,' and considers it as identical with the 'bone-beds' of Aust Cliff, Axmouth, and other places in England. According to him the species of fossil fishes that occur in it in Würtemberg are partly identical, partly distinct, from those in the 'Gang-breccia' which is situated at the lower limit of the keuper and belongs to the slate-clay (Lettenköhle). The saurian remains from the keuper of Schwabia have been partly published by Jäger†, partly by Plieninger and myself‡, and in this work I shall have further communications to make.

* Amt. Bericht. der Naturf. in Bremen im Jahr. 1844.
† Fossile Reptilien Wurtemberg's.
‡ Beiträge zur Paläontologie Würtemberg's.

Next to Würtemberg, Franconia deserves consideration on account of the saurian remains in its keuper. These remains, which are inclosed in sandstone, have engaged the attention both of Count Munster and of myself*. To the fossils more particularly described in the present work belong the remains of the gigantic *Plateosaurus Engelharti*, from the upper keuper at Heroldsberg near Nürnberg. Here must also be mentioned the keuper near Gotha, from the dolomite in which, Mining-master Credner notices some saurian teeth. A tooth given to me by his brother, Prof. Credner, in Giessen, from this formation, has belonged to the Labyrinthodon.

The muschelkalk, the centre member of the trias, consists especially of limestone, but sometimes also appears as dolomite, anhydrite, gypsum and rock-salt, whilst it only approaches to sandstone near its passage into the bunter sandstone. The muschelkalk is consequently a more calcareous member, uniting the keuper to the bunter sandstone, without which it rarely appears. Bronn† conjoins it with the other trias deposits under the name of the 'Salt-formation' (Salzgebirg), because they are distinguished by deposits of salt; but this is also true of other formations. The muschelkalk had originally the name of the newer, upper, or newest Flötzmuschelkalk, calcaire secondaire coquillier. In Germany the name Trochitenkalk, Trochite-limestone, from the numerous stems of crinoids that occur in it, was also current. The designation of Gryphite-limestone, used especially in Würtemberg, showed that the distinction between the lias and muschelkalk was not properly understood. But not only was the lias confounded with it; even much newer formations, belonging to the forest marble, the cornbrash and the Portland stone, were mistaken for the muschelkalk or mixed up with it. In consequence great uncertainty existed regarding the occurrence of the muschelkalk and its fossils, until Alex. von Humboldt‡ introduced a more precise division of this formation under the terms muschelkalk, calcaire coquillier, calcaire de Göttingue. He did not, however, succeed in separating from it the beds belonging to the Jura formation; and although he did not consider the lias as exactly identical with the muschelkalk, yet he adhered to the parallelism of the two formations. Elie de Beaumont§ pointed out the true diagnosis of the muschelkalk when he said that it is distinguished from the zechstein by containing no producti, and from the lias by wanting belemnites, ammonites with foliated sutures (*Ammonites persillées*), and also gryphites. We owe the most thorough investigation of the muschelkalk to the Councillor of Mines, Alberti, who, in his work on the geology of Würtemberg (1826), and subsequently (1834) in his 'Monograph of the Bunter Sandstone, the Muschelkalk and Keuper as one formation,'—the trias,—treated of it at full length. Lying above the bunter sandstone, and usually accompanying it, the muschelkalk appears first in the vicinity of Bâle, then in the western and, in more extent, in the eastern

* Beiträge zur Petrefactenk.; and various letters in the Jahrbüch für Mineralogie.

† Lethæa, vol. i. p. 130. ‡ Geognostischer Versuch, p. 273.

§ Ann. Scien. Nat. vol. xiv. p. 277.

Schwarzwald, filling in great part the interval between it and the Odenwald, whence it passes, intersected by the Main, towards Franconia, Thuringia and the rest of north-western Germany, where it is more often interrupted by the overlying keuper than in south-western Germany, in Alsace and in Lorraine. It appears in a more isolated manner in the vicinity of Berlin, and in Upper Silesia and south-western Poland is distinguished for its metallic wealth as in other places for containing salt.

The muschelkalk was long considered as poor in fossil bones, and in the older works little is to be found on the subject. Büttner (1710), Lerche (1730) and Schreber notice teeth, ribs and vertebræ of saurians, together with bones of land animals, from the muschelkalk of Thuringia, and particularly from the districts of Hornburg, Schraplau, Obhausen, Weidenbach, Farrenstedt, Querfurth and Gatterstedt. Freiesleben's statements are derived from these authors. Blumenbach* was probably induced by some bones of reptiles to affirm that Ornitholites or petrified birds were found in the muschelkalk of the Heimberg near Göttingen. Even in the year 1823 Humboldt† believed, not indeed that the muschelkalk itself, but that the brecciated rock and marl resting upon it, contained remains of quadrupeds, birds and fishes. The foundation for these statements was probably the very inconsiderable remains which were then known from Querfurth, Esperstädt and Göttingen. It was only when the publication of Cuvier's work on fossil osteology was nearly concluded, that the muschelkalk near Lüneville began to exhibit its wealth in osseous remains, and these were likewise discovered about the same time in this deposit near Bayreuth. Attention was then also directed to bones found in the muschelkalk of Schwabia, in the vicinity of Jena, in Upper Silesia and in Poland. But an accurate examination of these remains was still wanting. Schlotheim saw in them seals and dolphins; Cuvier thought he recognised the Plesiosaurus, an unknown Saurus and some gigantic tortoises; Jäger ascribed these bones to the Plesiosaurus and Ichthyosaurus; Gaillardot the younger compared them with the crocodile, monitor, Ichthyosaurus, Plesiosaurus, Testudo Trionyx and a new genus of tortoise. I also, so long as Cuvier's view regarding the Lüneville remains was the only basis to be depended on, considered the animals as related to the Plesiosaurus and the Tortoises; and even Münster was of the same opinion till he succeeded in finding a more perfect specimen of the skeleton of the animal, when the error which led to these views was evident. A more accurate investigation of these remains has shown that the muschelkalk contains neither birds nor mammals; the bones are not even those of Chelonia, but belong to saurians which are peculiar to the trias formation.

The lowest member of the trias is the bunter sandstone, which owes its name to Werner. The 'grès bigarré,' 'grès à oolithes de Nebra,' 'sandstone of Nebra,' of Humboldt; the 'Vosges sandstone' of De Beaumont comprise the same formation. Beaumont, and especially

* Naturgesch. 3te Aufl. S. 653. † Geognostischer Versuch, S. 275.

Murchison and Verneuil, consider that the Vosges sandstone is not triassic, but believe it to be older, and to belong to the zechstein,—a view against which Alberti in his 'Monographie' (p. 329) enters a protest, and does not admit of its division from the bunter sandstone. It was formerly impossible to decide on the age of this formation from petrifactions; but lately Dr. E. Rehman showed me, from the Fürstenberg collection at Donaueschingen, a petrifaction from the true Vosges sandstone of the Schwarzwald, the first, so far as I am aware, that has been discovered, in which I have recognised a Labyrinthodon, an animal of a family hitherto only found in the trias, so that Alberti's view of the age of the Vosges sandstone may be considered as proved. I shall afterwards more particularly describe this labyrinthodon. There are cases where the bunter sandstone can scarcely be distinguished from sandstones which really belong to the zechstein; and when not covered by the muschelkalk, it is still more difficult to separate it from the keuper. The members of the bunter sandstone, sometimes above a thousand feet thick, which have been observed in the south-west and north-west of Germany, are sandstones remarkable for their fine grain, slate-clays, roestone (in the Harz), gypsum and dolomite,—the latter more as subordinate members. In the Vosges and the Haardt, the bunter sandstone, covered by the muschelkalk, rests on the new red (Rothliegende). The bunter sandstone of that locality, and that on the right bank of the Rhine in the Schwarzwald and the Odenwald, are very similar. In the quarries near Sulzbad in the department of the lower Rhine, Alberti found the lowest member to be a red sandstone with impressions of plants, passing above into green and red slate-clays, and then slate-clays alternating with sandstone, sandy marls with dolomitic beds and red slate-clays, sandy marls with masses of argillaceous sandstone and shells of the muschelkalk, dolomite with sandy marls, and above the dolomitic marls of the lower muschelkalk (the *Wellenkalk*). In the north-west of Germany the lower sandstone seems to be wanting, and the zechstein is immediately covered by the bunter sandstone, forming slaty clays with subordinate beds of roestone, the latter with gypsum, sometimes excluding the slaty clays altogether. It is covered by a fine-grained sandstone, which passes above into a thick bed of slaty clay.

Petrifications were at first asserted to be either altogether wanting, or very rare in the bunter sandstone. Fossil plants have only recently been known in Wurtemberg. The remains of Cetaceæ, quoted by Voltz, from this formation at Wasselonne, and which are preserved in the museum at Strasburg, appear not to be fossil, which Hermann, from whom the statement comes, has not observed*. At Pyrmont, and near Bâle, fossil bones have actually occurred in the bunter sandstone. The first bones which I examined from this formation were given to me by Prof. Alex. Braun, from the Babenhausen quarries near Zweibrücken, and seemed to belong to an animal related to the Plesiosaurus. Still more important are the remains sent to me by Voltz and W. P. Schimper from the Strasburg Museum, which were found in this deposit at Sulzbad, and prove the presence

* Cuvier, Oss. Foss. (4 ed.) vol. iii. p. 374, *note*.

in it of Labyrinthodon, Nothosaurus, and other saurians. Soon after it was discovered that the bunter sandstone contained remains of saurians near Jena, and also at Bernburg. Even in Bohemia, where the existence of this formation is now proved, it includes remains of saurians, since it is almost certain that the animal described by Fitzinger as the *Palæosaurus Sternbergeri*, belongs to the bunter sandstone of this land.

D'Aubuisson's view, that in England the place of the muschelkalk was occupied by the Portland stone, cornbrash and forest marble, could not be maintained after the position and petrifactions of these deposits were more accurately examined. But some English geologists* still consider the trias formation with the lias as the older, the oolite and Wealden as the middle, and the chalk as the upper group of the secondary formations. The representative of the trias in England is the New Red Sandstone, the higher part of which is named the 'Upper New Red Sandstone.' This sandstone lies on the magnesian limestone (zechstein) belonging to the so-called palæozoic rocks, and consists of a series of yellowish or red beds of an arenaceous nature, alternating with red, green or blue marls, which are poor in petrifactions, but often contain rock-salt in abundance and crystalline gypsum, in which respect they resemble the trias formations of the continent of Europe. The muschelkalk is not found in England; and this absence of the intermediate group, with the close resemblance of the existing rocks to each other, and the almost entire want of petrifactions, makes it difficult to distinguish the upper from the lower sandstone. The sandstones and conglomerates of central England are usually considered as the bunter sandstone; to this must be added a portion of the formations designated as the 'Red Marl,' 'New Red Sandstone,' and 'Variegated Sandstone;' but the saliferous marls of Cheshire, as well as the greater part of the rocks comprised under the 'Red Marl' and 'Variegated Marls,' are considered as equivalents of the Keuper. The absence of any calcareous beds between the sandstone deposits of the trias and those of the zechstein, renders these also scarcely distinguishable; and the term 'New Red Sandstone' often comprehends the Keuper, the Bunter sandstone, and the sandstones of the Zechstein, the latter belonging to an older period of the earth, and containing no remains of Labyrinthodon, which occur in the other sandstones. But as long as it is not ascertained whether any and what species of Labyrinthodon are peculiar to each of these deposits, so long will even these fossil vertebrata furnish no sufficient means of separating the keuper of England from the bunter sandstone. In the trias formations of England, Labyrinthodon chiefly occurs †; the other trias saurians of Germany and France are as little known there, as on the European continent the Cladyodon ‡ from the new red sandstone of Warwick and Leamington, and the Rhynchosaurus §, whose remains have been

* Ansted, Geology, vol. i. p. 288.
† Owen, Geol. Trans. 2nd ser. vol. vi. pp. 503. 515.
‡ Owen, Second Rep. on Brit. Foss. Rept. p. 155.
§ Owen, Trans. Cambridge Philos. Soc. vol. vii. p. 355.

found at Grinsill near Shrewsbury in the upper new red sandstone, which is probably the keuper.

Among the trias formations of other parts of the earth, a deposit near the south-eastern extremity of Africa, described as 'New Red Sandstone,' deserves notice. In it a genus of saurians, the Dicynodon of Owen*, was found, which exhibits the closest alliance to the Rhynchosaurus of England. The connection of these two remarkable genera gives greater probability to the opinion that the sandstone in Africa containing Dicynodon is really triassic.

In North America, the sandstone exhibiting impressions of the feet of birds is also described as 'New Red Sandstone;' and this extensive formation is thus to be conjoined with the trias. Real bones seem rarely to occur in it. Hitchcock† notices some bones from this sandstone near Ketch's Mills, in the eastern part of East Windsor (Connecticut), and also casts of bones, which to judge by the description and the figures he has given, are of no value, and little adapted to impart any information regarding the animals to which they belonged, or the age of the rocks inclosing them.

[J. N.]

On the occurrence of Phosphoric Acid *in* Lava. By Gustav Bischof.

[Bulletin der Königl. Akad. der Wissen. zur Munchen. Jahrgang, 1847, p. 158.]

Bergemann has found in the lava of Niedermendig 1·8 per cent. of phosphoric acid, thus confirming the researches of Fownes, which had been called in question by Kersten and Elsner. He also states that the acid occurs in union with lime, or as apatite, although the quantitative analysis showed only traces of chlorine, but no fluorine. The apatite, irrespective of the chlorine, would amount to 3·95 per cent. The mineral is not, however, uniformly dispersed through the whole mass of the lava, but is entirely wanting in some parts, whilst in others, where it cannot be distinguished by the eye, it exists in great abundance. Its presence is the less remarkable, since in a volcanic bomb found on the side of lake Laach, and hence not far from the lava-stream of Niedermendig, very distinct apatite crystals were observed; and since apatite is also known to occur in one of the lava-currents of Vesuvius, in the drusy cavities of a mixture of augite and mica.

An indirect proof of the existence of phosphoric acid, not only in the Niedermendig lava, but generally in the basaltic and lava-like rocks forming the numerous summits in the environs of lake Laach, is furnished by the luxuriant growth of the trees on them. A rock, on which has grown since time immemorial an immense quantity of wood, chiefly beech, in whose ashes we find phosphates of lime, magnesia, peroxide of iron, protoxide of manganese, and alumina (10·1

* Geol. Trans. 2nd ser. vol. vii. p. 59, tab.

† Final Rep. on Geol. of Mass. vol. ii. p. 503, tab. 49, figs. 66, 67, 68; tab. 46, figs. 69–71.

per cent., according to Hertvig), must contain phosphoric acid. For no manure has ever been put on these mountains which could have brought these salts of phosphoric acid; and these elevations, many of them very steep, have assuredly never been cultivated. This is also true of the neighbouring Siebengebirge. Without repeating the analysis of the trachyte of Drachenfels, we may confidently assert that it must contain phosphoric acid. Even where chemical analysis is no longer able to demonstrate the existence of a certain element in a rock, in consequence of the minuteness of its amount, the examination of the plants growing on it, if the ground has not been manured, furnishes as valid a proof of the actual presence of an element as the analysis of the soil could do.

[J. N.]

Lovén *on the Migrations of the* Molluscous Fauna *of* Scandinavia.

[Zeitschrift für Malakozool. 1847, pp. 24–26. In L. and B.'s Jahrbuch, 1848, p. 256.]

The molluscous fauna of Scandinavia consists of two elements, the German and the Arctic. The first attains its maximum in Bohus-Lehn and Southern Norway, the second in Finmark; in central Norway the two are mixed. During the 'Post-Tertiary period,' only the high northern fauna existed in Scandinavia, a result which the author has deduced from the examination of the raised shell-beds on the west coast ever since 1839. At a later period the fauna of the North Sea has gradually assumed a more southern character, the German as well as the Arctic forms have moved further northwards, and some high northern species even died out in Scandinavia, whilst the German Ocean at present is inhabited by a pure Germanic fauna. Lovén thus distinguishes—(1) such species as are less numerous in high latitudes than in the North Sea, and in the Mediterranean are entirely wanting; (2) Hospites, including all the species, common to the Mediterranean; (3) Aborigines, or those chiefly developed in high northern latitudes. An accurate comparison gives the following numbers of Conchylia (*Gasteropoda Cochleata, Brachiopoda, Acephala*).

	Number of species of Conchylia.	Proportion of the Acephala to the *Gasteropoda cochleata*, assumed = 100.
Sicily	502	60
England	413	91
Ireland	339	83
German Scandinavia	252	89
Arctic Scandinavia	131	84
Massachussetts	182	82
Greenland	111	49

In general the proportion of the Acephala to the conchiferous Gasteropoda may be taken as = 50, as is the case in Greenland, which is entirely surrounded by northern currents, and also very nearly in Sicily; whilst in the intermediate region, where the two faunas commingle, the proportion of the hardy, more enduring Acephala is much larger, since they have not only preceded the other southern molluscs in their migrations, but have also remained longer behind the other species wandering towards the north.

[J. N.]

Herr von Middendorff's *Geological Observations in* Siberia (Geognostische Beobachtungen auf seiner Reise durch Sibirien) by G. V. Helmersen.

[From the Bulletin de l'Acad. Imp. de St. Pétersbourg, pour 1847, tom. vi. n. 13.]

Last year M. von Middendorff entrusted to me the geological observations which he had collected during his Siberian journey, with the request that I should prepare them for publication in his travels. A collection of rocks and petrifactions, now deposited in the Museum of the Academy, accompanied the notices, and were used by me in preparing my account. The petrifactions will form the subject of a separate memoir by Count Keyserling, who has already published a very instructive notice of a portion of them in the fifth volume of the Bulletin, in which four new species of Ceratites are described.

These and many Jurassic petrifactions, which were brought with them from the river Olenek and some other Jura shells, which M. von Middendorff found in rolled masses in the valley of the Taimyr, are the most interesting objects in the collection. The Ceratites indicate a formation, the muschelkalk, which is in general, and more particularly in Russia, rare and very slightly developed. Hitherto it was only known in the Great Bogdo Mountain in the steppe of the Volga, though supposed to occur on Kotelnoi, one of the islands of New Siberia, from which the collection of the Mining Institute possessed the fragment of a Ceratite. The discovery of these fossils on the Olenek entitles us, however, to believe that the muschelkalk is not unknown in continental Siberia, and a more precise determination of their mode of occurrence ought to form a leading object of future observers in these far northern regions. But the appearance of the Jura formation in the extreme north of the Old World deserves particular attention. In a short memoir read to the Academy last year, I pointed out how much this formation had recently extended its limits in European Russia, whereas formerly it was considered a rare and sporadic phænomenon. Count Keyserling proved its extent in the Petschora land, where it reaches the shores of the Icy Sea; and M. von Middendorff's observations leave no doubt that in Arctic Siberia also it stretches perhaps with slight interruptions from the Ural to the valley of the Olenek, and there is reason to believe* con-

* See Keyserling's Petschora Land.

tinues even into the basin of the Lena. M. von Middendorff found no trace of the chalk formation, and I have expressed the opinion that the Jura beds of Siberia, like those of the Petschora land, are covered immediately by the tertiary deposits, which have such an enormous extent along the Icy Sea, and have been very attentively observed by our traveller. That these tertiary beds, containing the remarkable Adam's-wood or Noah's-wood, with perfect skeletons of Mammoths, have only recently for the first, or perhaps the second time, emerged from the sea, is most distinctly shown, by their including, up to a certain height, and for a considerable distance from the shore, well-preserved shells of mollusca still living in the Arctic Sea.

Regarding the age of the beds forming the Taimyr or Byrianga Mountains no decided opinion can be formed, no organic remains having been found in them. Still their mineralogical character, the mode of their occurrence, and some other marks, place them without doubt in one of the most ancient periods in the formation of the earth. Further inquiry must also decide the age of the clayslate, greywacke, limestone, dolomite and sandstone, observed by M. von Middendorff on his journey from Jakutsk to Udskoi and the Schantar islands, and in the basin of the Amur. Still more interesting are a whole series of crystalline, eruptive rocks seen in various parts of Eastern Siberia, and among which we find trachyte for the first time in this region of the globe.

[J. N.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

The Reptiles *of the* Coal Formation. By Herman von Meyer.

[From a Review of 'Beiträge zur vorweltlichen Fauna des Steinkohlengebirges, von Dr. Goldfuss.' Bonn, 1847, 4to, 5 plates, in Neue Jenaische Algem. Lit. Zeitung, Juli 1848, Nos. 164, 165, pp. 654–658.]

The contributions to the ancient fauna of the coal formation contained in this memoir are of very high importance. The abundance of vegetables preserved in this deposit are well-known, but hitherto animal remains have been of much rarer occurrence. Thus the Arachnidæ are represented by a scorpion-like creature; the Crustaceans consist of variously formed Entomostraca; the earliest Orthoptera and Lepidoptera appear in this epoch; the Mollusca are composed of littoral and deep-sea shells; among the vertebrated animals only fishes were lately known, namely, about a hundred species of the shark and ray, and scarcely half that number of Ganoids. The assumption therefore that reptiles did not exist before the Zechstein period seemed to have a foundation in facts. This view must now however be modified. Although it is still uncertain whether the bones found by Phillips in the limestone of Ardwick near Manchester, forming the upper part of the coal formation, actually belonged to reptiles or not, still the reviewer* has made known the complete skeleton of a small animal from the slate-clay of Münster-Appel in Rhenish Bavaria, whose general aspect (*Habitus*) scarcely admits of any doubt that it was a reptile, and which the reviewer described, in the beginning of 1844, under the name of *Apateon pedestris*. Three years later the Director of Mines, Von Dechen, discovered in the sphærosiderite nodules of Lebach in the Saarbrück district, in which fishes had alone been previously found, the remains of a peculiar genus of Saurians. The author of this work (Dr. Goldfuss) exhibited the skull to the Natural History Society of the Lower Rhine, on the 18th of February 1847, under the name of the *Archegosaurus Decheni,* and at the same time described it as a crocodilian animal forming a transition to the lizards in consequence of the presence of a parietal foramen.

* In the following memoir, by the *Reviewer* is to be understood H. von Meyer, by the *Author*, Prof. Goldfuss.—Translator.

This skull, with other remains of the Archegosaurus discovered in the interval, was laid before the meeting of the German naturalists at Aix la Chapelle, where the reviewer had an opportunity of inspecting them. This examination, though only cursory, convinced him that in this case we had less to do with an animal resembling the crocodile than with one most nearly allied to the Labyrinthodonts of the Trias. His remarks on that occasion induced the author likewise to compare these animals with Labyrinthodon.

Since the discovery of the Pterodactyle, probably no event in the domain of palæontology has been more important than the discovery of the Archegosaurus. The author describes this genus in the thorough manner that characterizes all his works. Three species, *Archegosaurus Decheni, A. medius* and *A. minor*, are distinguished. The skull of the first species and the portions of its trunk which have been found, seem to have belonged to an animal three feet six inches long, so that even this, the largest species, was much smaller than the Labyrinthodonts of the Trias.

The determination of the limits of the various bones of the skull is associated with many difficulties, as the reviewer has repeatedly convinced himself by the examination of a skull presented to him by M. Schnur of Treves. The surface of the bones is only preserved in the region of the forehead, and there has been covered with lancet-shaped, scale-like elevations and depressions, contrasting very remarkably with the Labyrinthodonts of the Trias, in which the surface of the bones of the skull appears, as it were, covered with carved-out, small pits and furrows. In the Archegosaurus the anterior angle of the orbit of the eye lies nearly in the middle of the length of the skull. Comparing it with the Labyrinthodon, we find that this angle in Mastodonsaurus is placed rather more forwards; in Metopias the orbit falls entirely in the anterior, in Capitosaurus in the posterior half. The nostrils show nothing of much consequence. In *A. Decheni* the long, small, nasal bone, enclosed in the upper maxillary; the upper maxillary indented behind for the reception of the malar bone (*Jochbein*); the small size and the position of the lachrymal bone and the anterior frontal bone, as well as the form of the parietal bone, have little agreement with those of the Labyrinthodonts of the Trias, in which the reviewer could never find "that the parietal bone contributed to form the margin of the orbit," which, according to the author's view, was the case with the Archegosaurus; in the Labyrinthodon the parietal bone is rather prevented from taking part in forming this margin by the posterior frontal bone. In Archegosaurus a bone lying more outwards and bordering on the malar bone is considered the posterior frontal bone, which the reviewer marks on the skull of the Labyrinthodon as 'posterior orbital bone' (*hinteres Augenhöhlenbein*), but which the author denies to the Archegosaurus. If, however, we conceive the posterior frontal bone separated from the parietal bone, as the author assumes, then the form and position of the latter bone is not only more correct, but we also obtain a posterior orbital bone, and in the same place too where it is found in the Labyrinthodon. The reviewer, however, cannot conceal that he likewise is convinced that it is very difficult to find a limit between the parietal and the posterior frontal bone. Behind this series of cranial bones follows a second, which the author, proceeding from the former, describes as mastoid, tympanal and squamous bones (*Zitzenbein, Paukenbein u. Schuppenbein*); in the Labyrinthodon the reviewer found the malar bone also prolonged into this posterior region, and the position of the tympanal and mastoid bones, the latter more correctly designated temporal bone (*Schlafenbein*), is the same. The superior occipital bone extends farther out, on the upper side, than in the triassic Labyrinthodonts. When the author says that in Capitosaurus the frontal bone (*Hauptstirnbein*) does not touch the inner margin of the orbits, he seems to have confused this genus with Metopias, in which the frontal bone does not contribute to form the orbit, whereas in Capitosaurus and Mastodonsaurus this margin is formed in the same manner as in Archegosaurus. The circular parietal foramen in *A. Decheni* lay nearly in the middle of the parietal bone, and was relatively larger than in the known Labyrinthodonts; and in the two other species of Archegosaurus it was smaller, and, in consequence of its appearance in the anterior half-length of the parietal bone, came nearer to the orbit. The temporal fossa also exhibited some diversities; in Archegosaurus it begins anteriorly with a narrow fissure which suddenly widens posteriorly; whilst in Mastodonsaurus, in which it appears most distinctly, it is much shorter and expands in front in a circular manner. The occipital foramen, as well as the articular process of the occiput, are not yet made out, but from the other parts of the structure of the Archegosaurus, the reviewer has no doubt that this process was bicondylous, as in the Labyrinthodonts. The jaws, to beyond the orbit of the eye, were furnished with small, fine, conical teeth, beyond which some thicker ones have projected, but even the latter were not so strong as in the Labyrinthodonts. It is still uncertain whether the jaws, as in the latter animals, were furnished with several rows of teeth. Instead of the teeth only their impression in the stone remains, from which it is seen that they were striated longitudinally. The reviewer believes that these teeth were fixed in deep alveoli, which was not the case with those of the Labyrinthodon.

The distinction between *A. medius* and *A. minor*—the skulls of which more resemble each other than they do that of *A. Decheni*,—consists rather in the constant difference in size, than in other characters. In these species the thickness of the nasal bones more approximates to that of Capitosaurus, and the frontal bone is, as in Labyrinthodon, double [*i. e.* divided by a frontal suture]. In the orbits of the eyes the author found long, quadrangular plates, still partially arranged in a semicircle; whence it follows that the eye of these animals was furnished with an osseous ring, which the reviewer has not found in the Labyrinthodonts of the Trias. The under jaw has small teeth like the upper jaw, and these can also be followed to beyond the orbit. On the anterior end of the intermaxillary bone, small, fine teeth appear, and behind three stronger teeth, which the author considers canine teeth. This view the reviewer can confirm from the skull of the *A. minor*, which he has more carefully examined; the anterior teeth are more pointed and wider separated than in Labyrinthodon, and the three interior ones are small when compared with the large teeth which appear further back in the latter. The anterior frontal bone seems to the reviewer to lie in the same place, in which, according to the author, the lachrymal bone occurs in *Archegosaurus Decheni*; it appears as a flat-bone contracting to a point in front and with the anterior angle of the orbit forming a notch in its posterior extremity, thus perfectly agreeing with the Labyrinthodon. This bone always borders immediately on the frontal bone, and outwardly on a longer bone, which, as in the Labyrinthodon, is prolonged forwards as far as the region of the half-length of the nasal bones, and goes so far back posteriorly, as to take part in the formation of the margin of the orbit. In position and size this bone corresponds to the lachrymal bone in the Labyrinthodonts, in which, however, the union of the anterior frontal bone with the malar bone excludes it from the margin of the orbit.

The ribs of the Archegosaurus are only known from the impressions they have left in the stone. These, however, are sharp enough to justify the conjecture that the ribs were of an osseous consistence. Their form cannot be distinctly recognised; the processes were broad and strong. Of *Archegosaurus Decheni* seventeen dorsal vertebræ (*Ruckenwirbel*) are preserved; of *A. minor* seven short vertebræ, referred by the author to the neck, which consequently was half as long as the head; of *A. medius* there is a series of nineteen vertebræ extending to the pelvis. The ribs are not very long, only slightly curved, obtuse at both ends, and rounded in the middle. The broad exterior ends of these dorsal ribs were connected with a kind of ribs, which were twice as long and only half as thick as the dorsal ribs, and at the same time terminated in a point.

Immediately connected with the skull was an osseous apparatus of singular structure, which the author considers to have been the hyoid bone (*Zungenbein*), which would thus be larger than in any other animal. This apparatus consists of a flat-arched, central plate of an acute rhombic form, to the anterior part of which, on both sides, there was attached a wing-shaped process, furnished behind with a styliform process. From the reticulated centre of the upper surface of the rhombic plate delicate lines radiated, which in the lateral wings proceeded rather from the posterior external angle. The author believes that this apparatus was prolonged anteriorly into a thick point, on which behind, at both sides, two cylindrical processes were attached at right angles, which are regarded as the horns of the hyoid bone. The reviewer did not find this part preserved in the skull he examined; he found the other bones, however, the sharp, natural outline of which showed that no part was broken off, and hence this anterior part must have formed a separate bone, which is perhaps more correctly regarded as the sphenoid bone. The rhombic plate would then be the proper body of the hyoid bone, the lateral parts on its anterior half the posterior horn, and the styliform process (which the reviewer believes was not anchylosed to the horn), maintaining the same direction backwards and outwards, would represent the process, which in the crocodile, of a cartilaginous consistence, is attached to the posterior horn. The rhombic shape of the body also reminds us of the hyoid bone of the tortoises, the horns of which, however, are attached to the body more in a rib-like manner. The interpretation of this apparatus as the hyoid bone seems more probably correct, since in its vicinity traces of external gills exist, which appear in the form of a double oval arch formed of small, oblong laminæ, pectinated on the inner side. This hyoid bone also recalls, in the form of the body, the bones which were found with the skull of the Mastodonsaurus, so that even from this point of view the Archegosaurus would offer a close relation to the Labyrinthodon. In confirmation of this statement the reviewer would refer to the 'Contributions to the Palæontology of Wurtemberg*,' published by Plieninger and him, in which in tab. 3, fig. 1, 2, a rhombic bone resembling the body, and in tab. 4, fig. 1, 2, a wing-shaped bone resembling the right posterior horn of Archegosaurus are figured.

The large size of the hyoid bone must have given to the neck of the Archegosaurus a breadth equal to that of the head. The animal has been much shorter in the body than the crocodile; of the tail nothing remains. Some small thin bones are compared to the coracoid bones anchylosed to the clavicle and to the scapula of the Proteus. The remains of the extremities leave no doubt that the Archegosaurus was provided with actual hands and feet, terminating in distinct toes. But these limbs were weak, serving only to swim or creep.

The peculiarities of the skeleton correspond to those of the skin, which consisted of long, narrow, wedge-shaped, tile-like, horny scales, arranged in rows, which met on the ventral side in *Archegosaurus Decheni* at right angles, in *A. medius* in a curve.

The Archegosaurus was consequently most nearly allied to the Labyrinthodonts. The latter, as is well known, were at first considered by Owen as Batrachians, whose structure approached to that of the frog, whilst the reviewer, who had a much richer store of materials for investigation at command, inclined to the opinion that they were rather Saurians†. Owen is now also disposed to the same view, considering the Labyrinthodonts as Saurians arrested in their development (*Genesis*), on the level of the Batrachians, and which have the same import (*Bedeutung*) for the Saurians, and occupy the same systematic place among them, that the Batrachians do in the whole class of Reptiles‡. With this idea, the type handed down to us in

* Beiträge zur Paleontologie Wurtembergs. † Ibid.

‡ The following passages contain a more accurate statement of Professor Owen's original views of the affinities of the Labyrinthodon than is given above. "The modifications of the jaws, and more especially those of the bony palate of the *Labyrinthodon leptognathus*, prove the fossil to have been essentially Batrachian, but with affinities to the higher Sauria, leading in the form of the skull and the sculpturing of the cranial bones to the Crocodilian group, in the collocation of the larger fangs at the anterior extremities of the jaws to the *Plesiosaurus*, and in one part of the dental structure, in the form of the episternum, and the biconcave vertebræ, to the *Ichthyosaurus*."—Report on British Fossil Reptiles in the Report of Brit. Assoc. for 1841, p. 185. And subsequently, p. 188: "Thus all these

the Archegosaurus fully agrees; which, as the author correctly points out, furnishes a proof that representatives of a permanent Larva-condition existed among the loricated reptiles of the ancient world, in like manner as the sirens (*Fischmolge*) do among the recent Batrachians. [J. N.]

Contributions to the knowledge of VEINS (*Gangstudien, oder Beiträge zur Kenntniss der Erzgänge, herausgegeben* von B. COTTA, Heft i.—V. WEISSENBACH, *über Gangformationen, vorzugsweise Sachsens. Ein Fragment. Freiberg*, 1847).

[From a notice by Dr. von Dechen in the Archiv für Mineralogie, vol. xxii. p. 287.]

EVERY contribution to our knowledge of mineral veins is welcome, both in a scientific and practical point of view; it is therefore a very fortunate circumstance that the Royal Saxon Council of Mines at Freiberg have instituted a careful examination of the mineral veins in that district, and especially of the causes of their becoming poor or rich. These researches are conducted under the direction of a committee consisting of MM. Reich, Haupt, V. Warnsdorff, Leschner, and Cotta. Its results will, it is to be hoped, be communicated in successive numbers of the above work. The above memoir, incomplete in consequence of the too early death, in July 1846, of its author, Privy Councillor von Weissenbach, has caused the immediate issue of this part.

Herr von Weissenbach is known by the publication in 1836 of drawings of remarkable veins in the Saxon Erzgebirge noticed in the twelfth volume of the 'Archiv.' Since that time, from considerations of health, the author had changed his mode of life, and had been compelled to give up his connexion with practical mining; but this work shows that he had not ceased to occupy himself with geognosy, and more especially with the origin of veins.

The term vein-formation has a much less precise meaning than that of rock-formation. What constitutes vein-formations in general, how they are to be characterized, and how far they are essentially to be distinguished from others, is neither so clear a matter, nor one on which there is so general an agreement as in regard to rock-formations. A certain degree of caprice and diversity still prevails in the use of the term 'vein-formation.' Even if we limit our views to mineral veins, as Werner, Von Herder and Freiesleben did, still they can only be characterized and distinguished by comprehending in one definition the sum of the peculiarities of whole groups of these veins.

osseous remains from the Warwick and Leamington sandstones agree with each other and with the fossil remains of the great *Mastodonsaurus Salamandroides* of the German Keuper in their essentially Batrachian nature." The Batrachian and Sauroid affinities of these animals are further elucidated in the chapter on the teeth of the Labyrinthodonts in the same author's 'Odontography,' pp. 195–217. "In the extinct family of the Labyrinthodonts, the Batrachian type of organization was modified so as to lead directly from that order to the highest forms of reptiles, viz. the loricate Sauria," p. 217. To these views we believe Professor Owen still adheres.—EDIT. GEOL. JOURN.

In consequence of the continual transitions and combinations which the phænomena of mineral veins exhibit, it is not possible to distinguish them into groups as is done in rock-formations. In the groups of mineral veins the author can only recognise various products, modified by locality or degree of development, of one great formative process of nature, or the individual aspects of one vast geognostic formation. The families of mineral veins which can be accurately distinguished will always retain a totally diverse import from the formations of mineral veins which are here established; they can only be considered as members of one and the same formation.

The author distinguishes various classes of veins, of which the mineral veins form only one class, viz.

Sedimentary veins:—formations in open fissures caused by mechanical filling-up from above.

Friction-veins:—consisting of the products of friction or other mechanical destruction of the neighbouring rock.

Stalactitic or infiltration-veins:—fissures filled by incrustation.

Plutonic or rock-veins [Dykes]:—fissures filled with mineral masses, which also occur as plutonic mountain rocks.

Secretion-veins:—laminæ, geodes, and vein-like formations in the interior of rocks, formed by the secretion or accretion of matter from the surrounding rock.

Mineral veins.

The first five classes are distinguished according to the way and manner in which a fissure has been filled, and thus can scarcely be put in opposition to or classed with mineral veins, separated on wholly diverse grounds, or from the nature of the mass which fills them. Yet we will not differ with the author for this want of classification, which would have given him occasion to impart to the public his careful, multiplied and extensive observations on mineral veins, had not this portion of the work, as well as that on plutonic or rock-veins, been left incomplete.

It will be understood that in this classification various groups of veins may be distinguished in each class, and especially among the mineral veins, and that when these are designated vein-formations the author understands only groups of veins especially resembling each other, which may be chosen from the variety of veins, partly as various grades of development, partly as local modifications of the general formation of mineral veins.

Did any perfect certainty exist regarding the manner and various processes connected with the production of veins; did their phænomena exhibit beyond doubt, at once their causes and origin, then the knowledge of the epoch and manner in which they had been produced would furnish much more precise characters for their division into formations. But at present, these processes, and the origin of mineral veins, are far too little known, and the most diverse views prevail regarding them, which based only on one portion of the phænomena cannot be brought into harmony with the others, and even often contradict them. Much is still wanting before a satisfactory general theory of veins can be established, but this only the more requires that the phænomena should be accurately studied, described and considered from various points of view.

The sedimentary veins are on the whole rare, and seem of subordinate interest, though they may frequently give some information regarding the more recent formations, and in this point of view deserve more general and accurate observation than has hitherto been bestowed on them.

The friction-veins are filled with matter produced by the crushing and rubbing of the neighbouring rock itself. They have very often given occasion to the formation of veins filled with foreign matter, and consequently belonging to an entirely different class, and by the union of the two produce veins possessing a very mixed nature. The larger part of mineral veins are at least partially connected with the formation of friction-veins.

The author distinguishes here,—

1. Veins with products of decomposition.
2. Veins with products of friction.
3. Veins with products of compression.
4. Veins with angular fragments (*Brockengesteinen*).
5. Veins with rounded stones (*Kugelgestein*).
6. Veins in the coal formation.

The first three of these divisions are altogether identical, and pass completely the one into the other. The products of decomposition, rubbing and compression are usually conjoined; it is only in rare cases that they can be separately distinguished. Their occurrence with mineral veins, and also with slips or dislocations, partly in the coal formation, partly in other sedimentary rocks, is highly important, and still presents a wide field for observation. Veins enclosing angular fragments, also spheroidal stones and ramifications of the lamellæ of the wall-stone (auch Sphärengestein und Umzweigungen von Nebengesteinschaalen), are most common among mineral veins. They are not wanting however among the sedimentary and stalactitic veins. Included in these fragmentary rocks are the friction-conglomerates, formed on the limits between eruptive masses and the rocks previously existing. The veins, enclosing rounded stones, the author considers were most probably formed in this manner; that the walls of the fissure had a repeated rubbing motion on each other, and in this manner have ground the angular fragments that came between them into a spherical form. The fragments and distinct produce of the grinding process fill up the intervals between the balls, and acquire, from the access of moisture and processes of decomposition, a new consistence similar to that of the original rock. As instances of this formation are mentioned the Schurfer-vein, near the large air-hole (*Lichtloch*) at Altenburg, where the balls consist of a brownish-red felspar porphyry; the globe-vein (Kugelgang) in the deep mine at Zwitterstock, in which larger or smaller balls of gneiss occur.

Among veins in the coal formation some very interesting examples from the mining district of Plauen are described, which however are more local, and furnish no general type of the dislocations common in other coal districts.

The secretion-veins have furnished the author with the richest material for varied remarks. He understands by this veins and vein-masses (*Gangtrümmer*) which have had a chemical or crystalline origin, and are so enclosed in the firm wall-rock that the introduction of their substance could not have taken place immediately or in open canals from without, but must have been effected by a secretion, or separation and collection of matter from the enclosing rock in the immediate vicinity. It appears that in the formation of these secreted products, essential differences in mode of origin may exist, and consequently more numerous specific distinctions may be made among them than in the individual formations of the other classes of veins. In this class are distinguished: Plutonic secretion-veins, formed by collection of matter. Such secreted masses, formed predominantly of crystalline felspar or also of quartz, are especially common in the granites both of the Erzgebirge and the Penig-Mitweidaer Weissstein mountains, and also in the upper Lausitz. Indeed, generally speaking, a very felspathous, plutonic mountain-rock will not readily be found in which this phænomenon does not occur,—a result of the same forces which have caused the formation of the various species of minerals. Plutonic secretion-veins formed by the oozing out of matter into fissures (*Ausschwitzung*): the distinction is pointed out between veins in plutonic rocks formed by the oozing out of matter into fissures, and the plutonic eruptive veins in the same rocks;—the latter exhibit a more uniform structure through their whole mass, they are finer-grained than the rock in which they occur; the former, on the contrary, show exclusively a perpendicular position of the individual crystalline parts composing them towards the walls of the veins, and a laminar disposition in the direction of the vein (*Ganglagerstructur*); they are coarser-grained than the rock in which they occur. To the most remarkable secretion-veins in plutonic rocks belong the Stockscheider vein in the mines at Geyer, and in the Weisserdenzeche near Aue; the latter of which especially presents many very problematic phænomena. The closely-connected coarse crystalline deposits of tin at Zinnwald are referred to the class of mineral veins, and consequently not minutely described.

Veins in serpentine appear as secretion-veins, without any previous open fissure;—minute cracks caused by contraction may have first occasioned the present vein-like separations. On the margin they consist of noble serpentine (picrolite), in the middle of schillerspar. Grains and small roundish masses, in which the two minerals are united in a similar manner, occur in the rock between and near to these veins.

The veins in the serpentine of Waldheim, which are filled with chlorite, chlorite-earth, picrolite, asbestiform steatite, and a little mica or talc, traverse, with very even and easily separable sides (*Saalbänder*), the beds, or lie in the numerous division-planes like very thin intermediate strata. As these have occasioned dislocations, their true character as fissures cannot be doubted.

Masses and nests of quartz in slates, as in clay-slate, mica-slate and gneiss, are very numerous and common, but not the less remarkable, especially where, on the one hand, they are still mixed with felspar, or on the other, where they occur in undoubted sedimentary strata full of petrifactions, and often assuredly secreted through the instrumentality of water. It is certainly of very great importance to collect more observations on this subject.

Many interesting notices are given regarding amygdaloids and agate masses, especially regarding the relation between proper amygdaloids, geodes, and the masses filled with similar minerals, and regarding the quartz and agate masses in the felspar porphyries of Saxony.

The examples of reticulated laminæ in the balls of sphærosiderite (septariæ) are highly interesting, but might easily be increased, as these nodules are so very common and are collected for use on so large a scale.

Veins in marble present in miniature all the phænomena of veins, though they may owe their substance solely to the neighbouring rock. They are in every respect similar to the quartz veins in the flinty slate (Lydian stone), with which the masses of quartz in the porphyry mined at Altenberg has so much similarity.

The fibrous laminæ, as those of fibrous limestone in the calcareous clay-slate of Moutiers, of fibrous gypsum in the gypseous clays and schistose marls of all formations, are explained in a simple manner from the similar layers of ice formed in a mass of frozen earth.

The incrustations and laminæ of calc-spar, gypsum, iron pyrites, &c., in fissures of coal, illustrated by examples from Plauen and the vicinity of Zwickau, are not less important than the nests of veins and laminæ in the old secondary limestones.

[J. N.]

The Trebich Grotto, *near* Trieste. By A. von Morlot.

[From 'Berichte über die Mittheil. v. Freunden d. Naturwis. in Wien von W. Haidinger,' vol. iii. p. 380.]

The maritime districts of Illyria show only two geological formations; the one sandstone and slate, which is properly nothing more than the Vienna sandstone; the other, the so-called Karst, resting on this in extensive but isolated beds. The Karst formation, consisting especially of white and rather pure limestone, is not only washed-out, furrowed, and pierced with holes in many places, but the whole rock is so traversed, and, as it were, sown over with deep funnel-shaped and crateriform abysses, that the mass of strata, 1000 feet thick, is truly described as being fuller of pores than a sponge. Hence the rain speedily sinks into the interior of the mountain, and the only water seen on the surface is at most a few small pools, nowhere the most trifling streamlet. In the region of the sandstone and slate, on the contrary, running water, both in brooks and rivers, is not wanting; but whenever they reach the limestone formation they run into it, often through highly romantic, portico-like openings, and continue their course below ground, only returning to the light where the sandstone again appears. In heavy storms of rain the water accumulates in the interior of the mountains, and swelling up to a great height drives out the air, often with much violence, through the narrow fissures and the caverns connected with them above. This circumstance often shows that holes which on the surface are very small, are yet continued deep into the interior. Many of these holes were lately examined, and extensive wanderings undertaken below ground, with the view of discovering in the vicinity of Trieste some subterranean stream which might supply the town with water. At length an opening of no great width, but sinking perpendicularly into the ground, was discovered at Trebich, about a league north-east from Trieste, which was followed out with great perseverance. The fissure sometimes expanded into a wide cavern, sometimes contracted to a rent of scarce a finger's breadth, and requiring great labour in blowing up the rocks, to enable the workmen to proceed; but it never closed up entirely, and some opening, however small, always remained, keeping up the connexion. Sometimes it separated into branches, but by always adhering to the one from which the current of air issued, a very considerable depth was soon attained without any great deviation from the direct course. Once, in a wide part of the opening, all trace of its continuation was lost, and many attempts to recover it, by blowing up the rock, had been made in vain, when the workman, Antony Arich, an intelligent miner from Carinthia, heard during the night a loud roaring and howling, and concluded that the water in the interior, rising suddenly in consequence of heavy rain, was forcing the air through some narrow opening, and thus discovered near the roof of the cave a small fissure, which again led in the right direction.

At length, after eleven months' hard labour, Arich reached a very large and extensive grotto, 270 feet high, at the bottom of which, 1022 feet below the surface of the earth, and 62 feet above the sea-level, a considerable stream of running water was found. This lowest opening is still in the bituminous limestone of the Karst, but contains on a stair-like elevation a considerable deposit of sand, produced by the destruction of the sandstone and slate, over which the river has run in its course aboveground. The water enters the grotto through a low vault, and flowing among the numerous large blocks which have fallen from the roof, expands into a long narrow lake, on which a small raft was formed, to explore its further course, and is at length lost under a vault which, descending below the surface of the water, put a stop to the investigation. During heavy rain the water has been already seen to rise 240 feet; but to judge from an old float of a mill-wheel found in a higher part of the hole, it must sometimes attain a height of 300 feet above its usual level.

[J. N.]

On the Vicinity of Schemnitz *and* Kremnitz.
By Prof. v. Pettko.

[From 'Haidinger's Berichte,' vol. iii. pp. 208, 269.]

Professor Pettko endeavours to prove that the whole trachytic formation of Schemnitz and Kremnitz may be regarded as a single magnificent elevation-crater.

In preparing a sketch for a geognostic map of the district of Kremnitz, he was struck by the circumstance that several rocks had the same local distribution, to the total exclusion of others, which again were united in other local groups (rock-districts), of which he distinguished four, namely the districts of the granite, of trachyte, of sphærulite-porphyry (less correctly also named the tufa district), and of the tertiary sandstone. The first lies without the elevation-crater, and requires no further notice in this place. The two districts of the sphærulite-porphyry and the tertiary sandstones must, on the other hand, be combined in one, as it is impossible to carry out their superficial division, volcanic tufas having been observed to alternate in some places with sandstones containing brown coal.

The two districts that thus remain, though originally established only for the immediate vicinity of Kremnitz, are found, by more extended research, to maintain their complete independence throughout the whole trachytic group. The domain of the sphærulite-porphyry forms a single uninterrupted ellipse, occupying the centre, whilst the trachyte district presents a ring-shaped ridge, returning into itself, and in general overlooking the central portion. The great extent of its diameter, from five to six miles (twenty-three to twenty-eight miles English), and the mountainous character of the interior, has prevented this arrangement from being immediately apparent. The Szitna near Schemnitz, the Skalka, and the Klak near Kremnitz, the Sattelberg near Königsberg, are members of this group, rising to elevations which the porphyry never attains. Who does not recognize in this arrangement an elevation-crater? The mountain-towns Schemnitz, Kremnitz, and Königsberg, lie on its inner declivity; Hlinnik, now so justly celebrated, is situated nearly in the centre; the two large masses of diorite, traversed by mineral veins at Schemnitz and Kremnitz, are placed nearly diametrically opposite each other. The ridge of gneiss and syenite which stretches across from Glashütten, through the valley of Eisenbach to Unterhammer, and is accompanied by quartz rock, greywacke-like sandstones, and compact limestones, assumes its place between the central part and the circumference, and belongs, from its considerable elevation, to the latter.

For the exterior domain of the trachyte, the distinguishing rocks are trachyte and diorite, with trachyte-conglomerate; for the district of the sphærulite-porphyry again, this rock itself including the millstone porphyry, then pearlstone and freshwater quartz are fully characteristic. The last three are distinctly limited to the interior of the crater, and in the whole circuit of the ring-shaped trachyte district not one locality is known where they occur; as, on the other hand, the trachyte and diorite are entirely excluded from the interior. The analogy with the elevation-crater of Rocca Monfina in Italy, so well described by Abich, cannot be mistaken; only in the latter the porphyry of the centre attains the greater elevation, in the case before us the surrounding trachyte is the higher. The extensive beds of freshwater quartz must be considered as a more recent formation, from copious warm springs in the interior of the crater, of which the thermal waters of Glashütten and Eisenbach are the feeble remains.

The Gran was compelled to force a way through the elevation-crater itself. The river broke through the ring above the village of Jalna, and formed in the interior, probably for a long period, a lake in which the sandstone containing brown coal was deposited, until it again found a way out at Königsberg. It divides the crater into two halves, and has thus contributed to render its true character so very difficult to be recognised.

It is remarkable that the laws established by Beudant for the disposition of the trachytic rocks are in perfect harmony with this new view. He says that the trachyte everywhere rises to the greatest elevations, and forms as it were the kernel on which, with gradually decreasing height, the porphyry, pearlstone and millstone are deposited. It is evident that he considered the individual projecting members of the trachyte ring as so many central points, from which he descended towards the Gran in the interior of the crater. A further symmetry of disposition arose from the occurrence of the volcanic tufa on both sides of the trachyte, this rock in reality occupying extensive tracts, not only in the interior of the crater, but also on its exterior declivities.

In reference to the geological age of the Schemnitz veins, there are especially three circumstances from which this may be pretty distinctly known ; these are the epoch of the elevation which caused the fissures, then the formations which the veins do, and lastly those which they do not traverse.

1. The veins at Schemnitz are nearly parallel to each other, and also to the high ridge of gneiss which runs across from the Glashütten valley to that of Hodritsch, and follows almost the inner border of the ring of trachyte mountains. It is not improbable that the elevation of this ridge has also caused the formation of the fissures. On the gneiss, along with subordinate beds of quartz-rock, clay-slate and sandstone, rests a compact limestone of great extent and thickness, which is again covered by a limestone conglomerate. In the latter, at Eisenbach, blocks occur, consisting almost entirely of nummulites, and also nummulites dispersed singly in an arenaceo-calcareous basis. These bodies are no longer regarded as exclusively tertiary fossils, but they occur here in a deposit which is not their original place, and which may therefore be tertiary, even although the nummulites may have lived in the more recent secondary epochs. Now these strata are themselves elevated, and consequently the elevation, and hence also the formation of the fissures must have taken place after the deposition of the tertiary conglomerate, and thus at all events not earlier than the tertiary period, probably in its middle division. This circumstance may even fix the age of the great elevation-crater itself.

2. The rocks traversed by the Schemnitz mineral veins are greenstone and greenstone tufa. There is nothing to show that the greenstone of this district is older than the connected trachyte, whilst the frequent transitions of the two rocks into each other, and their common local disposition, forming together the great ring-shaped moun-

tain ridge, decidedly point to their synchronous formation. If we now assume, with the greater number of geologists, that the trachyte belongs to the tertiary period, then the Schemnitz greenstone must also be tertiary, and the veins which traverse it are naturally still more recent, and, if the greenstone belongs to the older, will probably take their place in the middle tertiary period.

The eastern basis of the greenstone mountains is covered with a breccia-like tufa of undetermined thickness, which passes gradually into the true greenstone, and is most appropriately named a greenstone-tufa. It contains, where arenaceous, numerous impressions of leaves of dicotyledons and also brown coal, which near the veins is changed into siliceous anthracite. This tufa is undoubtedly penetrated by the more eastern veins, and since it cannot be more ancient than the greenstone, the veins that traverse it must also have been formed not earlier than the middle of the tertiary epoch.

3. The basalt at Schemnitz is decidedly more recent than the trachyte, as at Kieshubel it is seen very distinctly penetrating this rock and enclosing numerous fragments of it; but it appears to have been already in existence when the fissures of the Schemnitz veins were formed, since it imposes a limit to their further extension towards the east. In proceeding eastwards from the high gneiss ridge, the veins running parallel to it are successively crossed; the last but one is found immediately in front of the basalt; the last and most eastern, the so-called green vein, should, from its direction, either traverse the basalt or be traversed by it. But neither happens; the vein disappears at a considerable distance from the basalt and without reaching it, thus proving that there was a tendency to form more fissures further to the east, but that the compact basalt proved an insurmountable obstacle, and hence must have already been in existence. This also shows that the formation of these fissures took place at least in the middle tertiary period.

Though no one of these reasons by itself might have been sufficient to prove the comparatively recent origin of the Schemnitz veins, as they all depend on somewhat hypothetical suppositions; still taking them altogether, and considering that they all agree in pointing to one and the same age, and that there is nothing which contradicts this view or leads to the supposition of a greater antiquity, the formation of these veins during the middle tertiary period may be considered as well-established, however great the anomaly when compared with the date assigned to most other veins. [J. N.]

On the Fossil Plants discovered on the Upper Rhone. By O. Heer.

[From Leonhard and Bronn's Jahrbuch für 1848, p. 369.]

The author has collected many fossil plants in a very fine-grained bluish-grey marl which overlies the tertiary coal of the Upper Rhone. A similar but coarser-grained marl is found under the beds, in which leaves of plants also occur, but far fewer in number and not so well preserved. It lies upon a coarse-grained sandstone, and a similar sandstone covers the upper-marl beds and crops-out on the surface. All these strata have a rather considerable inclination and dip towards the south-west.

Heer has collected fifty-eight species of plants, mostly leaves, but also fruit, and even a few flowers. The leaves and fruits are remarkable for their very beautiful state of preservation, since not only the form of the margin of the leaf, but even the finest veins are preserved. These plants belong to twenty-one families and thirty-three genera. As deserving particular notice may be mentioned some remarkably fine ferns (Aspidium, Polypodium, Pteris), of which one seems to be nearly allied to the *Pteris stenophylla*, a native of the warmer parts of America, whilst the others approach to those now living in Europe; further, three species of cypress, one of which, a Callitris (*C. antiqua*, Heer), was one of the most common trees in the woods, and two Taxodiæ, which seem to be identical with the Œningen species (*T. Œningense*, A. Braun, and *T. distichum fossile*); three species of oak, of which two resembled the evergreen oaks of southern Europe; eleven willows, one of them (*Salix macrophylla*, Heer) distinguished for its uncommonly large leaves; six species of maple, and among them *Acer productum*, *A. cuspidatum*, and *A. trilobatum*, Al. Braun; a nut-tree, both leaf and fruit; the Liquidambar, Diospyros, Vaccinium, Betula, Rhus, Cratægus, and others. Twenty-four of the genera are still found in our present flora, whereas the remainder belong to more southern zones, as the cypresses, the storax-tree, the ebony, rhus, and others.

On examining the mode of occurrence of these fossil plants in the marls, a certain regularity in their distribution may be observed, showing that the plants grew in this place, and were not drifted to it from other quarters. Thus in one place the long leaves of a Typha abound, and here undoubtedly was a marsh or a mossy forest-stream; this is confirmed by the circumstance that whole stones are found full of leaves of the Carex, between which occur freshwater shells (*Planorbis* and *Cyclas*), occasionally also the leaves and fruit of the maple, which without doubt had fallen into this brook or marshy lake; in other localities the cypresses, and in others the deciduous-leaved trees preponderate. The Taxodiæ, however, and the many willows show that the forest stood in a marshy, moory tract.

This fossil flora has most resemblance to that of Œningen. In both localities a great number of willows and maples flourished, partly it would appear even the same species; in both among the coniferæ (*Nadelhölzer*) the cypress-like species predominated. On the other hand, poplars so common in Œningen are wanting in the Upper Rhone, and in their place is frequently found a tree like a lime-tree, which however has not yet been rightly determined. Œningen belongs to the upper freshwater molasse-formation, and consequently no great change in the character of the flora has taken place during the molasse-period, if the coal of the Upper Rhone actually belongs to the lower freshwater molasse, as A. Escher von der Linth concludes from the dip of the beds.

Unfortunately no comparison can be instituted with the coal of

Käpfnach or that near Rufi on the Schännisberg, since no determinable plants occur in either of these localities. In Käpfnach the mode of entombment seems to have been altogether different from that on the Upper Rhone. In the latter the plants must have been almost immediately enveloped in the marls, otherwise the leaves could not have been thus preserved with even their most delicate veins. From the circumstance that along with the ripe fruit of the Callitris, as it is found on the trees in the spring from the previous year, also young new fruit still hangs on the branches, and further from the young, still unformed, fruit of the maple, it may be concluded that the great catastrophe which destroyed the forest and buried it in the mass of marl, took place in the end of spring or the beginning of summer. In Käpfnach, on the contrary, the plants seem only to have been covered and enveloped in the marls after they had begun partially to decay. In the latter a black marl (named Strassberg) rests immediately on the coarse-grained sandstone; above this follows the coal (*Flötz*), covered in some places by a fœtid marl with Limnææ, Planorbes, and Melaniæ; to this succeeds a bluish-grey marl altogether similar to that on the Upper Rhone, and above this sandstone with *Melania Escheri*, Anodonta, &c. Since the marls that enclose the coal beds contain freshwater shells in great numbers, it is probable that the plants which formed them were covered for a long time by the fresh water in which these mollusks lived, and that in consequence of this all the more delicate tissues of the plants perished; and hence in the blue marls above the coal, which are as fine-grained and as well-adapted to preserve the leaves of plants as those in the Upper Rhone, no leaves occur. Remains of reed-like plants alone are found in them. This also explains why, in the stems of the palms met with in the coal of Käpfnach, only the fasciculæ of vessels are observed, whilst all the finer tissues have vanished. Sometimes whole bundles of these vascular fasciculæ may be seen lying close together, which have been named *Fasciculites* by the geologists, and *fir-needles* (leaves) by the workmen in the coal-mines.

[J. N.]

ALPHABETICAL INDEX

TO

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

The fossils referred to are described, and those of which the names are printed in italics are also figured.

END OF VOL. IV.

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